

**Committee for Risk Assessment**  
**RAC**

Annex 1  
**Background document**  
to the Opinion proposing harmonised classification  
and labelling at Community level of

**Glutaraldehyde**

**EC number: 203-856-5**  
**CAS number: 111-30-8**

CLH-O-0000004237-75-03/F

The background document is a compilation of information considered relevant by the dossier submitter or by RAC for the proposed classification. It includes the proposal of the dossier submitter and the conclusion of RAC. It is based on the official CLH report submitted to public consultation. RAC has not changed the text of this CLH report but inserted text which is specifically marked as 'RAC evaluation'. Only the RAC text reflects the view of RAC.

**Adopted**  
**6 June 2014**



## **CLH report**

### **Proposal for Harmonised Classification and Labelling**

**Based on Regulation (EC) No 1272/2008 (CLP Regulation),  
Annex VI, Part 2**

**Substance Name: Glutaraldehyde**

**EC Number: 203-856-5**

**CAS Number: 111-30-8**

**Index Number: 605-022-00-X**

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# Part A.

## 1 PROPOSAL FOR HARMONISED CLASSIFICATION AND LABELLING

### 1.1 Substance

**Table 1: Substance identity**

|                               |   |
|-------------------------------|---|
| <b>Substance name:</b>        | glutaral; glutaraldehyde; 1,5-pentanedial   |
| <b>EC number:</b>             | 203-856-5   |
| <b>CAS number:</b>            | 111-30-8  |
| <b>Annex VI Index number:</b> | 605-022-00-X  |
| <b>Degree of purity:</b>      | ≥ 48-52 %*  |
| <b>Impurities:</b>            | Confidential; No impurity is considered relevant for the classification of glutaraldehyde |

\* Glutaraldehyde is produced and placed on the market as an aqueous solution containing 50 % glutaraldehyde by weight. If the amount of glutaraldehyde in water exceeds 50 %, a change in composition of glutaraldehyde takes place because of gradual polymerization reaction of glutaraldehyde molecules. The highest concentration in which glutaraldehyde remains stable/monomeric for a long period of time (< 1 year) is 50 % aqueous glutaraldehyde. However, for classification purposes the (eco)toxicological endpoints are expressed as 100 % glutaraldehyde unless stated otherwise.

### 1.2 Harmonised classification and labelling proposal

**Table 2: The current Annex VI entry and the proposed harmonised classification**

|  | <b>CLP Regulation</b>  | <b>Directive 67/548/EEC (Dangerous Substances Directive; DSD)</b> |
|--|--|---|
| <b>Current entry in Annex VI, CLP Regulation</b> | Acute Tox. 3*; H331<br>Acute Tox. 3*; H301<br>Skin Corr. 1B; H314<br>Resp. Sens. 1; H334<br>Skin Sens. 1; H317 | T; R23/25<br>C; R34<br>R42/43<br>N; R50                           |

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|   |   |   |
|---|---|---|
|   | <p>Aquatic Acute 1: H400</p> <p>SCLs and M-factors:</p> <p>Skin Corr. 1B; H314 :<br/> <math>C \geq 10\%</math></p> <p>Skin Irrit. 2; H315:<br/> <math>0,5\% \leq C &lt; 10\%</math></p> <p>Eye Dam. 1; H318:<br/> <math>2\% \leq C &lt; 10\%</math></p> <p>Eye Irrit. 2; H319:<br/> <math>0,5\% \leq C &lt; 2\%</math></p> <p>STOT SE 3; H335: <math>C \geq 0,5\%</math></p> <p>Skin Sens. 1; H317: <math>C \geq 0,5\%</math></p> | <p>Conc. limits:</p> <p>T; R25: <math>C \geq 50\%</math></p> <p>Xn; R22:<br/> <math>2\% \leq C &lt; 50\%</math></p> <p>T; R23: <math>C \geq 25\%</math></p> <p>Xn; R20:<br/> <math>2\% \leq C &lt; 25\%</math></p> <p>C; R34: <math>C \geq 10\%</math></p> <p>Xi; R37/38-41:<br/> <math>2\% \leq C &lt; 10\%</math></p> <p>Xi; R36/37/38:<br/> <math>0,5\% \leq C &lt; 2\%</math></p> <p>R43: <math>C \geq 0,5\%</math></p> |
| <b>Current proposal for consideration by RAC</b>                                      | <p>Acute Tox 1; H330<br/> Removal of asterisk (*) from Acute Tox 3; H301<br/> Skin Sens. 1A<br/> Resp. Sens. 1<br/> STOT SE 3; H335<br/> Aquatic Chronic 2; H411<br/> Supplemental labelling statement: EUH071</p> <p>SCLs and M-factors:</p> <p>Skin Sens. 1 A: Removal of SCL of 0.5 %<br/> STOT SE 3; H335: <math>C \geq 0,00005\%</math><br/> M-factor M=10 to Aquatic Acute 1</p>  | <p>T+; R26</p> <p>R43: <math>C \geq 0,5\%</math> or <math>C \geq 0.1\%</math><sup>a)</sup></p> <p>Xi; R37: <math>C \geq 0,00005\%</math></p> <p>N; R50: <math>C \geq 2,5\%</math></p>   |
| <b>Resulting harmonised classification (future entry in Annex VI, CLP Regulation)</b> | <p>Acute Tox. 1; H330</p> <p>Acute Tox. 3; H301</p> <p>Skin Corr. 1B ; H314</p> <p>Resp. Sens. 1; H334</p> <p>Skin Sens. 1A; H317</p>   | <p>T+; R26</p> <p>T; R25</p> <p>C; R34</p> <p>Xi; R37</p> <p>R42/43</p>   |

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|  |   |   |
|--|---|---|
|  | <p>STOT SE 3; H335</p> <p>Aquatic Acute 1; H400,<br/>Aquatic Chronic 2; H411</p> <p>Supplemental labelling<br/>statement: EUH071</p> <p>SCLs and M-factors:<br/>Skin Corr. 1B; H314 :</p> <p>C ≥ 10%</p> <p>Skin Irrit. 2; H315:<br/>0,5% ≤ C &lt; 10%</p> <p>Eye Dam. 1; H318:<br/>2% ≤ C &lt; 10%</p> <p>Eye Irrit. 2; H319:<br/>0,5% ≤ C &lt; 2%</p> <p>STOT SE 3; H335: C ≥<br/>0,00005 %</p> <p>M=10</p> | <p>N; R50</p> <p>Conc. limits:</p> <p>T; R25: C ≥ 50%</p> <p>Xn; R22:<br/>2% ≤ C &lt; 50%</p> <p>C; R34: C ≥ 10%</p> <p>Xi; R38-41:<br/>2% ≤ C &lt; 10%</p> <p>Xi; R36/38:<br/>0,5% ≤ C &lt; 2%</p> <p>Xi; R37: C ≥ 0,00005%<br/>R43: C ≥ 0,5% or C ≥<br/>0.1% <sup>a)</sup></p> <p>N; R50: C ≥ 2,5 %</p> |
|--|---|---|

<sup>a)</sup>It is proposed to either retain the existing SCL of C ≥ 0.5 % or align the SCL with the GCL of 1A (0.1%) according to the CLP criteria. Both options are justified.

### 1.3 Proposed harmonised classification and labelling based on CLP Regulation and/or DSD criteria

**Table 3: Proposed classification according to the CLP Regulation**

| CLP Annex I ref | Hazard class   | Proposed classification | Proposed SCLs and/or M-factors | Current classification <sup>1)</sup> | Reason for no classification <sup>2)</sup>            |
|-----------------|--|-------------------------|--------------------------------|--------------------------------------|---|
| 2.1.            | Explosives   | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.2.            | Flammable gases  | -                       | -                              | -                                    | Data lacking  |
| 2.3.            | Flammable aerosols   | -                       | -                              | -                                    | Data lacking  |
| 2.4.            | Oxidising gases  | -                       | -                              | -                                    | Data lacking  |
| 2.5.            | Gases under pressure   | -                       | -                              | -                                    | Data lacking  |
| 2.6.            | Flammable liquids  | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.7.            | Flammable solids   | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.8.            | Self-reactive substances and mixtures                                    | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.9.            | Pyrophoric liquids   | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.10.           | Pyrophoric solids  | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.11.           | Self-heating substances and mixtures                                     | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.12.           | Substances and mixtures which in contact with water emit flammable gases | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.13.           | Oxidising liquids  | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.14.           | Oxidising solids   | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.15.           | Organic peroxides  | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 2.16.           | Substance and mixtures corrosive to metals                               | -                       | -                              | -                                    | Data conclusive but not sufficient for classification |
| 3.1.            | Acute toxicity - oral  | Acute Tox. 3:           | -                              | Acute Tox. 3*;                       |   |

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|              |  |  |                         |  |   |
|--------------|--|--|-------------------------|--|---|
|              |  | H301   |                         | H301   |   |
|              | Acute toxicity - dermal                            | -  | -                       | -  | Data conclusive but not sufficient for classification |
|              | Acute toxicity - inhalation                        | Acute Tox. 1: H330                               | -                       | Acute Tox. 3*; H331  |   |
| <b>3.2.</b>  | Skin corrosion / irritation                        |  |                         | Skin Corr. 1B ; H314<br><br>Skin Corr. 1B; H314: C ≥ 10 %<br>Skin Irrit. 2; H315: 0,5 % ≤ C < 10 % |   |
| <b>3.3.</b>  | Serious eye damage / eye irritation                | -  |                         | Eye Dam. 1; H318: 2 % ≤ C < 10 %<br>Eye Irrit. 2; H319: 0,5 % ≤ C < 2 %                            |   |
| <b>3.4.</b>  | Respiratory sensitisation                          | Resp. Sens. 1; H334                              | -                       | Resp. Sens. 1; H334  |   |
| <b>3.4.</b>  | Skin sensitisation                                 | Skin Sens. 1A; H317                              | Removal of SCL of 0.5 % | Skin Sens. 1; H317<br><br>Skin Sens. 1; H317: C ≥ 0,5 %  |   |
| <b>3.5.</b>  | Germ cell mutagenicity                             | -  | -                       | -  | Data conclusive but not sufficient for classification |
| <b>3.6.</b>  | Carcinogenicity                                    | -  | -                       | -  | Data conclusive but not sufficient for classification |
| <b>3.7.</b>  | Reproductive toxicity                              | -  | -                       | -  | Data conclusive but not sufficient for classification |
| <b>3.8.</b>  | Specific target organ toxicity –single exposure    | STOT SE 3; H335                                  | 0,00005 %               | STOT SE 3; H335: C ≥ 0,5 %   |   |
| <b>3.9.</b>  | Specific target organ toxicity – repeated exposure | -  | -                       | -  | Data conclusive but not sufficient for classification |
| <b>3.10.</b> | Aspiration hazard                                  | -  | -                       | -  | Data conclusive but not sufficient for classification |
| <b>4.1.</b>  | Hazardous to the aquatic environment               | Aquatic Acute 1: H400<br>Aquatic Chronic 2: H411 | M=10                    | Aquatic Acute 1: H400  |   |
| <b>5.1.</b>  | Hazardous to the ozone layer                       | -  | -                       | -  | Data conclusive but not sufficient for classification |

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<sup>1)</sup> Including specific concentration limits (SCLs) and M-factors

<sup>2)</sup> Data lacking, inconclusive, or conclusive but not sufficient for classification

**Labelling:**     Signal word: Danger  
                  Pictograms: GHS05, GHS06, GHS08, GHS09  
                  Hazard statements: H301, H330, H314, H335, H334, H317, H410  
                  Supplemental hazard statement: EUH071  
                  Precautionary statements: No precautionary statements are proposed since they are not included in Annex VI of Regulation (EC) No 1272/2008

### **Proposed notes assigned to an entry:**

None proposed.

**Table 4: Proposed classification according to DSD**

| Hazardous property  | Proposed classification | Proposed SCLs                                  | Current classification <sup>1)</sup>  | Reason for no classification <sup>2)</sup>            |
|---|-------------------------|--|---|---|
| Explosiveness   | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Oxidising properties  | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Flammability  | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Other physico-chemical properties<br><i>[Add rows when relevant]</i>        | -                       | -  | -   | -   |
| Thermal stability   | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Acute toxicity  | T+; R26<br>T; R25       | Removal of SCLs from acute inhalation toxicity | T; R23/25<br>T; R25: C ≥ 50 %<br>Xn; R22: 2 % ≤ C < 50 %<br>T; R23: C ≥ 25 %<br>Xn; R20: 2 % ≤ C < 25 % |   |
| Acute toxicity – irreversible damage after single exposure                  | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Repeated dose toxicity  | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Irritation / Corrosion  | Xi; R37                 | Xi; R37<br>C ≥ 0,00005 %                       | C; R34<br>C; R34: C ≥ 10 %<br>Xi; R37/38-41: 2 % ≤ C < 10 %<br>Xi; R36/37/38: 0,5 % ≤ C < 2 %           |   |
| Sensitisation   |                         | R43: C ≥ 0,5 % or C ≥ 0.1% <sup>a)</sup>       | R42/43<br>R43: C ≥ 0,5 %  |   |
| Carcinogenicity   | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Mutagenicity – Genetic toxicity   | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Toxicity to reproduction – fertility  | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Toxicity to reproduction – development                                      | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Toxicity to reproduction – breastfed babies.<br>Effects on or via lactation | -                       | -  | -   | Data conclusive but not sufficient for classification |
| Environment   |                         | N; R50<br>C ≥ 2,5 %                            | N; R50  |   |

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<sup>1)</sup> Including SCLs

<sup>2)</sup> Data lacking, inconclusive, or conclusive but not sufficient for classification

<sup>a)</sup> It is proposed to either retain the existing SCL of  $C \geq 0.5\%$  or align the SCL with the GCL of 1A (0.1%) according to the CLP criteria. Both options are justified.

**Labelling:**     Indication of danger: T+, C, N  
R-phrases: R26; R25; R34; R37; R42/43; R50  
S-phrases: S1/2; S26; S36/37/39; S45; S61

## **2 BACKGROUND TO THE CLH PROPOSAL**

### **2.1 History of the previous classification and labelling**

The health hazard classification of glutaraldehyde according to Dangerous Substances Directive (DSD) 67/548/EEC was agreed in the Commission Working Group on the Classification and Labelling of Dangerous Substances in July 1995 meeting (ECBI/65/95) and the environmental hazard classification was agreed in the Environmental Effects Group in December 1995 meeting (ECBI/96/95). Glutaraldehyde was included in Annex I of DSD in the 22nd ATP (96/54/EC). In the 29th ATP (2004/73/EC) general environmental concentration limits were added to the N; R50 classification. The classification according to the DSD but without the general environmental concentration limit was transferred into Annex VI of the CLP Regulation.

According to DSD, glutaraldehyde is currently classified for its acute toxic effects via oral and inhalation routes as T; R23/25; for its corrosive effects as C; R34 with specific concentration limits and for its skin and respiratory sensitizing effects as R42/43. The corresponding classifications according to the CLP Regulation are Acute Tox. 3\*; H301, Acute Tox. 3\*; H331, Skin Corr. 1B; H314 with specific concentration limits, Skin Sens. 1; H317 and Resp. Sens. 1; H334.

Glutaraldehyde is being reviewed as an existing active substance under the Biocidal Products Directive (98/8/EC). The hazards of glutaraldehyde have been assessed by the Finnish Competent Authority as part of the Review Programme. The effects assessment (Document II-A of the Competent Authority Report) was discussed and agreed at the Biocides Technical Meeting III 2011. We consider that following this agreement, it is now an appropriate time to submit a harmonized classification and labelling proposal before the inclusion or non-inclusion to Annex I to Directive 98/8/EC.

The present proposal suggests to add an M-factor of 10 to the Aquatic Acute Category 1 CLP classification. Change of criteria in the 2nd ATP (286/2011) of the CLP Regulation leads to a proposal to classify glutaraldehyde to Aquatic Chronic Category 2. The proposal also includes revision of the acute toxicity classification. Removal of the asterisk from Acute Tox. 3; H301 is proposed as well as tightening the classification for the inhalation route from Acute Tox. 3\* to Acute Tox. 1. In addition, data on skin, eye and respiratory tract irritation has been included and based on the data, classification as STOT SE 3; H335 with a SCL of 0,00005 % is proposed. The data on skin and respiratory sensitisation has been included and evaluated considering the new criteria for sub-categorisation of sensitisers in the 2<sup>nd</sup> ATP (286/2011) of the CLP Regulation. Based on data classification as Skin Sens. 1A and as Resp. Sens. 1 is proposed.

### **2.2 Short summary of the scientific justification for the CLH proposal**

The classification proposal is based on the Document II-A and the Document III-A of the Competent Authority Report (CAR) which are provided in section 13 of the IUCLID file.

The available data on glutaraldehyde supports the revision of the current harmonised CLP classification from Acute inhalation toxicity 3 (H331) to Acute inhalation toxicity 1 (H330). In the inhalation study, a generation system for aerosol is described, but the resulting glutaraldehyde in the air is described as "very fine aerosol < 2.8 µm or as a vapour". This implies that the test atmosphere was a mixture of liquid and vapour phases, and therefore it would be prudent to apply the criteria for vapour. In order to clarify whether the test substance should be considered as aerosol or vapour, the applicant performed a physical-chemical study mimicking the system used in the inhalation

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study (Wittmer 2012, BASF A6.01.3\_01a). At measured concentrations of 0.224 and 0.349 mg/L, the vapour phase accounted for 65 and 68 % of the glutaraldehyde, respectively, supporting the use of the criteria for vapours. The LC50 values are 0.35 mg/L in male rats and 0.28 mg/L in female rats. These are both < 0.5 mg/L and therefore allocation to Category 1 for inhalation toxicity is appropriate.

The asterisk (\*) indicating minimum CLP classification for Acute oral Toxicity 3 (H301) is no longer necessary since the data confirms the classification.

Glutaraldehyde is currently classified as Skin Corr. 1B with specific concentration limits for respiratory tract irritation STOT SE 3; H335: C  $\geq$  0,5%. This stems from the direct translation of R37 (at specific concentration limits) under Directive 67/548/EEC into the corresponding classification according to the CLP Regulation. However, the presented human and animal data in this CLH report confirm that glutaraldehyde causes respiratory tract irritation also via a specific mechanism, namely sensory irritation. Therefore, classification as STOT SE 3; H335 is proposed based on both corrosivity and sensory irritation in the respiratory tract.

Glutaraldehyde is currently classified as Skin Sens. 1 with a specific concentration limit of C  $\geq$  0.5% and as Resp. Sens. 1. The data on both skin and respiratory sensitisation has been included and evaluated according to the new criteria in the 2<sup>nd</sup> ATP. The presented human and animal skin sensitisation data allow classification of glutaraldehyde into sub-category 1A. The existing SCL is superfluous to the 0.1% GCL of sub-category 1A and therefore it is proposed to be removed. The presented human data on respiratory sensitisation might be considered pointing towards sub-category 1B, however since the sub-category 1A cannot be excluded glutaraldehyde is proposed to be classified as Resp. Sens 1.

The Finnish CA considered also classification of glutaraldehyde as category 2 mutagen because of the strong *in vitro* evidence, but concluded that the evidence was not sufficient for classification. The *in vivo* genotoxicity studies suffered from the problem of fast reactivity of the test substance which resulted in uncertainty of whether the test substance and/or the reactive metabolites had reached the evaluated target tissue. Results of the *in vivo* studies were clearly negative except for one intraperitoneal micronucleus test, where cytotoxicity and an inconsistent pattern of slight increases in micronucleated polychromatic erythrocytes (PCEs) were seen. The conclusion on mutagenicity is that site of contact mutagenicity remains a possibility that has not been explored by the available mutagenicity studies, but for the purpose of biocide risk assessment the risk to humans was considered sufficiently covered based on the negative results of the carcinogenicity and reproductive toxicity studies. Further mutagenicity testing for the purpose of classification was not considered justifiable.

The lowest aquatic acute toxicity value (0.07 mg/l) confirms the existing environmental hazard classifications (Aquatic Acute 1 according to CLP and N; R50 according to DSD) for glutaraldehyde and gives cause to set an M-factor of 10 to Aquatic Acute 1 classification and corresponding specific concentration limit (N; R50; C >2.5%) to N; R50 classification. The lowest chronic toxicity value 0.025 mg/l with the fact that glutaraldehyde is rapidly degradable leads to Aquatic Chronic 2 classification according to the criteria of the 2nd ATP of the CLP regulation.

## 2.3 Current harmonised classification and labelling

### 2.3.1 Current classification and labelling in Annex VI, Table 3.1 in the CLP Regulation

**Table 5: Current Annex VI Table 3.1 Classification and Labelling**

| Classification                    |                          | Labelling                      |                          | Specific Conc. Limits, M-factors  |
|-----------------------------------|--------------------------|--------------------------------|--------------------------|---|
| Hazard Class and Category Code(s) | Hazard statement Code(s) | Pictogram, Signal Word Code(s) | Hazard statement Code(s) |   |
| Acute Tox. 3 *                    | H331                     | GHS06                          | H331                     | Skin Corr. 1B;<br>H314 : $C \geq 10\%$<br>Skin Irrit. 2;<br>H315: $0,5\% \leq C < 10\%$<br>Eye Dam. 1;<br>H318: $2\% \leq C < 10\%$<br>Eye Irrit. 2; H319:<br>$0,5\% \leq C < 2\%$<br>STOT SE 3;<br>H335: $C \geq 0,5\%$<br>Skin Sens. 1;<br>H317: $C \geq 0,5\%$ |
| Acute Tox. 3 *                    | H301                     | GHS08                          | H301                     |   |
| Skin Corr. 1B                     | H314                     | GHS05                          | H314                     |   |
| Resp. Sens. 1                     | H334                     | GHS09                          | H334                     |   |
| Skin Sens. 1                      | H317                     | Dgr                            | H317                     |   |
| Aquatic Acute 1                   | H400                     |                                | H400                     |   |

### 2.3.2 Current classification and labelling in Annex VI, Table 3.2 in the CLP Regulation

**Table 6: Current Annex VI Table 3.2 classification and labelling**

| Classification                       | Labelling  | Concentration limits  |
|--------------------------------------|--|---|
| T; R23/25<br>C; R34 R42/43<br>N; R50 | T; N<br>R: 23/25-34-42/43-50<br>S: (1/2-)26-36/37/39-45-61 | T; R25: $C \geq 50\%$<br>Xn; R22: $2\% \leq C < 50\%$<br>T; R23: $C \geq 25\%$<br>Xn; R20: $2\% \leq C < 25\%$<br>C; R34: $C \geq 10\%$<br>Xi; R37/38-41: $2\% \leq C < 10\%$<br>Xi; R36/37/38: $0,5\% \leq C < 2\%$<br>R43: $C \geq 0,5\%$ |

## **2.4 Current self-classification and labelling**

### **2.4.1 Current self-classification and labelling based on the CLP Regulation criteria**

The existing harmonised classification was notified by a majority of the 1471 notifiers to the Classification and Labelling Inventory. Some notifiers (189; 13 %) classified the substance as Acute Tox. 2; H330 instead of Acute Tox 3\*; H331 and 19 (1,3 %) notifiers as Acute Tox 1; H330 instead of Acute Tox 3\*; H331. One notifier classified glutaraldehyde as Acute Tox. 4; H312. The EUH071 statement was notified by 45 (3 %) notifiers. STOT SE 3; H335 classification was notified by 94 (6,4 %) notifiers. STOT SE 1; H370 and STOT RE 1; H372 classification was notified by 1 notifier. Skin Sens. 1B and Resp. Sens. 1B classification was notified by 13 (0.9 %) notifiers, the rest of the notifiers classified glutaraldehyde as Skin Sens. 1 and as Resp. Sens. 1.

Aquatic Chronic 2; H411 classification was notified by 2 notifiers and Aquatic Chronic 1; H410 classification by 1 notifier (as the sole environmental classification).

In addition, classification as Met. Corr. 1; H290 was notified by 135 (10 %) notifiers. Seven notifiers classified glutaraldehyde as Flam. Liq. 3.

### **2.4.2 Current self-classification and labelling based on DSD criteria**

Not applicable.

## **3 JUSTIFICATION THAT ACTION IS NEEDED AT COMMUNITY LEVEL**

Glutaraldehyde is an active substance in the meaning of Biocidal Products Directive 98/8/EC and therefore subject to harmonised classification and labelling in accordance with Article 36(2) of the CLP Regulation.

## Part B.

### SCIENTIFIC EVALUATION OF THE DATA

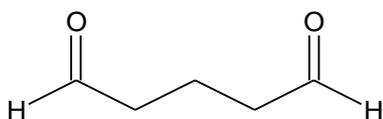
#### 1 IDENTITY OF THE SUBSTANCE

##### 1.1 Name and other identifiers of the substance

Table 7: Substance identity

|                            |  |
|----------------------------|--|
| EC number:                 | 203-856-5                                    |
| EC name:                   | glutaral                                     |
| CAS number (EC inventory): |  |
| CAS number:                | 111-30-8                                     |
| CAS name:                  | pentanedial                                  |
| IUPAC name:                | 1,5-pentanedial                              |
| CLP Annex VI Index number: | 605-022-00-X                                 |
| Molecular formula:         | C <sub>5</sub> H <sub>8</sub> O <sub>2</sub> |
| Molecular weight range:    | 100.11 g/mol                                 |

##### Structural formula:



## 1.2 Composition of the substance

**Table 8: Constituents (non-confidential information)**

| Constituent    | Typical concentration | Concentration range | Remarks |
|----------------|-----------------------|---------------------|---------|
| glutaraldehyde | 50 %                  | 48-52 %             |         |

Current Annex VI entry:

CLP: Acute Tox. 3\*; H301, Acute Tox. 3\*; H331, Skin Corr. 1B, Skin Sens. 1 and Resp. Sens. 1., Aquatic Acute 1; H400.

DSD: T; R23/25, C; R34, R42/43, N; R50

**Table 9: Impurities (non-confidential information)**

| Impurity     | Typical concentration | Concentration range | Remarks |
|--------------|-----------------------|---------------------|---------|
| Confidential |                       |                     |         |

There is one impurity which is present at concentration  $\leq 0.5$  %. This impurity does not affect the classification of glutaraldehyde. The impurity is considered confidential and is therefore not given in this report but only in the IUCLID file and flagged confidential.

**Table 10: Additives (non-confidential information)**

| Additive | Function   | Typical concentration | Concentration range | Remarks |
|----------|------------|-----------------------|---------------------|---------|
| water    | stabilizer | 50 %                  | 48-52%              |         |

### 1.2.1 Composition of test material

Glutaraldehyde is produced and placed on the market as an aqueous solution containing 50 % glutaraldehyde by weight. If the amount of glutaraldehyde in water exceeds 50 %, a change in composition of glutaraldehyde takes place because of gradual polymerization reaction of glutaraldehyde molecules. The highest concentration in which glutaraldehyde remains stable/monomeric for a long period of time (< 1 year) is 50 % aqueous glutaraldehyde. However, for classification purposes the (eco)toxicological endpoints are expressed as 100 % glutaraldehyde unless stated otherwise.

### 1.3 Physico-chemical properties

**Table 11: Summary of physico - chemical properties**

| Property                                     | Value   | Reference   | Comment (e.g. measured or estimated) |
|--|---|---|--------------------------------------|
| State of the substance at 20°C and 101,3 kPa | Colourless liquid<br>(50% glutaraldehyde)   |   |                                      |
| Melting/freezing point                       | Peak maximum ca. – 18 °C<br>Extrapolated onset temperature ca. –33 °C;<br>range about –50 to –15 °C   | Schmidt, P. (2002)<br>BASF A3.01.1_01   |                                      |
|  | -18 to -21.2 °C (performed at atmospheric pressure)   | McKemie, T.H. (2000a)<br>Dow A3.1.1   |                                      |
| Boiling point                                | 101.5 °C at 987.1 hPa<br>101.95 °C at 1013.25 hPa<br>100.7 °C at 1013 hPa   | Siemann, L. (1999)<br>BASF A3.01.2_01<br>Anonymous (1995)<br>BASF A3.01.2_02<br>McKemie, T.H. (2000b)<br>Dow A3.1.2 |                                      |
| Relative density                             | 1.129 kg/dm <sup>3</sup>  | Siemann, L. (1999)<br>BASF A3.01.2_01<br>McKemie, T.H. (2000c)<br>Dow A3.1.3  |                                      |
| Vapour pressure                              | 44 Pa (20 °C, 100 % GA)   | Olson, J.D. (1998)<br>BASF A3.02_03<br>Rick, D.L. and West, R.J. (2006)<br>Dow 3.2                                  |                                      |
| Surface tension                              | ca. 68 mN/m at 20 °C (0.2% aqueous preparation of the test item corresponds to a 0.1% solution of pure glutaraldehyde)<br><br>72.4 mN/m at 20 °C (1g/l corresponding to 0.5 g/l or 0.05% solution of pure glutaraldehyde) | Sametschek, E. (2004)<br>BASF A3.13_01<br><br>McKemie, T.H. (2000e)<br>Dow A3.13                                    |                                      |
| Water solubility                             | Glutaraldehyde is an aqueous solution and as such is fully soluble (≥ 51.3 g glutaraldehyde/100 ml)   | Drögemüller, A. (2002)<br>BASF A3.05_01<br>Wells, D.F (1994a)<br>Dow A3.5   |                                      |

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|   |  |   |  |
|---|--|---|--|
| Partition coefficient n-octanol/water                                       | <p>logP<sub>ow</sub> -0.41 (pH 5, temp. 23 +/- 1 °C)<br/> logP<sub>ow</sub> -0.36 (pH 7, temp. 23 +/- 1 °C)<br/> logP<sub>ow</sub> -0.80 (pH 9, temp. 23 +/- 1 °C)</p> <p>logP<sub>ow</sub> -0.33 (at 25 °C, pH not reported)</p>  | <p>Sametschek, E. (2002)<br/> BASF A3.09_01</p> <p>Shepler, K. (1996)</p> <p>Dow A3.9</p> |  |
| Flash point   | <p>No flashpoint was observed for either sample at temperatures up to 95 °C</p> <p>184.8 °F = 85 °C</p>  | <p>Siemann, L. (1999)<br/> BASF A3.01.2_01</p> <p>Fowler, T. (2009)<br/> Dow 3.12</p>     |  |
| Flammability  | Not flammable  | <p>Simms, R. (2006)<br/> BASF A3.10_02</p> <p>Leder, J. (1989)<br/> Dow A3.11</p>         |  |
| Explosive properties  | <p>Not applicable, Glutaraldehyde does not contain any reactive groups that might cause spontaneous explosive decomposition.</p> <p>Glutaraldehyde is not considered to present a danger of explosion.</p>   | <p>Dow</p> <p>Gödde, M. (2004)<br/> BASF A3.10_01</p>                                     |  |
| Self-ignition temperature   | -  | -   |  |
| Oxidising properties  | <p>No noticeable changes in temperature or evolution of gas were observed for any of the mixtures. The substance has no chemical groups indicating oxidizing properties.</p> <p>Not applicable, aldehydes by nature behave as reducing agents and are easily oxidised rather than reduced.</p> | <p>Siemann, L. (1999)<br/> BASF A3.01.2_01</p> <p>Leder, J. (1989)<br/> Dow A3.11</p>     |  |
| Granulometry  | -  | -   |  |
| Stability in organic solvents and identity of relevant degradation products | Not applicable as the products will not be formulated with organic solvents.   | <p>Dow<br/> BASF</p>  |  |

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|                       |  |   |  |
|-----------------------|--|---|--|
| Dissociation constant | Due to the nature of the test substance, determinations were not possible<br><br>Does not have any ionisable/dissociable groups therefore not applicable | Siemann, L. (1999)<br>BASF A3.01.2_01<br><br>Dow                            |  |
| Viscosity             | 12.75 mm <sup>2</sup> /s at 25 °C<br><br>20.15 mPa/s (at 20 °C)<br>4.72 mPa/s (at 40 °C)   | Siemann, L. (1999)<br>BASF A3.01.2_01<br>McKemie, T.H. (2000f)<br>Dow A3.14 |  |

## 2 MANUFACTURE AND USES

### 2.1 Manufacture

### 2.2 Identified uses

Glutaraldehyde is used as a biocidal active substance in disinfection and in product and process preservation. It has a broad spectrum activity against Gram-positive and Gram-negative bacteria, bacterial spores, fungi (yeasts and moulds) and viruses. Besides biocidal use, glutaraldehyde is used as a laboratory reagent, in development of X-ray film, and in cross linking.

Glutaraldehyde is a registered substance under the REACH Regulation (1907/2006). The registration dossiers have been considered when preparing the CLH dossier (last date for checking 24/05/2012). No new relevant data is presented in the registration dossiers. There are, however, relevant data used in the biocide assessment that is not included in REACH registration dossiers.

### 3 CLASSIFICATION FOR PHYSICO-CHEMICAL PROPERTIES

No classification is proposed based on the evaluated data in the CAR.

### 4 HUMAN HEALTH HAZARD ASSESSMENT

The Document II-A (Draft, December 2012) of the Competent Authority Report (CAR) including the health hazard assessment is provided in section 13 of the IUCLID file.

#### 4.1 Toxicokinetics (absorption, metabolism, distribution and elimination)

##### 4.1.1 Non-human information

**Table 12: Toxicokinetic and metabolism studies**

| Route<br>Guideline<br>GLP                                 | Species<br>Strain<br>Sex<br>No of animals   | Dose levels<br>Frequency of<br>application<br>Label   | Investigations   | Reference  |
|---|---|---|--|--|
| Oral (gavage)<br>OECD 417<br>GLP                          | Rat<br>Wistar<br>(CrIGlxBrIHan:Wl)<br>4 ♂ + 4 ♀ per group in<br>balance/excretion study,<br>blood/plasma level<br>study, bile excretion<br>study<br>3 ♂ + 3 ♀ per group in<br>tissue distribution<br>study, | Single oral<br>dose of 5 or 75<br>mg/kg<br>[2,4- <sup>14</sup> C]-<br>glutaraldehyde  | Balance/excretion<br>Blood/plasma level<br>Tissue distribution<br>Bile excretion   | Beimborn, D.B. and Leibold, E.<br>(2004)<br>Dow A6.02/01,<br>BASF A6.02_01<br><br>Key study                |
| Oral (gavage),<br>Dermal<br>Similar to OECD<br>417<br>GLP | Rat<br>Fischer 344<br>4 ♀ per group ( <i>in vivo</i><br>experiments)<br>15 ♀ ( <i>in vitro</i><br>experiment)   | Single oral<br>dose of 5 or 75<br>mg/kg<br>Single dermal<br>application,<br>120 µl of 0.75<br>% or 7.5 %<br>solutions<br>No labelling | <i>In vivo</i> oral pharmacokinetics<br><i>In vivo</i> dermal<br>pharmacokinetics<br><i>In vitro</i> partitioning between<br>red blood cells, plasma<br>protein and free<br>glutaraldehyde | Mendrala A.L., Clark A.J.,<br>Sushynski, J.M. (2004)<br><br>Dow A6.02/02<br>BASF A6.02_02<br><br>Key study |

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| Route<br>Guideline<br>GLP   | Species<br>Strain<br>Sex<br>No of animals  | Dose levels<br>Frequency of<br>application<br>Label  | Investigations   | Reference   |
|---|--|--|--|---|
| Oral <i>via</i> drinking<br>water<br>OECD 417<br>GLP  | Rat<br>CrI:W1(Han)<br>4 ♀ per group<br>(12 ♀ per dose level)   | 50 ppm and<br>1000 ppm for<br>24 h<br>(equivalent to a<br>mean dose of<br>6.8 and 87<br>mg/kg bw)<br>[2,4- <sup>14</sup> C]-<br>glutaraldehyde<br>(also non-<br>labelled<br>glutaraldehyde)                        | Excretion/Balance<br>Blood/plasma level<br>Tissue distribution<br>Metabolite identification<br>(intended)  | Hansen, S.C., Clark, A.J,<br>McClymont, E.L., Staley, J.L.<br>(2007)<br><br>Dow A6.02/03<br>BASF A6.2_09  |
| <i>In vitro</i><br>Skin penetration<br>No guideline<br>GLP  | Fischer 344 rats (♂, ♀)<br>CD@-1 mice (♂, ♀)<br>Albino Hartley guinea<br>pigs (♂, ♀)<br>New Zealand White<br>rabbits (♂, ♀)<br>Human (♀)         | Single 6 h<br>application of<br>250 µl of 0.75<br>% and 7.5 %<br>solutions<br>[1,5- <sup>14</sup> C]-<br>glutaraldehyde  | <i>In vitro</i> percutaneous<br>absorption through skin<br><br>( <i>Supportive information only<br/>due to major methodological<br/>problems</i> )                     | Tallant, M.J., Beskitt, J.L., and<br>Frantz, S.W. (1991)<br><br>Dow A6.02/4 (full report)<br><br>Frantz, S.W., Beskitt J.L., Tallant,<br>M.J. (1993)<br><br>BASF A6.02_6 (published report) |
| Oral (gavage)<br>OECD 417<br>GLP  | Rat<br>Wistar<br>3 ♂ + 3 ♀ per group   | Single oral<br>dose of 5 or 75<br>mg/kg<br>[2,4- <sup>14</sup> C]-<br>glutaraldehyde   | Excretion in urine, faeces,<br>CO <sub>2</sub><br>Metabolite identification<br>(intended)  | Zhang, F., Hansen, S.C., Clark,<br>A.J. (2007)<br><br>Dow A6.02/05<br>BASF A6.02_5  |
| <i>In vivo</i> skin<br>penetration and<br>pharmacokinetics<br>Comparable to<br>OECD 427<br>No GLP | Fischer 344 rats<br>4 ♂ + 4 ♀ per dose<br>level and experiment<br><br>New Zealand White<br>rabbits<br>1 ♂ + 1 ♀ per dose<br>level and experiment | Single 24 h<br>application of<br>0.075, 0.75 or<br>7.5 %<br>glutaraldehyde<br>(rats)<br>Single 24 h<br>application of<br>0.75 or 7.5 %<br>glutaraldehyde<br>(rabbits)<br>[1,5- <sup>14</sup> C]-<br>glutaraldehyde | <i>In vivo</i> skin penetration<br>Material retained in skin and<br>tissues<br><br>( <i>Supportive information only<br/>due to major methodological<br/>problems</i> ) | McKelvey, J.A., Anuszkiewicz, C.<br>M. and Tallant, M.J. (1985)<br><br>Dow A6.02/6  |

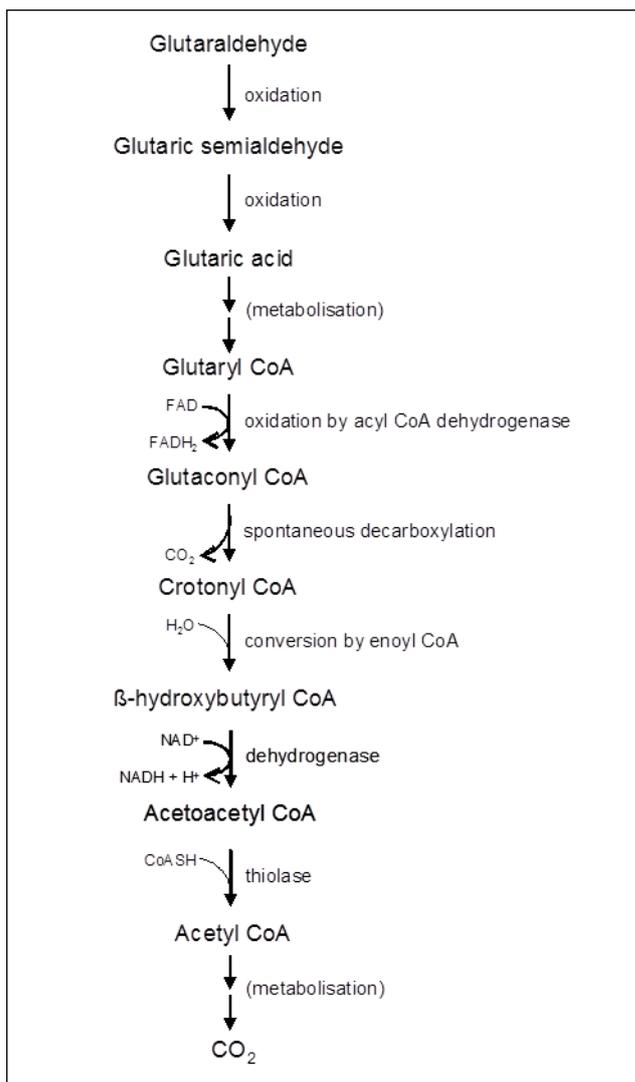
**Oral absorption.** The test substance was rapidly but incompletely absorbed from the gastrointestinal tract, with no remarkable differences between sexes. Bioavailability was calculated to be 37 % after a single dose of 75 mg/kg bw, and about 51 % after a single dose of 5 mg/kg bw. Based on presented data, oral absorption of 40 % is used for estimating the systemic dose. Glutaraldehyde mostly absorbs as molecules other than glutaraldehyde (or is rapidly converted after absorption), as at the time of C<sub>max</sub> the rat blood contained approximately 0.16 % and 1.6 % of the total dose as glutaraldehyde following low and high dose, respectively.

**Dermal absorption.** None of the studies can be considered to give sufficient information for establishing a value for dermal absorption due to methodological problems. It can be considered that most of the glutaraldehyde in the skin will react immediately, leaving little free glutaraldehyde for absorption. Nevertheless, the absorption of metabolites needs to be considered as well, and furthermore it was shown that small amounts of free glutaraldehyde can also be detected from the blood after dermal dosing (Mendrala et al. 2004, BASF A6.02\_02/Dow A6.02/02). In the study using human skin (Tallant et al. 1991, Dow A6.02/4), the total combined radioactivity in the receptor fluid and in the full combusted skin sample was 6.6 % for a 0.75 % glutaraldehyde solution, and 4.8 % for a 7.5 % glutaraldehyde solution. A conservative value of 10 % for dermal absorption is proposed.

**Distribution.** Free glutaraldehyde is rapidly removed from circulation, presumably through macromolecular binding or metabolism. When using radioactive labelling, the label was distributed in all organs and tissues (Beimborn and Liebold 2004, BASF A6.02\_01 and Dow A6.02/01), while free glutaraldehyde is mostly assumed to be rapidly metabolised. Free glutaraldehyde could be detected in blood after a high dose, while only trace amounts or none were seen after a low dose, the majority of glutaraldehyde having been metabolised and/or bound. The concentration in the blood decreases rapidly (Mendrala et al. 2004, BASF A6.02\_02 and Dow A6.02/02). The radioactive label, representing metabolites and/or breakdown products, was still detectable at 168 h after administration.

**Metabolism.** It has been demonstrated that glutaraldehyde is largely metabolised either before or soon after absorption, but no detailed metabolic pathways have been suggested. Furthermore, the only metabolite identified is glutaric acid. The scheme presented in Figure 1 is based on the proposals of Ballantyne and Jordan (2001), Beauchamp R.O *et al.* (1992) and Salway J. G. (1994). The scheme is poorly substantiated with regard to the pathway from glutaraldehyde to glutaryl CoA, and the scheme as a whole should be considered as one of the possible alternatives of probably multiple reaction pathways that depend on the initial reaction, among other things. Acetyl CoA is an important branching point for several routes in metabolism, including fatty acid synthesis. Due to very fast metabolism, the relevant metabolites can be assumed to have been taken into account in the toxicological studies.

**Excretion.** The excretion of radioactivity was rapid and occurred mainly via faeces, where around 62 % of the total dose was found after a single dose of 75 mg glutaraldehyde/kg bw. In exhaled air and urine, there were around 20 and 11 % of the administered dose, respectively (Beimborn and Liebold 2004, BASF A6.02\_01, Dow A6.02/01). Similar results were obtained using a 15-fold lower dose of 5 mg glutaraldehyde/kg bw, with the difference that exhaled air and urine now contained 29 and 14 % of the administered dose, respectively, indicating higher bioavailability. In bile duct cannulated animals, the total amount excreted in bile was 2.6 % at high dose and 1.8 % at low dose. There was no indication of bioaccumulation in any of the tissues (Beimborn and Liebold 2004, BASF A6.02\_01, Dow A6.02/01).



**Figure 1: Proposed metabolic pathway**

#### 4.1.2 Human information

No data available.

#### 4.1.3 Summary and discussion on toxicokinetics

**Table 13: Summary of toxicokinetics**

|                        |  |
|------------------------|--|
| <b>Oral absorption</b> | Rapid but partial absorption from the gastrointestinal tract; no remarkable differences between sexes. Bioavailability after a single dose: 37 and 51 % for 75 and 5 mg/kg bw, respectively. Oral absorption of 40 % is used for estimating the systemic dose. |
|------------------------|--|

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|                          |   |
|--------------------------|---|
|                          | Glutaraldehyde is mostly absorbed as compounds other than glutaraldehyde (or is rapidly converted after absorption). At C <sub>max</sub> the rat blood contained 0.16 and 1.6 % of the total dose as glutaraldehyde following low and high dose, respectively.  |
| <b>Dermal absorption</b> | None of the studies is of sufficient quality for establishing a value for dermal absorption. Most of the glutaraldehyde absorbing in the skin will react immediately, but small amounts of free glutaraldehyde can be detected from the blood after dermal dosing. Human skin <i>in vitro</i> study: total radioactivity in receptor fluid + full combusted skin sample was 6.6 % for a 0.75 % glutaraldehyde solution, and 4.8 % for a 7.5 % glutaraldehyde solution. A conservative value of 10 % is used unless further information is provided. |
| <b>Distribution</b>      | Radioactive label was distributed in all organs and tissues, while free glutaraldehyde is mostly assumed to be rapidly metabolised. Free glutaraldehyde was detected in blood after a high dose, while only trace amounts or none were seen after a low dose. The concentration in the blood decreases rapidly. The radioactive label, representing metabolites and/or breakdown products, was still detectable at 168 h after administration.  |
| <b>Metabolism</b>        | Glutaraldehyde is largely metabolised either before or soon after absorption, but no detailed metabolic pathways have been suggested. Furthermore, the only metabolite identified is glutaric acid. Relevant metabolites are assumed to have been taken into account in the toxicological studies.  |
| <b>Excretion</b>         | Single high dose of 75 mg/kg bw: Rapid excretion of radioactivity via faeces (62 % of total dose), exhaled air (20 %) and urine (11 %). Single low dose of 5 mg/kg bw: Similar results as above, but exhaled air and urine contained 29 and 14 % of the administered dose, respectively. Bile duct cannulated animals: 2.6 % was excreted in bile at high dose and 1.8 % at low dose. No indication of bioaccumulation in any tissue.   |

## 4.2 Acute toxicity

### 4.2.1 Non-human information

#### 4.2.1.1 Acute toxicity: oral

**Table 14: Summary table of relevant acute oral toxicity studies**

| Method Guideline<br>GLP          | Species<br>Strain<br>Sex<br>No/group                      | Dose levels<br>Duration of exposure  | Value<br>LD <sub>50</sub> /LC <sub>50</sub>   | Remarks  | Reference   |
|----------------------------------|---|--|---|--|---|
| OECD 401,<br>GLP                 | Rat<br>Sprague-Dawley<br>Albino<br>5 ♂ + 5 ♀<br>per group | Test substance: 50 %<br>glutaraldehyde<br>100, 200, 400 mg/kg bw<br>in ♂ (test substance)<br>100, 141, 200 mg/kg bw<br>in ♀ (test substance)<br>14 day post exposure<br>period | LD <sub>50</sub> ♂ 123 mg<br>glutaraldehyde/k<br>g bw<br>LD <sub>50</sub> ♀ 77 mg<br>GA/kg bw<br>LD <sub>50</sub> ♂ + ♀ 100<br>mg<br>glutaraldehyde/k<br>g bw<br>Respective<br>values for 50 %<br>test substance:<br>246, 154, 200<br>mg/kg bw                  | <b>Spontaneously dying<br/>animals:</b> necropsy findings<br>included red, mottled lungs,<br>red stomachs, discoloured<br>intestines, dark red kidneys<br><b>Survivors:</b> no remarkable<br>gross lesions   | Myers, R.C.<br>and<br>Christopher,<br>S.M (1992)<br>Dow A6.1.1<br>Key study |
| Similar to<br>OECD 401<br>No GLP | Rat<br>Sprague-Dawley<br>5 ♂ + 5 ♀<br>per group           | Test substance: 50 %<br>glutaraldehyde<br>Test doses: 215, 316,<br>464 and 1470 mg/kg bw<br>(test substance)<br>14 day post-exposure<br>period                                 | LD <sub>50</sub> ♂ 158 mg<br>glutaraldehyde/k<br>g bw<br>LD <sub>50</sub> ♀ 143 mg<br>glutaraldehyde/k<br>g bw<br>LD <sub>50</sub> ♂ + ♀ 151<br>mg<br>glutaraldehyde/k<br>g bw<br>Respective<br>values for 50 %<br>test substance:<br>316, 285, 301<br>mg/kg bw | <b>Spontaneously dying<br/>animals:</b><br><ul style="list-style-type: none"> <li>Acute congestion; the<br/>stomach of these animals<br/>was dilated and the wall of<br/>the glandular stomach was<br/>thickened</li> <li>In forestomach and<br/>glandular stomach, there<br/>were leathery bloody<br/>ulcerations, purulent<br/>abscesses and purulent<br/>fibrinous coatings</li> <li>The mucosa of the small<br/>intestines partly appeared<br/>reddened and the intestinal<br/>contents were tinged with<br/>blood</li> </ul> <b>Survivors:</b> no abnormalities | Jaekch, R.<br>(1994a)<br>BASF<br>A6.01.1_01<br>Key study                    |

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Glutaraldehyde was toxic when administered by the oral route. The toxic effects are considered to be caused by the corrosive effect on the mucosal surfaces of the GI tract.

In the study provided by Dow, an LD<sub>50</sub> of 77 mg/kg bw in the rat was derived for pure glutaraldehyde (154 mg/kg bw/day of the test substance; Myers and Christopher 1992, Dow A6.1.1). Male rats were treated with doses of 100, 200 and 400 mg/kg (test substance), and female rats with doses of 100, 141 and 200 mg/kg (test substance). Mortalities occurred on days 1 and 2 post dosing at all dose levels except for 100 mg/kg bw. Survivors recovered within 4-5 days. Signs of toxicity included sluggishness, lacrimation, piloerection, diarrhoea, and a trace amount of blood in the urine of 2 animals. Red, perinasal soiling and perineal soiling was also noted. Necropsy findings of mortalities revealed red, mottled lungs, red stomachs (some haemorrhaged, 1 full of red liquid), discoloured intestines, and dark red kidneys. Necropsy revealed no remarkable gross lesions on the examination of survivors.

In the study provided by BASF, an LD<sub>50</sub> of 143 mg/kg bw for the rat was derived for pure glutaraldehyde (285 mg/kg bw/day of the test substance; Jaekch 1994a, BASF A6.01.1\_01). Rats of both sexes were treated with test substance doses ranging from 215 to 1470 mg/kg bw. Mortalities were seen at all tested doses, and all treated animals suffered from symptoms indicative of generalized toxicity. Observations included poor general state, dyspnea, apathy, piloerection, staggering, trembling and exsiccosis. Necropsy of the rats that died revealed acute congestion, dilation of the stomach and thickening of the wall of the glandular stomach; furthermore, both in the forestomach and the glandular stomach, leathery bloody ulcerations as well as purulent abscesses and purulent fibrinous coatings were seen. The mucosa of the small intestines partly appeared reddened and the intestinal contents were tinged with blood.

### 4.2.1.2 Acute toxicity: inhalation

**Table 15: Summary table of relevant acute inhalation toxicity studies**

| Method<br>Guideline<br>GLP       | Species<br>Strain<br>Sex<br>No/group                  | Dose levels<br>Duration of<br>exposure  | Value LD <sub>50</sub> /LC <sub>50</sub>   | Remarks   | Reference  |
|----------------------------------|---|---|--|---|--|
| Similar to<br>OECD 403<br>No GLP | Rat<br>Sprague-<br>Dawley<br>10 ♂ + 10 ♀<br>per group | 50 %<br>glutaraldehyde (,<br>49.5 % water)<br>Nominal<br>concentrations:<br>0.23, 0.41, 0.53,<br>0.68, 0.9 mg/l<br>Analytical<br>concentrations:<br>0.10, 0.18, 0.28,<br>0.39 and 0.44 mg/l<br>Exposure: 4 h<br>Post-exposure<br>observation<br>period: 14 days | LC <sub>50</sub> ♂ 0.35 mg/l<br>LC <sub>50</sub> ♀ 0.28 mg/l<br>♂ + ♀: 0.28 mg/l<br>< LC <sub>50</sub> < 0.39<br>mg/l<br>Values are based<br>on analytical GA<br>aerosol/vapour<br>concentrations and<br>need not be<br>corrected for 50 %<br>glutaraldehyde<br>used | Necropsy of the animals that<br>died during the experiment:<br>acute congestion,<br>pronounced emphysema of<br>the lungs, edematization and<br>infarctoid hyperemia.<br>Surviving animals: no<br>pathological abnormalities<br>reported | Klimisch, H.J.<br>(1994)<br><br>BASF A6.01.3_01<br><br>Key study |

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| Method Guideline GLP   | Species Strain Sex No/group              | Dose levels Duration of exposure  | Value LD <sub>50</sub> /LC <sub>50</sub>   | Remarks   | Reference  |
|--|--|---|--|---|--|
| Similar to OECD 403 No GLP   | Rat Sprague-Dawley 10 ♂ + 10 ♀ per group | 50 % glutaraldehyde (, 49.5 % water) Nominal concentrations: 0.35, 0.58 and 0.72 mg/l Analytical concentrations: 0.22, 0.31 and 0.63 mg/l Exposure: 4 h Post-exposure observation period: 14 days | LC <sub>50</sub> ♂ 0.52 mg/l<br>LC <sub>50</sub> ♀ 0.45 mg/l<br>LC <sub>50</sub> ♂ + ♀ 0.49 mg/l<br>Values are based on analytical glutaraldehyde aerosol/vapour concentrations and need not be corrected for 50 % glutaraldehyde used | Necropsy of the animals that died during the experiment: general congestion and slightly increased blood content, small emphysema areas in the lung, 3 cases of pronounced emphysema of the lungs.<br>Surviving animals: no pathological abnormalities reported                                     | Klimisch, H.J. (2001)<br><br>BASF A6.01.3_02                         |
| Non-guideline No GLP   | Rat Fischer 344 6 ♂ + 6 ♀ per group      | 0, 10, 20 and 50 ppm 4 h exposure with 14-day post exposure period  | LC <sub>50</sub> ♂ 0.090 mg/l<br>LC <sub>50</sub> ♀ 0.16 mg/l<br>LC <sub>50</sub> ♂ + ♀ 0.125 mg/kg bw   | Study concerns glutaraldehyde heated to approximately 65 °C, and is therefore not usable for classification purposes.<br>50 ppm and 20 ppm groups: patchy or general colour change in the lungs, perinasal and periocular encrustation.<br>10 ppm and control groups: No significant gross lesions. | Greenspan, B.J., Longo, L. and Eisler, D.L. (1982)<br><br>Dow A6.1.3 |
| OECD 403 (but only one dose level and additional minor deficiencies) GLP | Rat Sprague Dawley 5 ♂ + 5 ♀ per group   | Single dose level: 27 ppm (0.11 mg/L) 4 h exposure with 14-day post exposure period   | Not determined due to a single dose level<br>LC <sub>50</sub> > 0.11 mg/L  | Necropsy findings at 14 days: rhinitis and goblet cell hyperplasia in the nasal cavity<br>No mortalities<br>High humidity (76-77 %) might have reduced the irritant effects<br>Additionally, the study determined the LC <sub>50</sub> for glutaraldehyde heated to 60 °C (44 ppm = 0.18 mg/L)      | Norris, J.C. and Kintigh, W.J. (1995)<br><br>Dow A6.1.3/2            |

Glutaraldehyde was very toxic when administered by inhalation.

In the two acceptable studies provided by BASF, the LC<sub>50</sub> was between 0.28 mg/L and 0.52 mg/L (males 0.35 and 0.52 mg/L; females 0.28 and 0.45 mg/L). In the high dose group (0.63 mg/L), 15 animals of 20 died within 2 days after the exposure, and no further mortalities occurred. In the medium dose group (0.31 mg/L), 3 animals died between days 3 and 7 after the exposure. There were no mortalities in the low dose group of 0.22 mg/L. A generation system for aerosol is described, but the resulting glutaraldehyde in the air was described as "very fine aerosol < 2.8 µm or as a vapour". In order to clarify whether the test substance should be considered as aerosol or vapour, the applicant performed a physical-chemical study mimicking the system used in the

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inhalation study. At measured concentrations of 0.224 and 0.349 mg/L, the vapour phase accounted for 65 and 68 % of the glutaraldehyde, respectively.

In the study provided by Dow (Greenspan et al. 1982, A6.1.3), glutaraldehyde vapour was generated using air heated to around 65 °C. The study report does not describe any means of cooling down the vapour, and therefore it is concluded that the study is not usable for classification purposes because of the unknown temperature of glutaraldehyde vapour. The study is nevertheless included here as supportive information. The LC<sub>50</sub> for heated glutaraldehyde was 0.090 mg/L in male rats and 0.16 mg/L in female rats. In the high dose group (50 ppm), one male died during exposure and all other males during the following 3 days, and 3/6 females died during the 3 days after exposure. In the 20 ppm group, 2 males and 2 females died during the post-exposure period. Altogether, 12 mortalities occurred during the first 3 days and one on day 7. The other study by Dow (Norris and Kintigh 1995, A6.1.3/2) only concerned one dose level of 0.11 mg/L which was close to the LC<sub>50</sub> indicated above. No mortalities occurred, but there were rhinitis and goblet cell hyperplasia in the nasal cavity of 3 males and 2 females out of the 4 animals investigated for each sex. The relative humidity in this study was 76-77 %, which is higher than required and might possibly have reduced the irritant effect.

## 4.2.1.3 Acute toxicity: dermal

Table 16: Summary table of relevant acute dermal toxicity studies

| Method<br>Guideline<br>GLP | Species<br>Strain<br>Sex<br>No/group  | Dose levels<br>Duration of exposure  | Value<br>LD <sub>50</sub> /LC <sub>50</sub>  | Remarks  | Reference                                     |
|----------------------------|---|--|--|--|---|
| Non-guideline,<br>non-GLP  | Rabbit;<br>4 groups of 4 ♂ with 50 % solution;<br>4 groups of 4 ♂ with 25 % solution;<br>1 group of 6 ♂ with 5 % solution | 50 % solution: 0.5, 1.0, 2.0 and 4.0 ml/kg; single application with 14 day post exposure period<br>25 % solution: 2, 4, 8 and 16 ml/kg; single application with 14 day post exposure period<br>5 % solution: 16 ml/kg; single application with 14 day post exposure period | <u>GA pure</u> : LD <sub>50</sub> 875 mg/kg for ♂ (as calculated from LD <sub>50</sub> for 50 % solution)<br><u>GA 50 %</u> : LD <sub>50</sub> 1.75 g/kg | Spontaneously dying animals:<br><ul style="list-style-type: none"> <li>• Red lungs</li> <li>• Mottled, red and light red or tan livers</li> <li>• Dark red spleens</li> <li>• Mottled red and tan kidneys; kidney sections red</li> <li>• Intestines opaque</li> <li>• Effects were linked to concentration: the lowest concentration (5 %) resulted in no mortalities and milder effects in fewer animals. No effects were reported for 4/6 animals.</li> </ul> | Myers, R.C. (1981)<br>Dow A6.1.2<br>Key study |

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| Method<br>Guideline<br>GLP                                     | Species<br>Strain<br>Sex<br>No/group               | Dose levels<br>Duration of exposure  | Value<br>LD <sub>50</sub> /LC <sub>50</sub>   | Remarks   | Reference  |
|--|--|--|---|---|--|
| (Reportedly EPA Pesticide Assessment Guidelines, Section 81-2) | Rabbit<br>New Zealand white<br>5 ♂ + 5 ♀ per group | 50.2 % glutaraldehyde<br>Test doses: 2000 mg/ kg bw<br>Post-exposure observation period: 14 days   | <u>GA pure</u> : LD <sub>50</sub> > 1000 mg/kg bw for ♂ + ♀ (as calculated from LD <sub>50</sub> for 50 % solution)<br><br><u>GA 50 %</u> : LD <sub>50</sub> > 2000 mg/kg | Mortalities: none.<br>Clinical signs: mucoid faeces (days 1 and 2), wet brown urogenital staining (4 h after application).<br><br>Local skin effects: Severe erythema, moderate to severe edema and eschar with subsequent exfoliation (all animals). In addition, there were signs of corrosion, fissuring and desquamation. Signs of severe skin irritation persisted in all animals over the complete observation period.                          | Kiplinger, G.R. (1995)<br>BASF A6.01.2_01<br><br>Key study |
| Similar to OECD 402  | Rat<br>Sprague-Dawley<br>5 ♂ + 5 ♀ per group       | 50 % glutaraldehyde (0.5 % methanol, 49.5 % water)<br>Test doses: 400, 1000 and 2000 mg/kg bw<br>Post-exposure observation period: 14 days | <u>GA pure</u> : LD <sub>50</sub> > 1000 mg/kg bw for ♂ + ♀ (as calculated from LD <sub>50</sub> for 50 % solution)<br><br><u>GA 50 %</u> : LD <sub>50</sub> > 2000 mg/kg | Highest dose group: one mortality.<br>Clinical signs of toxicity were observed in all test groups and included a poor general state, dyspnea, apathy, excitation, staggering, atony, trembling, ruffled fur and diarrhoea.<br><br>Local effects were seen in all test groups and included necrosis and oedema of different levels of severity.<br><br>The LD <sub>50</sub> value is valid for the test substance as tested in a 50 % aqueous solution | Jaekkh, R. (1994b)<br>BASF A6.01.2_02                      |

Glutaraldehyde caused local effects when administered by the dermal route. One study showed a calculated LD<sub>50</sub> of 875 (386-1975) mg/kg in the rabbit (Myers, R.C. 1981, Dow 6.1.2), while in two other studies the LD<sub>50</sub> was above 1000 mg/kg in both the rabbit and the rat (Kiplinger, G.R. 1995, BASF 6.1.2\_1 and Jaekkh, R. 1994b, BASF 6.1.2\_2). All the data is generally well in line, but the somewhat higher mortality in the non-GLP study (Myers, R.C. 1981, Dow 6.1.2) can be concluded to be partially due to the poor treatment of the animals, as the rabbits were immobilized for 24 h during treatment with a corrosive substance. Although the humaneness of the study can be questioned and the resulting mortality may be disproportionate, the study should be considered acceptable for the data requirement. Judging by the full data set, it is concluded that the LD<sub>50</sub> of 875 mg/kg is not reliable and the LD<sub>50</sub> is set at above 1000 mg/kg bw.

The results (Myers, R.C. 1981, Dow 6.1.2 in particular) indicate that the effects were more directly linked to concentration than to a systemic dose level: 0.5 ml/kg of a 50 % solution (corresponding to 0.25 ml of 100 % glutaraldehyde) caused severe skin damage and one mortality, while 16 ml/kg of a 5 % solution (corresponding to 0.8 ml of 100 % glutaraldehyde) caused no mortalities and milder effects, and no effects were reported for 4/6 animals. The same concentration dependence is seen in repeated dose toxicity studies by the dermal route.

Due to the direct corrosive effect there is a danger of irreversible damage to the skin upon exposure to the undiluted solution. Toxicity is considered to be secondary to the local tissue damage rather than a result of percutaneously absorbed material.

#### **4.2.1.4 Acute toxicity: other routes**

Not evaluated in this dossier.

#### **4.2.2 Human information**

No information available.

#### **4.2.3 Summary and discussion of acute toxicity**

Glutaraldehyde was found moderately toxic when tested via the oral route (LD50 of 77 mg/kg bw in the rat was derived for pure glutaraldehyde (154 mg/kg bw/day of the test substance). The toxic effects are considered to be caused by the corrosive effect on the mucosal surfaces of the GI tract.

Glutaraldehyde was very toxic via the inhalation route (The LC50 values were 0.35 mg/L in male rats and 0.28 mg/L in female rats; values are based on analytical glutaraldehyde aerosol/vapour concentrations and need not be corrected for 50 %).

The dermal LD50 of the active substance, 50 % glutaraldehyde, is above 2000 mg/kg bw. The toxicity is based on local effects and is dependent on the concentration of the substance. It is reported that concentrations above 50 % will not be manufactured or used. The assessment of the 50 % active substance can therefore be considered as the worst-case assessment. Glutaraldehyde (50 %) does not warrant classification for acute dermal toxicity according to Directive 67/548/EEC, or according to the CLP regulation 1272/2008.

#### **4.2.4 Comparison with criteria**

The LD50 value from acute oral toxicity studies was 77 mg glutaraldehyde/kg bw (154 mg/kg bw for the test substance). This LD50 value is within the range of 50-300 mg/kg for classification as Acute Tox. 3; H301 under the CLP Regulation, and 25-200 mg/kg for classification as T; R25 under Directive 67/548/EEC. The asterisk (\*) indicating minimum CLP classification for Acute oral Toxicity 3; H301 is no longer necessary since the data confirms the classification.

In the inhalation study, a generation system for aerosol is described, but the resulting glutaraldehyde in the air was described as "very fine aerosol < 2.8 µm or as a vapour". This implies that the test atmosphere was a mixture of liquid and vapour phases, and therefore it would be prudent to apply the criteria for vapour. In order to clarify whether the test substance should be considered as aerosol

or vapour, the applicant performed a physical-chemical study mimicking the system used in the inhalation study. At measured concentrations of 0.224 and 0.349 mg/L, the vapour phase accounted for 65 and 68 % of the glutaraldehyde, respectively, supporting the use of the criteria for vapours. The LC50 values are 0.35 mg/L in male rats and 0.28 mg/L in female rats. These are both < 0.5 mg/L which is the classification limit for vapours in category Acute Tox. 1 under the CLP Regulation and limit for classification as "very toxic" under Directive 67/548/EEC. Therefore classification of glutaraldehyde as Acute Tox. 1; H330 is appropriate under the CLP Regulation and as T+; R26 under Directive 67/548/EEC. No specific concentration limit for acute inhalation toxicity is suggested under the Directive 67/548/EEC, since the calculated value (4 %) is very close to the general concentration limit of 7% for R26 (Calculation carried out as follows: Rat acute inhalation LC50 = 0.28 mg/L/4h. Cut off for R26 is 0.5 mg/L/4h (vapour);  $0.5/0.28 = 1.8$ . The general concentration limit is 7% therefore SCL would be  $7/1.8 = 4.0$  %). Since the mechanism of inhalation toxicity is corrosivity, glutaraldehyde should also be labelled as EUH071 (Corrosive to the respiratory tract) according to the CLP Regulation, Annex I, section 3.1.2.3.3 and Note 1 in section 3.1.4.1.

No classification is proposed via the dermal exposure route since the obtained LD50 value is above 2000 mg/kg bw. The criteria for classification as Acute Tox. 4; H312 under CLP is  $1000 < ATE < 2000$  mg/kg bw and the criteria for classification as Xn; R21 under DSD is  $400 < LD_{50} \leq 2000$  mg/kg.

#### 4.2.5 Conclusions on classification and labelling

**CLP:** Acute Tox. 3; H301 and Acute Tox. 1; H330. A supplemental hazard statement EUH071 is also proposed.

**DSD:** T; R25 and T+; R26

#### RAC evaluation of acute toxicity

##### Summary of the Dossier submitter's proposal

###### *Oral*

The CLH report included two oral rat acute toxicity studies, both conducted according to OECD TG 401 with 50% glutaraldehyde. In the first study (Myers et al., 1992) the LD<sub>50</sub> values were 77 mg/kg in females and 123 mg/kg in males with a combined (males and females) LD<sub>50</sub> of 100 mg/kg. In the second study (Jaekch et al., 1994a) the LD<sub>50</sub> values were 143 mg/kg in females and 158 mg/kg in males with a combined LD<sub>50</sub> of 151 mg/kg. All values were presented as pure glutaraldehyde. As all LD<sub>50</sub> value were within the range 50-300 mg/kg, the dossier submitter proposed to confirm the classification of Acute Tox. 3 – H301.

###### *Inhalation*

The CLH report included two rat inhalation acute toxicity studies considered reliable for classification by the dossier submitter (Klimisch et al. 1994 and 2001), conducted similar to OECD TG 403. In addition, two other studies were included as supportive information but not used for classification. The LC<sub>50</sub> values in the two studies were 0.28 mg/L (females) and 0.45 mg/L (females), respectively. Necropsy revealed acute congestion, emphysema, edematization and infarctoid hyperaemia. The test substance was 50% glutaraldehyde in both cases but LC<sub>50</sub> values were based on measured concentrations of

glutaraldehyde in air and therefore no correction is needed. In a physical-chemical study mimicking the system used in the inhalation study, the vapour phase accounted for 65 and 68% of the measured concentration of glutaraldehyde at 0.224 and 0.349 mg/L, respectively. As the lowest LC<sub>50</sub> values were below 0.5 mg/L (vapour), the dossier submitter proposed amending the classification to Acute Tox. 1 – H330. In addition, as the mechanism of toxicity was deemed to be through corrosivity, the DS proposed the addition of the supplemental hazard statement EUH071 (corrosive to the respiratory tract).

#### *Dermal*

Two dermal acute toxicity studies, conducted with 50% glutaraldehyde in rabbits, were included in the CLH report. One was conducted similar to OECD TG 402 (Jaekkh et al., 1994b) while the other was reportedly conducted according to EPA guidelines 81-2 (Kiplinger et al., 1995). Severe irritation or corrosion was seen in both studies. The LD<sub>50</sub> for the test substance was >2000mg/kg in both studies, equivalent to >1000 mg/kg for pure glutaraldehyde. No classification for dermal acute toxicity was proposed.

In summary, glutaraldehyde is already classified as Acute Tox. 3\* - H331 and Acute Tox. 3\* - H301. This classification is based on a translation from the DSD classification and also included specific concentration limits (SCL). No SCLs are set for acute toxicity under the CLP criteria. The DS proposed to confirm the minimum classification for Acute Tox. 3 – H301 and to change the classification for acute toxicity through inhalation to Acute Tox. 1 – H330.

#### **Comments received during public consultation**

Comments were received from three Member State Competent Authorities (MSCA) and three companies. All MSCAs agreed with the proposed amendments of the acute toxicity classifications for the oral and inhalation routes, while one questioned the decision not to classify for dermal exposure. The DS explained that the dermal data were not reliable enough to base a classification on. All three companies disagreed with the acute inhalation classification, arguing that the exposure of animals was predominantly to aerosols and therefore the LC<sub>50</sub> values should be compared with the criteria for dusts/mists. This would result in a classification of Acute Tox. 2 – H330. The DS disagreed with the commenting companies, arguing that the criteria for vapours are more appropriate. More information, including detailed argumentation by both the commenting parties and the DS, can be found in the RCOM.

One MSCA expressed concerns about inconsistency in assigning EUH071 to the substance compared with other similarly classified substances and raised the issue of whether SCLs would be set. Two companies also expressed disagreement with the application of EUH071, arguing that it was superfluous as the proposal already included classification as corrosive, irritant to the respiratory tract and toxic via inhalation. The DS argued that the proposed application of EUH071 was consistent with the criteria in Annex I to CLP (Note 1 in Table 3.1.3) and with previous RAC recommendations, but did not address setting SCLs.

#### **Assessment and comparison with the classification criteria**

**Oral:** The corrected LD<sub>50</sub> values acquired from the oral rat studies ranged from 77 mg/kg in females to 158 mg/kg in males. The toxic effects were considered to be caused by the corrosive effect on the mucosal surface of the GI tract. All values were within the range 50-300 mg/kg and therefore the classification as Acute Tox. 3- H301 is warranted.

**Inhalation:** The corrected LC<sub>50</sub> values provided were between 0.28 mg/L in females and up to 0.52 mg/L in males.

In a 50 % aqueous solution of glutaraldehyde, the Saturated Vapour Concentration (SVC) cannot be calculated using the vapour pressure of 100% glutaraldehyde. The partial

vapour pressure in a 50% solution is given to be 0.13 hPa for glutaraldehyde (Olsen, 1995) instead of the standard 0.44 hPa.

A theoretical SVC for glutaraldehyde in a 50% aqueous solution can then be calculated as  $0.0412 \times 100.11 \text{ (g/mol)} \times 0.13 \text{ hPa}$ . This results in 0.53 mg/L. But in practice this will only occur in an environment completely saturated with glutaraldehyde.

In order to clarify whether the test substance should be considered as an aerosol or vapour, the applicant under the biocidal active substance process performed a physical/chemical study mimicking the system used in the inhalation study. At measured concentrations of 0.224 and 0.349 mg glutaraldehyde/L the vapour phase accounted for around 66%. That means that two-thirds of the glutaraldehyde is presented as vapour. To take this assumption further, the saturated partial glutaraldehyde vapour phase will then be around two-thirds of 0.53 mg/L = 0.35 mg/L as determined in the physical/chemical study.

The LC<sub>50</sub> values obtained from the inhalation studies are within the range 0.28 mg/L to 0.52 mg/L.

A newly submitted study (consistent with OECD TG 403) which was not reported in the CLH report but was mentioned by the industry during the public consultation and later submitted (comment No. 10 in the RCOM; Klimisch, 1981), estimated the possible risk on inhalation of a mixture of the **vapor** of the test substance and air. The Inhalation Hazard Test (IHT) was conducted to test saturated vapour. The atmosphere was generated by passing an air stream through a layer of test substance. Using this method, aerosols are often formed due to bubbling of the test substance. However, the fraction of aerosol is expected to be low.

Results from this study:

| Exposure period           |      | 1 h   | 3 h   | 7 h   |
|---------------------------|------|-------|-------|-------|
| Volatile components 20 C. |      | 0/12  | 1/12  | 6/6   |
| Mean Conc.                | Mg/l | 16    | 17    | 13    |
|                           | PPM  | 3,800 | 4,100 | 3,300 |

The table indicates that at an assumed vapour concentration of 0.35 mg/L, one out of 12 animals died after 3 hours of exposure.

In the CLP guidance it is stated that "A LC<sub>50</sub> well below the SVC will be considered for classification according to the criteria for vapours; whereas an LC<sub>50</sub> close to or above the SVC will be considered for classification according to the criteria for mists".

RAC concludes that the LC<sub>50</sub> value of 0.28-0.52 mg/L is close to the SVC of 0.53 mg/L (theoretical calculated SVC) and the highest practically achievable vapour concentration of 0.35 mg/L and therefore the criteria for aerosols should be applied. Together with the conclusion from the new submitted study, where animals were exposed to vapours only, and only 1 animal out of 12 died within 3 hours of exposure, classification for glutaraldehyde as Acute Tox 2 – H330 is appropriate.

**Dermal:** LD<sub>50</sub> values were reported in two studies to be > 1000 mg/kg (calculated from LD<sub>50</sub> values for a 50% solution). An additional study (Myers, 1981) estimated an LD<sub>50</sub> value of 875 mg/kg. However, based on the study design and on judging by the full data set, the LD<sub>50</sub> value is set at above 1000 mg/kg and classification for acute dermal toxicity is not warranted.

In addition to classification for acute toxicity, the substance shall also be labelled with EUH071 (corrosive to the respiratory tract).

### 4.3 Specific target organ toxicity – single exposure (STOT SE)

See section 4.4.3

#### RAC evaluation of specific target organ toxicity – single exposure (STOT SE)

##### Summary of the Dossier submitter's proposal

Although glutaraldehyde is not classified for STOT SE, it currently has SCLs as STOT SE 3- H335: C ≥ 0,5 %, stemming from a translation of SCLs for Xi; R37: 0,5% ≤ C < 10 % under DSD. As the substance is considered corrosive and can be inhaled, the DS regarded classification as STOT SE 3 – H335 as appropriate. In addition, the DS argued that the substance is a sensory irritant. The CLH report included one peripheral sensory irritation (PSI) test (Werley et al., 1995). Exposure to glutaraldehyde vapour resulted in an almost immediate, dose-dependent decrease in the respiratory rate in mice, with an RD<sub>50</sub> (concentration at which respiratory rate decreased by 50%) of 13.9 ppm. Five human case and epidemiology studies were also summarised in the CLH report. All documented workers' exposure to glutaraldehyde and symptoms of skin, eye, throat and lower respiratory tract irritation. As the sensory irritation RD<sub>10</sub> was approx. 0.4 ppm and a threshold of 0.39 – 0.47 ppm for this effect was seen in human volunteers, the DS proposed SCLs of 0.00005%.

##### Comments received during public consultation

One MSCA expressed doubts over whether the data were sufficient for classification for respiratory irritation. Three companies expressed strong opposition to the derivation of SCLs by the DS, arguing that an atmospheric concentration of glutaraldehyde sufficient to cause symptoms in animals or humans could not be used to derive a concentration limit in an aqueous solution of glutaraldehyde. One company proposed to retain the current SCL of 0.5 % and the others did not propose an alternative SCL. The DS agreed with the comments received and provided a comparison with formaldehyde and acetaldehyde to estimate the respiratory irritation potential of glutaraldehyde. The DS proposed to retain the current SCL of 0.5 %, based on this comparison.

##### Assessment and comparison with the classification criteria

Glutaraldehyde is corrosive and can be inhaled. Several human case and epidemiological studies indicated respiratory irritation in humans and there were signs of peripheral sensory irritation in mice. Therefore, RAC agrees to classify glutaraldehyde as STOT SE 3 - H335 and to retain the SCL of 0.5%. In addition to this classification, the substance shall also be labelled with EUH071 (corrosive to the respiratory tract).

### 4.4 Irritation

#### 4.4.1 Skin irritation

##### 4.4.1.1 Non-human information

Table 17: Summary table of skin irritation studies

| Species | Method | Average score<br>24, 48, 72 h | Reversibility<br>yes/no | Result | Reference |
|---------|--------|-------------------------------|-------------------------|--------|-----------|
|         |        |                               |                         |        |           |

ANNEX 1 - BACKGROUND DOCUMENT TO RAC OPINION ON GLUTARALDEHYDE

|                                    | Test substance  | Erythema   | Edema  |  |   |  |
|------------------------------------|---|--|--|--|---|--|
| Rabbit,<br>New<br>Zealand<br>White | OECD 404<br>GLP<br>Male and female<br>3/sex/group<br>50 % GA  | 2.8, 3.0, 2.7  | 3.2, 2.7, 2.0  | Not reversible<br>Necrosis and<br>desquamation<br>were present at<br>day 10  | Corrosive   | Myers, R.C. (1988)<br><br>Dow A6.1.4(s)<br><br>Key study |
| Rabbit,<br>White<br>Vienna         | No guideline<br>Glutaraldehyde 50<br>% aq. solution<br>applied undiluted<br>for 4 h, then<br>removed by<br>rinsing with Lutrol<br>and 1:1 Lutrol in<br>water<br>3 males and 1<br>female | 2.0, 2.0, not<br>assessed<br><br>(the scale is<br>different from<br>the OECD scale:<br>0 = none<br>1 = questionable<br>2 = slight<br>3 = distinct<br>4 = very distinct)          | 2.5, 1.75, not<br>assessed<br><br>(the scale is<br>different from<br>the OECD scale:<br>0 = none<br>1 = questionable<br>2 = slight<br>3 = distinct<br>4 = very distinct) | Not reversible<br>Necrosis,<br>erythema and<br>oedema were<br>present at day 8<br>(necrosis<br>confirmed by<br>gross<br>pathology) | Corrosive   | Grundler, O.J. (1994a)<br><br>BASF A6.01.4_01            |
| Rabbit,<br>White<br>Vienna         | No guideline<br>Glutaraldehyde 50<br>% aq. solution<br>applied undiluted<br>for 1 h, then<br>removed by<br>rinsing with Lutrol<br>and 1:1 Lutrol in<br>water.<br>2 females              | not assessed, 2.0,<br>not assessed<br><br>(the scale is<br>different from<br>the OECD scale:<br>0 = none<br>1 = questionable<br>2 = slight<br>3 = distinct<br>4 = very distinct) | 2.0, 2.0, not<br>assessed<br><br>(the scale is<br>different from<br>the OECD scale:<br>0 = none<br>1 = questionable<br>2 = slight<br>3 = distinct<br>4 = very distinct)  | Not reversible<br>There was<br>severe scaling<br>at 8 days, as<br>well as<br>erythema and<br>edema                                 | Irritating<br>(but after<br>exposure<br>of only 1<br>h) | Grundler, O.J. (1994b)<br><br>BASF A6.01.4_02            |

In the study provided by Dow (Myers 1988, A6.1.4(s)), 50 % glutaraldehyde produced severe skin irritation: necrosis, desquamation, scabs and alopecia when applied dermally to rabbit for 4 h. In the same study, a parallel test was performed with exposure times of 1 h and 3 min. Following an exposure of 1 h, necrosis was observed in 2 and desquamation in 4 of the 5 surviving animals (one animal died on day 5, but there were no indications that death was related directly to treatment). These effects persisted until the end of the observation period of 7 days. An exposure of 3 min resulted in minor erythema in 1 animal, and no other effects were observed.

The studies provided by BASF (Grundler 1994a, A6.01.4\_01 and Grundler 1994b, A6.01.4\_02) were not performed according to the OECD guideline: the observation period was only 8 days, the scaling system was different and observations were not done at 72 h. Regardless of the methodology, the results are scientifically clear and in line with the results provided by Dow. Exposure time of 4 h (Grundler 1994a, BASF A6.01.4\_01) resulted in necrosis, erythema and edema in all animals. In addition, an exposure of 1 h was used (Grundler 1994b, BASF A6.01.4\_02) resulting in erythema and edema, and at the end of the observation period of 8 days, there was severe scaling in both of the 2 animals tested. An exposure of 3 min resulted in no edema, and erythema that was considered questionable, but at the end of the observation period of 8 days, there was scaling in 1 of the 2 animals.

#### 4.4.1.2 Summary and discussion of skin irritation

Glutaraldehyde 50% was found to be corrosive when tested on rabbit skin. Glutaraldehyde has an existing classification as Skin Corr. 1 B; H314 according to the CLP Regulation and C; R34 according to the DSD, both with specific concentration limits. The present studies thus confirm the existing classification.

#### 4.4.1.3 Comparison with criteria

Glutaraldehyde 50 % was found to cause necrosis when applied to rabbit skin for 1 h, however shorter exposure times (3 min) did not cause necrosis. This finding fulfils the criteria in the CLP regulation for Skin Corr. 1B (responses in 1 of 3 animals are observed following exposure time between 3 min and observations up to 14 days). Under DSD, classification as C; R34 should be assigned if a substance causes full thickness destruction of skin tissue as a result of up to 4 hours exposure. Therefore glutaraldehyde 50% should be classified as C; R34.

#### 4.4.1.4 Conclusions on classification and labelling

Glutaraldehyde is classified in Annex VI, table 3.1 of the CLP Regulation as Skin Corr. 1B, H314 with the following specific concentration limits:

Skin Corr. 1B; H314 :  $C \geq 10\%$   
Skin Irrit. 2; H315:  $0,5\% \leq C < 10\%$   
Eye Dam. 1; H318:  $2\% \leq C < 10\%$   
Eye Irrit. 1; H319:  $0,5\% \leq C < 2\%$   
STOT SE 3; H335:  $C \geq 0,5\%$

The current classification according to DSD (Annex VI, table 3.2 of the CLP Regulation) is C; R34 with the following specific concentration limits:

C; R34:  $C \geq 10\%$   
Xi; R37/38-41:  $2\% \leq C < 10\%$   
Xi; R36/37/38:  $0,5\% \leq C < 2\%$

In conclusion:

**CLP:** Glutaraldehyde should be classified as **Skin Corr. 1B** on the basis that necrosis resulted already from an exposure of  $> 3 \text{ min} \leq 1 \text{ h}$ . Therefore **no change is proposed to the existing classification as Skin Corr 1 B; H314 and the existing SCLs for skin corrosion/irritation should be retained**. However, based on the data on skin corrosion and on respiratory tract irritation (see section 4.4.3), classification as STOT SE 3; H335 is proposed. The existing SCLs for STOT SE 3; H335 is also proposed to be revised (see section 4.4.3)

**DSD:** Glutaraldehyde meets the criteria for classification as Corrosive (C). The risk phrase R34 should be assigned: Causes burns. Therefore **no change is proposed to the classification** for skin corrosion/irritation and **the existing SCLs for skin corrosion/irritation should be retained**. However, based on the data on skin corrosion and on respiratory tract irritation (see section 4.4.3), classification as Xi; R37 is proposed. The existing SCLs for Xi; R37 is proposed to be revised (see section 4.4.3)

**RAC evaluation of skin corrosion/irritation****Summary of the Dossier submitter's proposal**

Glutaraldehyde is already classified as Skin Corr. 1B – H314, with specific concentration limits of Skin Irrit. 2; H315:  $0.5\% \leq C < 10\%$ , Eye Dam. ; H318:  $2\% \leq C < 10\%$  and Eye Irrit. 2; H319:  $0.5\% \leq C < 2\%$ . The DS presented three rabbit irritation studies; one conducted according to OECD TG 404 (Myers et al., 1988) and two non-guideline studies (Grundler et al. 1994a and 1994b). All studies were conducted with 50% glutaraldehyde. Necrosis was observed after exposure for 1h, which had not reversed by the end of the observation period (8-10 days). The DS proposed no changes to the classification or SCLs.

**Comments received during public consultation**

Two MSCAs and two companies offered their general agreement to no change in the classification.

**Assessment and comparison with the classification criteria**

As visible necrosis was seen after exposure of longer than 3 minutes but less than 1 hour, which had not fully resolved within 10 days, RAC agreed to retain the classification of Skin Corr. 1B – H314. Generic concentration limits for corrosion/irritation are different under CLP and DSD. Glutaraldehyde was classified as C;R34 under DSD, translated as Skin Corr. 1B under CLP. The entry in Table 3.2 of Annex VI showed combined GCL/SCLs, which were translated as SCLs into CLP (see table 1 below)

Table 1

| <b>C;R34/Skin Corr. 1B</b> | <b>Generic concentration limits</b>  | <b>Current entry for glutaraldehyde</b>  |
|----------------------------|--|--|
| DSD                        | C;R34: $C \geq 10\%$<br>Xi; R36/38: $5\% \leq C < 10\%$  | C;R34: $C \geq 10\%$<br>Xi; R37/38-41: $2\% \leq C < 10\%$<br>Xi; R36/37/38: $0.5\% \leq C < 2\%$  |
| CLP                        | Skin Corr. 1B; H314: $C \geq 5\%$<br>Skin Irrit. 2; H315: $1\% \leq C < 5\%$<br>Eye Dam. 1; H318: $3\% \leq C < 5\%$<br>Eye Irrit. 2; H319: $1\% \leq C < 3\%$ | Skin Corr. 1B; H314: $C \geq 10\%$<br>Skin Irrit. 2; H315: $0,5\% \leq C < 10\%$<br>Eye Dam. 1; H318: $2\% \leq C < 10\%$<br>Eye Irrit. 2; H319: $0,5\% \leq C < 2\%$<br>STOT SE 3; H335: $C \geq 0,5\%$ |

As a result of the translation, the current entry for glutaraldehyde has a higher SCL for corrosivity than the GCL under CLP. There are no data, either in the CLH report or the CAR, that would support such a conclusion. This therefore appears to be a translation error. However, glutaraldehyde also has lower SCLs for skin irritation, eye damage and eye irritation than the GCL. This may well be justified due to experimental studies for products, but there is no record in any TC C&L documents of this having been decided or of any justification in the summaries of the three studies reported.

RAC concludes that based on a lack of available data, the specific concentration limits should be removed from the entry and the generic concentration limits applied.

## 4.4.2 Eye irritation

### 4.4.2.1 Non-human information

**Table 18: Summary table of eye irritation studies**

| Species                         | Method  | Effects  |  |   | Reversibility<br>yes/no | Result   | Reference  |
|---------------------------------|---|--|--|---|-------------------------|--|--|
|                                 |   | Cornea   | Iris   | Conjunctiva   |                         |  |  |
| Rabbit,<br>New Zealand<br>White | (Reportedly EPA<br>FIFRA 81-4)<br><br>GLP<br><br>Male and female<br>3/sex<br><br><u>Test substance</u><br>glutaraldehyde<br>45 % aq. solution<br><br><u>Applied volume:</u><br>0.1 ml<br><br><u>Rinsing:</u> none | Opacity<br>average<br>score 24,<br>48, 72 h:<br><br>4.0, 4.0,<br>4.0   | Scoring not<br>possible due<br>to severe<br>corneal<br>opacity,<br>swelling,<br>adhesion<br>and/or<br>discharge. | Redness: 1.0,<br>2.0, 2.0<br><br>Chemosis: 4.0,<br>3.8, 4.0   | No                      | Severely<br>irritating   | Myers, R.C.<br>(1987a)<br><br>Dow A6.1.4(e)<br><br>Key study         |
| Rabbit,<br>White<br>Vienna      | Draize test<br><br>Male and female<br>3/sex<br><br><u>Test substance</u><br>glutaraldehyde<br>50 % aq. solution<br><br><u>Applied volume:</u><br>0.1 ml<br><br><u>Rinsing:</u> none                               | Opacity,<br>scattered/<br>diffuse<br>(24 h) to<br>nearly<br>complete<br>(8 d),<br>affected<br>area: 75 to<br>100 % | Folds above<br>normal,<br>swelling and<br>circum-<br>corneal<br>injection  | Redness,<br>swelling with<br>partial<br>eversion of the<br>eyelids,<br>swelling with<br>half-closed<br>lids (seen until<br>day 8), eye<br>discharge | No                      | Severely<br>irritating<br><br>Primary<br>irritation index:<br>58 | Grundler, O.J.<br>(1994c)<br><br>BASF<br>A6.01.4_03<br><br>Key study |

Glutaraldehyde was severely irritating to rabbit eyes. Glutaraldehyde (45 or 50 %) was administered to rabbit eye in two key studies. Severe corneal injury, iritis and severe conjunctival irritation in each of 6 rabbits were recorded in the study provided by Dow (Myers, 1987a, Dow A6.1.4(e)). Ocular effects included a purulent discharge, conjunctival necrosis, adhesion of the nictitating membrane and cornea and pannus. Corneal opacity and conjunctival swelling were so severe that complete scoring of the cornea and iritis was not possible for most of the observation period. Adhesion of the nictitating membrane to the cornea as well as the purulent discharge further interfered with the ocular examinations. The effects were not reversible but continued until the end of the observation period of 21 days (Myers, 1987a, Dow A6.1.4(e)).

In the study provided by BASF (Grundler, 1994c, BASF A6.01.4\_03) administration of 50% glutaraldehyde resulted in increasing opacity of the cornea which was nearly complete at day 8. In the iris, folds above normal were observed as well as swelling and circum-corneal injection. In the conjunctiva redness, swelling with partial eversion of the eyelids, swelling with half-closed lids (seen until day 8), eye discharge were recorded.

#### 4.4.2.2 Summary and discussion of eye irritation

Glutaraldehyde (45 or 50 %) caused severe damage to the rabbit eye.

#### 4.4.2.3 Comparison with criteria

According to the CLP criteria, classification as Eye Dam. 1 should be assigned if a substance produces effects at least in one animal of 3 in cornea, iris or conjunctiva that are not expected to reverse or have not fully reversed within an observation period of normally 21 days; and/or a substance produces a positive response in 2 of 3 tested animals of corneal opacity  $\geq 3$  and/or iritis  $\geq 1.5$  calculated as the mean scores following grading at 24, 48 and 72 hours after installation of the test material. The CLP does not provide criteria for tests using up to 6 rabbits, however in the CLP guidance there is US EPA/UN recommendation on studies with up to 6 rabbits have been used. Since glutaraldehyde (45 or 50 %) produced effects in rabbit eye which fulfil the criteria described above, classification as Eye Dam. 1; H318 (Causes serious eye damage) according to the CLP Regulation is warranted.

According to DSD, a substance should be assigned the risk phrase R41 (Risk of serious damage to eyes) if it causes severe ocular lesions in the eye of the animal (means of the scores: cornea opacity equal to or greater than 3, iris lesion greater than 1.5) which occur within 72 hours after exposure and which persist for at least 24 hours. If using 3 animals then in at least 2 animals the values should be: cornea opacity equal to or greater than 3, iris lesion equal to 2. Therefore, according to the criteria, the risk phrase R41 is warranted.

#### 4.4.2.4 Conclusions on classification and labelling

Glutaraldehyde causes severe damage to rabbit eyes. Therefore glutaraldehyde should be classified as follows:

**CLP:** Classification as Eye Dam. 1 for irreversible effects on the eye. The corresponding hazard statement (H318) will nevertheless not be proposed because of the **classification as skin corrosive (Skin Corr 1B; H314) which covers the effects on eyes. No change to the existing SCLs for eyes is suggested** (see section 4.4.1.4).

**DSD:** The risk phrase R41 is warranted: Risk of serious damage to eyes. This risk phrase will nevertheless not be proposed because of the **classification as corrosive C; R34 which covers the effects on eyes. No change to the existing SCLs for eyes is suggested** (see section 4.4.1.4).

#### **RAC evaluation of eye damage/irritation**

##### **Summary of the Dossier submitter's proposal**

The CLH report summarised two rabbit eye irritation studies, both supporting classification as Eye Dam. 1 - H318. However, glutaraldehyde is currently classified as Skin Corr. 1B - H314 (causes severe skin burns and eye damage), covering classification for eye damage. The DS proposed no change in the classification or specific concentration limits.

##### **Comments received during public consultation**

Two MSCAs and two companies offered their general agreement to no change in the classification.

**Assessment and comparison with the classification criteria**

RAC agrees with the DS that glutaraldehyde is a severe eye irritant and that the classification is already covered by the classification for corrosion and that no change to the classification is needed.

**4.4.3 Respiratory tract irritation****4.4.3.1 Non-human information****Table 19: Summary table of a respiratory tract irritation study**

| Species                                 | Method  | Number of animals, test concentration, exposure   | Result   | Reference  |
|---|---|---|--|--|
| Mouse<br>ND4<br>Swiss<br>Webster<br>(♂) | Peripheral sensory irritation test (PSI)<br><br>No guideline<br><br>The sensory irritation of the respiratory tract was determined by measuring the decrease of respiratory rate as a function of GA vapour concentration | 4 ♂ per group<br><br><u>Test concentrations:</u> 1.60, 3.99, 4.65, 5.60, 7.47, 17.7 and 36.7 ppm glutaraldehyde vapour<br><br><u>Procedure:</u><br>1) 10 min acclimatization period<br>2) 10 min of head-only air exposure to determine the baseline respiration rate<br>3) 30 min head-only exposure (test substance)<br>4) 10 min post-exposure with air (recovery) | RD <sub>50</sub> : 13.9 ppm<br><br>There was a direct and linear correlation between the respiratory rate and GA concentration<br><br>The lowest concentration (1.60 ppm) caused a 26 % decrease in respiratory rate, and the highest concentration (36.7 ppm) a 59 % decrease in respiratory rate<br><br>The decrease in respiratory rate was almost immediate upon exposure, and did not recover to normal levels during the 10 min post-exposure observation period.<br><br>No clinical signs were reported during the study. | Werley et al. 1995<br><br>BASF A6.01.4_04<br><br>Key study |

For the purpose of peripheral sensory irritation potential measurement, Swiss Webster male mice were exposed to glutaraldehyde vapour and the respiratory rate was recorded in an open source study (Werley et al. 1995). In rodents, sensory irritation leads to a concentration-dependent reduction in the respiratory rate mediated via the trigeminal nerve reflex, and this can be measured experimentally (non-OECD test, the Alarie assay; ECHA guidance IRSA R.7.a). It can be expected that a substance that is capable of stimulating the trigeminal nerve in mice will also have this potential in humans (ECHA guidance IRSA R.7.a). Glutaraldehyde vapour exposure resulted in an almost immediate decrease in respiratory rate, which was related to prolongation of the expiratory phase of the respiratory cycle, indicative of peripheral sensory irritation of the respiratory tract. A clear effect-concentration relationship was evident and an RD<sub>50</sub> of 13.9 ppm was derived (the exposure concentration that causes a 50 % decrease in respiratory rate). Glutaraldehyde was thus described as a moderately potent peripheral sensory irritant.

#### 4.4.3.2 Human information

With respect to the human evidence on glutaraldehyde-induced respiratory tract irritation the following available open source information on human volunteers and on occupational exposure is presented as summaries.

- **Cain S.W. et al., Odour and Chemesthesis from Exposures to Glutaraldehyde Vapour. Int. Arch Occup Environ Health 80(8): 721-31, 2007. Dow 6.12.4(1); BASF 6.12.2\_08**

Glutaraldehyde odour detection and chemesthetic (sensory irritation) detection by the eye and nose were studied in 50 female volunteers. The threshold of odour detection was around 0.3 ppb. The study described the odour around 35-100 ppb as discernible green apple odour that was not irritating during 15 min exposure. It was concluded that exposures that start decidedly below irritating (100 ppb and below) seem unlikely to turn irritating over time. However, in briefer exposures (5 s for nose, 25 s for eyes) with concentration range of 229-772 ppb (1.5-fold increments), the chemesthetic thresholds (points of 50% detection) for ocular and nasal detection were determined to be 390 ppb and 470 ppb, respectively. Conclusion: in an experimental setup, glutaraldehyde odour can be detected at 0.3 ppb. Based on this study, irritation is expected to occur at concentrations higher than 390 ppb (eyes) and 470 ppb (nose), with a sharp dependence on the concentration of glutaraldehyde.

- **Pisaniello et al.: Glutaraldehyde exposures and symptoms among endoscopy workers in South Australia. Appl. Occup. Environ. Hyg. 12: 171-177, 1997. Dow 6.12.4(4); BASF 6.12.4\_3**

135 endoscopy nurses exposed to glutaraldehyde and 132 unexposed nurses in the same hospitals were interviewed and their worksites were inspected. Inhalational exposure while using glutaraldehyde was determined and dermal exposure was assessed with skin pads. The measured overall geometric mean inhalational exposure concentration was 32 ppb, the highest mean of 93 ppb being in endoscopy areas with no local exhaust ventilation. Nurses exposed to glutaraldehyde reported more headache, lethargy and symptoms in the skin, eye and throat than the control group. The throat symptoms were mostly itching or tingling (10 vs. 4 % in the control group) and an unpleasant taste (9 vs. 3 %). No information is given on asthma or respiratory sensitization. Conclusion: Headache, lethargy and symptoms in the skin, eye and throat were connected with combined inhalation and dermal exposure to glutaraldehyde.

- **Vyas et al.: Survey of symptoms, respiratory function and immunology, and their relation to glutaraldehyde and other occupational exposures among endoscopy nursing staff, Occupational and Environmental Medicine 57: 752-759, 2000**

Endoscopy nurses (348 nurses in 59 endoscopy units) in the United Kingdom and 18 ex-employees who had left their job for health reasons were surveyed. Any work-related symptoms were surveyed using questionnaires. Exposure measurements included personal airborne biocide sampling for peak and background concentrations. All ex-employees and 91 % of the current nurses were primarily exposed to glutaraldehyde, while the rest were exposed to a succinaldehyde-formaldehyde composite. Work related contact dermatitis was reported by 44 % of current workers exposed to glutaraldehyde and 44 % of ex-employees. The prevalence of work related symptoms in current glutaraldehyde exposed workers was 14 % for the eyes, 20 % for the nose, and 9 % for the lower respiratory tract, while these were all at least 50 % among the ex-employees. There were 30 current nurses with lower respiratory tract symptoms. For these, peak expiratory flow rates were recorded

during one month and analysed using the OASYS-2 analysis program. The program revealed three cases of possible asthma, but re-evaluation of the data by two physicians concluded that none of these showed evidence of bronchial asthma. The mean percentage of the predicted forced expiratory volume in 1 second (FEV1) was 104.5 % for the current workers with no lower respiratory tract symptoms and 99.3 % for those with lower respiratory tract symptoms; for ex-employees it was 93.8 %. Exposures were above the maximum exposure limit of 0.2 mg/m<sup>3</sup> (50 ppb) in eight of the units investigated. There was a clear relation between peak glutaraldehyde concentrations and work related chronic bronchitis and nasal symptoms but not to other symptoms. Conclusion: Glutaraldehyde caused clear irritant effects in the skin, eyes, nose and the lower respiratory tract, but asthma was not diagnosed. The results concerning asthma have been questioned in the journal where the article was published. There were few FEV1 results for the ex-employees but the significantly lower value for this group may be indicative of the reason for leaving the workplace where exposure to glutaraldehyde had occurred.

• **Katagiri H. et al., Indoor glutaraldehyde levels in the endoscope disinfecting room and subjective symptoms among workers. *Industrial Health* 44: 225-229, 2006**

Exposure to glutaraldehyde in the air was measured at 6 hospitals in a total of 8 rooms where endoscope washing and disinfection took place. The subjective symptoms of 31 exposed women were compared to those of 101 unexposed control women using a questionnaire. Glutaraldehyde concentrations in the air had geometric means of 1.3 to 19.6 ppb, while personal measurements showed exposure levels of up to 94.2 and 84.9 ppb during the changing of the glutaraldehyde solution in the automatic washers. This high-exposure task is performed every 2 to 4 weeks. The women that were exposed to glutaraldehyde reported a variety of symptoms more frequently than those in the control group. These included asthma (2/31 vs. 0/101 in the control group), cough (9/31 vs. 5/101), pharynx irritation (3/31 vs. 1/101) and pain in the eyes (8/31 vs. 0/101). No attempts were made to clarify or verify the claimed symptoms.

• **Nayebzadeh A., The effect of work practices on personal exposure to glutaraldehyde among health care workers, *Industrial Health* 45: 289-295, 2007**

Air samples were taken in 19 locations in five hospitals in the breathing zone by personal sampling to measure exposure to glutaraldehyde during 5 to 15 min. The work practices were monitored and classified as "appropriate", "poor" and "unsafe", and resulted in mean exposure rates of 12, 51 and 80 ppb, and maximum concentrations of around 68, 150 and 150 ppb, respectively. Irritant effects (burning or itchy eyes; itchy nose) and headache were found to correlate with the work practices and consequently with peak exposure to glutaraldehyde. Correlation could not be established between work practices and cough/sneezing/runny nose. Although there was no control group without exposure to glutaraldehyde, it should be noted that even in the group with "appropriate" work practices 14 of the 27 cases reported headache and 11-22 % reported various irritant effects (but it is not mentioned whether e.g. "burning eyes" and "itchy eyes" were mutually exclusive categories). The quantity of glutaraldehyde solution used did not correlate with exposure. Conclusion: Work practices determine the exposure rate to a large extent, while even appropriate practices may result in exposure rates above the OEL of 50 ppb. The quantity of glutaraldehyde solution or the efficiency of general ventilation do not correlate with exposure.

#### **4.4.3.3 Summary and discussion of respiratory tract irritation**

In the PSI study on mice (Werley et al. 1995), following glutaraldehyde exposure the breathing rate of the mice decreased in a concentration-dependent manner. The vapour concentration producing a 50 % decrease in the breathing rate (RD50) was determined to be 13.9 ppm. In addition, the breathing rate decreased almost immediately after the exposure commenced. It was concluded that glutaraldehyde is a moderate sensory irritant in mice. An approximate derivation of RD10, albeit with considerable uncertainties, was calculated by the dossier submitter. The derived RD10 value is approximately 0.4 ppm (400 ppb).

In a study on human volunteers the chemesthetic thresholds (points of 50% detection) for ocular and nasal detection were determined to be at 390 ppb and 470 ppb (0.39 ppm and 0.47 ppm), respectively (Cain et al. 2007). The experimental setup ensured independence of these values from perception of the odour of glutaraldehyde, therefore they represent the sensitivity of sensory irritation. These values are very close to a previous estimate of the chemesthetic threshold of 300 ppb for glutaraldehyde (see Ballantyne and Jordan 2001). The difference between the odour detection (0.3 ppb) and the chemesthetic detection of three orders of magnitude in concentration is typical of the pattern of other volatile organic compounds with similar potency. Taken together, this study is a clear demonstration of the sensory irritation potential of glutaraldehyde in humans.

The human occupational exposure evidence on glutaraldehyde-induced respiratory tract irritation included effects in the nose and eyes and in the lower respiratory tract. Symptoms were described as burning and itchy eyes, itchy nose, pain in the eyes, sneezing, runny nose, coughing, pharynx irritation, tingling in the throat etc. There was variation in the effects described and the relationship between exposure concentrations/times and effects could not be established with certainty in most studies. The aforementioned studies could however be considered as supportive information on respiratory tract irritation potential of glutaraldehyde. However it is difficult to draw definite conclusions on the mechanisms of these effects.

The respiratory tract irritation covers two different mechanisms, namely the sensory irritation which is mediated via autonomic nerve receptors on mucosal tissues of eyes and upper respiratory tract, and local cytotoxic effects which are commonly caused by corrosive substances. Glutaraldehyde is a corrosive agent and is classified as Skin Corr 1B according to the CLP Regulation. In the light of the studies presented in this dossier, glutaraldehyde-evoked respiratory irritation may arise via two different mechanisms, namely via the corrosive cytotoxic effects on the respiratory tract and via sensory irritation.

#### **4.4.3.4 Comparison with criteria**

According to the CLP Regulation, a substance can be classified as STOT SE 3; H335 (May cause respiratory irritation) if it causes transient effects such as respiratory irritant effects (localized redness, oedema, pruritis and/or pain) that impair function with symptoms such as cough, pain choking and breathing difficulties (data primarily from human studies). Subjective human observations can be supported by objective measurements (such as electrophysiological measurements, markers of inflammation in nasal BAL fluids). There are no validated animal tests that deal specifically with respiratory tract irritation, however useful information may be obtained from other studies and be used as weight of evidence.

The presented human occupational exposure studies describe subjective observations on respiratory tract irritation with various symptoms. However due to lack of clear relationship between exposure and the development of signs of respiratory tract irritation which should be reversible these studies should be regarded as part of weight of evidence. The study on human volunteers using a

psychophysical method, however, gave clear evidence of the sensory irritation potential of glutaraldehyde, and thresholds for sensory irritation could be determined (390 ppb for eyes and 470 ppb for nose).

The Alarie test on mice measures the sensory irritation potential of a chemical. Although it is a non-OECD test the data from the test can be used as part of weight of evidence. The test revealed a clear concentration-dependent effect on the breathing rate in exposed mice, with a RD50 value of 13.9 ppm.

In conclusion, glutaraldehyde was described as a moderately potent peripheral sensory irritant in the mouse PSI test (Alarie test). Together with the human data on volunteers, the results imply that glutaraldehyde is a respiratory tract irritant via the sensory irritation mechanism.

As glutaraldehyde is a corrosive substance it can cause respiratory tract irritation via a local cytotoxic mechanism when inhaled below those concentrations which cause respiratory tract corrosion. Therefore, glutaraldehyde can cause respiratory tract irritation via two mechanisms, namely via corrosivity and via sensory irritation.

There are no guidance values for STOT SE 3, therefore if a substance shows clear evidence at any dose level then this could support classification as STOT SE 3 (CLP guidance on criteria).

#### 4.4.3.5 Conclusions on classification and labelling

The current classification of glutaraldehyde as STOT SE 3 at a specific concentration limit of  $C \geq 0.5$  % obviously stems from the direct translation of R37 (at specific concentration limits) under Directive 67/548/EEC. The mechanism of respiratory tract irritation was corrosivity. However, the presented human and animal data in the current CLH dossier show that glutaraldehyde causes respiratory tract irritation also via a specific mechanism, namely sensory irritation. Therefore, classification as STOT SE 3; H335 is proposed based on two mechanism: corrosivity and sensory irritation in the respiratory tract.

In conclusion, it is proposed to classify glutaraldehyde as follows:

**CLP: STOT SE 3; H335.**

**DSD: Xi; R37.**

**SCL:** The existing SCL for STOT SE 3; H335 is  $C \geq 0,5$  %. However, based on the presented data on respiratory tract irritation via the sensory irritation mechanism with the calculated RD10 value of approximately 0.4 ppm for mice and a threshold of 0.39 - 0.47 ppm for the human volunteers, a lower **SCL of 0,00005 %** is proposed under both CLP and DSD.

#### **RAC evaluation of respiratory sensitisation**

##### **Summary of the Dossier submitter's proposal**

Glutaraldehyde is already classified as Resp. Sens. 1 – H334. The CLH report included one mouse Immunoglobulin E (IgE) study (Kimber et al., 1994) indicating a dose-dependent increase in serum IgE after exposure to glutaraldehyde. In addition, 22 human studies were summarised in the CLH report. Despite the abundance of data indicating that glutaraldehyde is a respiratory sensitiser in humans, uncertainties remained as to the concentrations causing the reactions and the frequency of response in the exposed population. Therefore, the DS concluded that no sub-categorisation is

possible and proposes no change in the classification.

### **Comments received during public consultation**

Comments were received from two companies agreeing with the proposal not to change the classification.

### **Assessment and comparison with the classification criteria**

RAC agrees with the DS that glutaraldehyde is a respiratory sensitiser. RAC also agrees that the available data do not allow for further sub-categorisation and agrees to retain the classification of Resp. Sens. 1 – H334.

## **4.5 Corrosivity**

See section 4.4

## **4.6 Sensitisation**

### **4.6.1 Skin sensitisation**

#### **4.6.1.1 Non-human information**

**Table 20: Summary table of skin sensitisation studies**

| <b>Species</b>   | <b>Method</b>  | <b>Number of animals sensitised/total number of animals<br/>(or description of other results)</b>   | <b>Result</b> | <b>Reference</b>   |
|--|--|---|---------------|--|
| Guinea pig<br>Dunkin Hartley<br>Haz:(DH)fBR<br>(10 ♂+ 10 ♀/<br>GA group) | (Reportedly US EPA<br>OPP Section 798.4100,<br>1985)<br><br>Similar to OECD 406<br><br>GLP<br><br>Guinea pig<br>maximisation test<br><br>intradermal induction<br>0.1% GA, topical<br>induction 2 % GA | Aqueous GA:<br><ul style="list-style-type: none"> <li>• 13/19 (challenge)</li> <li>• 6/19 (re-challenge)</li> </ul><br>Alkalinised GA:<br><ul style="list-style-type: none"> <li>• 5/20 (challenge)</li> <li>• 1/20 (re-challenge)</li> </ul> | Sensitising   | Blaszczak, D.L. (1993)<br>Dow A6.1.5/01<br><br>Key study |

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| Species                        | Method   | Number of animals sensitised/total number of animals<br>(or description of other results)  | Result      | Reference  |
|--------------------------------|--|--|-------------|--|
| Mouse<br>BALB/c<br>(4 ♀/group) | LLNA<br>No guideline, no GLP<br>50 % aqueous GA diluted in acetone to final GA concentrations of 0, 2.5, 5, 12.5 and 25 %  | Stimulation indices for 2.5, 5, 12.5 and 25 % GA, as compared to the vehicle control group: 15.5, 23.4, 38.7 and 34.9                                    | Sensitising | Kimber, I. (1994)<br>Dow A6.1.5/02<br>Key study    |
| Guinea pig,<br>Pirbright White | Open epicutaneous test with guinea pig<br>No guideline, no GLP<br>Test substance: Relugan GT (GA 25 %, water 67 %, methanol 8 %)<br>25 % GA was used in both induction and challenge | 10/10<br><u>Induction</u> : thick bloody scabs (10/10)<br><u>Challenge</u> : distinct spotted erythema (10/10)<br><u>Negative control</u> : no reactions | Sensitising | Zeller, H. (1975)<br>BASF A6.01.5_01<br>Supportive |
| Mouse<br>CBA/Ca<br>(4 ♀/group) | LLNA<br>No guideline, no GLP<br>Test substance: five concentrations of GA in two different vehicles (acetone:olive oil or propylene glycol)  | EC3 value 0.07% (in AOO)<br>EC3 value 1.5 % (in PG)  | Sensitising | Basketter, D.A. et al 2003<br>Key study            |

The skin sensitisation potential of glutaraldehyde has been assessed in a guinea pig maximization test (GPMT), in a mouse local lymph node assay (LLNA) and in a guinea pig open epicutaneous test. In addition, there are a few open source studies available with relevant data on skin sensitisation potential of GA.

In a GPMT test according to Magnusson and Kligman and similar to OECD TG 406 (Blaszczak 1993, Dow A6.1.5/01) 20 animals (10 males, 10 females) were exposed to aqueous or alkalinised glutaraldehyde. 2,4-Dinitrochlorobenzene (DCNB; 0.1%) was used as a positive control in 10 animals (5 males, 5 females) and 20 animals served as irritation controls (5 males and 5 females at challenge; 5 males and 5 females at re-challenge). In the main test the treatment regimen involved induction by intradermal injection (0.1 % aqueous or 0.1 % alkalinised GA formulated as 1:20 either in propylene glycol or in Freund's complete adjuvant/water emulsion) in the clipped shoulder region on day 1, induction by topical application (2% aqueous or alkalinised GA) on the clipped shoulder region on day 7 and challenge (0.2% aqueous or alkalinised GA) by topical administration on day 21 and re-challenge (0.2% aqueous or alkalinised GA) on day 28 on the clipped skin of the flanks.

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One animal was found dead on day 8 in the aqueous GA group, all other animals survived throughout the study. Necropsy revealed emaciation but no internal abnormalities were found.

Following challenge, all animals (incidence index 100 %, 10/10 animals) treated with the positive control DNCB (0.1 %) gave clear dermal responses with the irritation control animals giving no response at the same concentration. A response was considered positive with a score of 1 or greater. The irritation controls for GA at challenge and re-challenge treated with the same concentrations were negative. The incidence index of sensitisation to 0.1% aqueous glutaraldehyde was 68% (13/19 animals) at challenge (reading after 24 h) and 32% (6/19 animals) at re-challenge. The incidence index of sensitisation to 0.1 % alkalinized glutaraldehyde was 25% (5/20 animals) at challenge and 5% (1/20) at re-challenge. The scoring scale used in the original study was 0.5-3 giving slightly higher incidence indexes (79% for 0.1% aqueous GA and 65% for 0.1% alkalinized GA) however for comparison of the results to the CLP classification criteria only the scores 1 and greater have been considered.

The severity index was determined for the response readings by dividing the sum of total grades (scores 0.5-3) in a given group by the number of animals exposed. The positive control (DNCB) severity indices at 24 h and 48 h at challenge were 1.7 and 1.5, respectively. The challenge severity indices for aqueous GA at 24 h and 48 h were 0.8 and 0.5, respectively. At re-challenge the values were 0.5 and 0.1. For alkalinized GA the challenge severity indices at 24 h and 48 h were 0.5 and 0.2, respectively. At re-challenge the values were 0.2 and 0.1.

In conclusion, an intradermal induction dose of 0.1 % aqueous glutaraldehyde exhibited a moderate to strong potential in producing sensitisation whereas intradermal induction dose of 0.1% alkalinized glutaraldehyde exhibited a weak to moderate potential. The reason for the decrease in the incidence of the responses at re-challenge is not clear. However, the presence of responses at both challenge and re-challenge is indicative of sensitisation since the irritation controls were negative.

In a mouse LLNA (Kimber, I. 1994, Dow A6.1.5/02) four female mice per group were exposed to glutaraldehyde concentrations of 0%, 2.5%, 5%, 12.5 % or 25 %. At the time the study was carried the OECD TG 429 was not yet adopted however the test is in principle similar to the TG429. The GA doses were applied on the dorsum of both ears daily for three consecutive days. On day 6 mice were injected with <sup>3</sup>H-thymidine and five hours later the mice were sacrificed and the draining auricular lymph nodes were removed and pooled for each dose group. Single cell suspensions were prepared by mechanical disaggregation through a stainless steel gauge. Pooled cells were washed twice with PBS, and precipitated with 5 % trichloroacetic acid (TCA) for 12 hours, pelleted and resuspended in TCA whereafter the radioactivity was measured by beta-scintillation counting. The results are expressed as DPM-value/dose group divided by DPM-values of the control group (vehicle only, acetone) thus giving the stimulation index (SI) for each dose group. Increasing concentrations of GA elicited SI of 15.5, 23.4, 38.7 and 34.9, respectively, indicating that glutaraldehyde has the potential to induce skin sensitisation. The EC3 -value indicating the estimated concentration required to produce a 3-fold increase in draining lymph-node cell proliferative activity was not calculated.

The EC3-value for glutaraldehyde has been determined in open source studies. In a LLNA study by Basketter et al. (2003) GA was tested using two vehicles, acetone:olive oil (AOO) and propylene glycol (PG). Concentrations of GA used in AOO were 0.039%, 0.052%, 0.13 %, 0.26% and 0.52 % and in PG 0.26%, 0.52%, 1.3 % and 2.6 %. The LLNA was carried out using the standard protocol (Kimber and Basketter 1992). The calculated EC3 values for GA were 0.07% in AOO and 1.5% in PG. In another LLNA study by Basketter et al. (2000) the calculated EC3 for glutaraldehyde was 0.2% in AOO.

In a non-guideline guinea pig open epicutaneous test (Zeller, H. 1975, BASF A6.01.5\_01) glutaraldehyde formulation Relugan GT (25 % GA, 8% methanol, 67% water) was tested on female guinea pigs (10 animals). For induction, a skin area of about 25 cm<sup>2</sup> was clipped of each animal on the fore region of each flank. Four hours later the application site (the left flank) was degreased with ether and 25 % glutaraldehyde was applied (3 times) topically using a piece of cotton wool. The application was repeated once daily on five consecutive days per week, over two weeks (total of 10 applications). The shaved right flank remained untreated. Challenge was performed after 11 days following induction. Both flanks of each animal were clipped and after four hours the right flank of each animal was degreased with ether and 25 % glutaraldehyde was applied (single application). Three control animals, which had not been subjected for induction, were treated similarly. The animals were examined for skin reactions 12 hours later.

Following induction the skin of the 10 treated animals showed thick bloody scabs. Following challenge distinct spotted erythema was reported for all 10 treated animals whereas the control animals showed no skin reaction. In conclusion, the study showed that 25 % glutaraldehyde was sensitising to guinea pig skin.

### 4.6.1.2 Human information

With respect to the human evidence on glutaraldehyde-induced skin sensitisation potential the following available open source information on human volunteers and on skin patch tests is presented as summaries. In the publication by Shaffer and Belsito (2000) there are references to 13 other case-reports or skin patch tests published before 2000.

• **Marzulli F.N. & Maibach H.I., The use of graded concentrations in studying skin sensitizers: Experimental contact sensitization in man. *Fd Cosmet. Toxicol.* 12: 219-227, 1974.**

Two concentrations of glutaraldehyde (0.1 % and 5.0 %) were used for induction and one concentration (0.5 %) for challenge in a Draize test. The subjects were male human volunteers. In inductions, 0.5 g of the test material was applied to the upper lateral portion of the arm and covered with an occlusive patch. This was repeated 10 times over a period of 3.5 weeks. After a 2-week break in exposures, a challenge of 72 h was performed using a non-irritant concentration of 0.5 % glutaraldehyde. None of the 102 volunteers gave a positive response at the induction concentration of 0.1 % glutaraldehyde, while 7 of 30 reacted at the induction concentration of 5.0 % glutaraldehyde. Conclusion: The NOAEC for sensitization was 0.1 % and LOAEC 5.0 % because of the 50-fold dose spacing.

• **Shaffer M.P. & Belsito D.V., Allergic contact dermatitis from glutaraldehyde in health-care workers. *Contact Dermatitis* 43: 150-156, 2000.**

In the University of Kansas dermatology clinics, 516 patients were tested for skin sensitisation to various chemicals in a skin patch test between July 1994 and June 1999. Out of these, 468 were tested for glutaraldehyde and 17 were found positive (3.6 %). There were 51 health care workers and 9 of these were positive (17.6 %), while among the non-health care workers there were 8 positive from 417 (1.9 %). Two of the health care workers gave a positive result to both glutaraldehyde and formaldehyde, and additional 2 were positive to formaldehyde but not glutaraldehyde. Among the non-health care workers, 42 were positive to formaldehyde and 5 of these also to glutaraldehyde. Conclusion: Glutaraldehyde exposure had caused skin sensitisation in nearly one fifth of the tested health care workers, being the most common positive test result among

the chemicals tested. Two of the nine glutaraldehyde-positive patients were also positive to formaldehyde.

### 4.6.1.3 Summary and discussion of skin sensitisation

All animal studies indicate that glutaraldehyde is a potential skin sensitizer. There were unequivocal positive responses in guinea pigs (Blaszczak 1993, Dow A6.1.5/01; Zeller, H. 1975, BASF A6.01.5\_01) and in mice (Kimber, I. 1994, Dow A6.1.5/02, Basketter et al 2000,; Basketter et al 2003). Human data confirms the results from animal experiments of glutaraldehyde being a skin sensitizer.

### 4.6.1.4 Comparison with criteria

Glutaraldehyde is currently classified as Skin Sens. 1. Along with the new criteria in the 2<sup>nd</sup> ATP of CLP Regulation (286/2011) it is possible to classify sensitizers in sub-categories. The criteria for classification of skin sensitizers to sub-category 1A based on a GPMT study is  $\geq 30\%$  responding  $\leq 0.1\%$  intradermal induction dose or  $\geq 60\%$  responding at  $> 0.1\%$  to  $< 1\%$  intradermal induction dose. The criteria for sub-category 1B is  $\geq 30\%$  to  $< 60\%$  responding at  $> 0.1\%$  to  $\leq 1\%$  intradermal induction dose or  $\geq 30\%$  responding at  $> 1\%$  intradermal induction dose. In the described GPMT study (Blaszczak 1993, Dow A6.1.5/01) an intradermal induction dose of  $0.1\%$  aqueous glutaraldehyde evoked skin sensitisation in 68% of the treated animals, therefore it should be classified in sub-category 1A.

The criteria for classification of skin sensitizers based on LLNA study is EC3 value  $\leq 2\%$  for sub-category 1A and EC3 value  $> 2\%$  for sub-category 1B. In the described LLNA study (Kimber, I. 1994, Dow A6.1.5/02) glutaraldehyde was clearly sensitising based on the obtained SI values however the EC3 was not calculated. In two open source studies (Basketter et al. 2000, Basketter et al. 2003) EC3 values of 0.07 and 0.2 % have been obtained therefore glutaraldehyde should be classified in sub-category 1A.

Taken together, the most informative animal data allow and justify classification of glutaraldehyde into sub-category 1A. Other animal studies (Zeller, H. 1975, BASF A6.01.5\_01) confirmed the sensitisation potential of glutaraldehyde however sub-categorization is not possible due to the non-compliant nature of the study and the high dose used. In addition, the most relevant human data support the results of animal studies as summarised below:

The Draize test data on human volunteers (Marzulli and Maibach, 1974) showed that the topical induction concentration of 5% gave a positive response in 7/30 males (23.3 %) whereas the induction concentration of 0.1 % did not cause any response in 102 males. However it is difficult to draw definite conclusion on the potential of glutaraldehyde since there were only two doses with large spacing (50-fold) and the description of the size of the area of GA application was not given, therefore sub-categorization is not possible.

In a skin patch test (Shaffer and Belsito, 2000), 17 of the 468 tested subjects (3.6 %) were allergic to glutaraldehyde. Moreover, positive reactions were more than eight times likely in the health care workers (17.6 %) than in non-health care workers (1.9%). In all of the health-care workers positive response to glutaraldehyde were found to be currently relevant, in other words they were exposed to or were known to be exposed to products containing glutaraldehyde. On the other hand in non-

health care workers current relevance of glutaraldehyde was not found in any. Both of these results point to a high frequency of occurrence of skin sensitisation and could thus allow sub-categorization into 1A. In addition, there are 13 other case-reports mainly on health care workers and skin patch tests on glutaraldehyde referenced in Shaffer and Belsito (2000) that could support the aforementioned conclusion.

#### 4.6.1.5 Conclusions on classification and labelling

Glutaraldehyde is currently classified as Skin Sens. 1 under the CLP Regulation. According to the criteria in the 2<sup>nd</sup> ATP of CLP (286/2011), classification as **Skin Sens. 1A; H317** is proposed. Under DSD glutaraldehyde is currently classified as R43 and no change is proposed to the existing classification.

In conclusion, it is proposed to classify glutaraldehyde as follows:

**CLP: Skin Sens. 1A; H317**

**DSD: R43**

**SCL:** The classification criteria according to CLP and sub-categorization for the skin sensitisation potency render the current SCL (0.5%) superfluous and thus the SCL is proposed to be removed. The available data justifies the 0.1% GCL for Skin Sens. 1A and there is no need to set a new SCL.

For the classification under DSD there are two options with regard to SCL: either to keep the existing SCL of 0.5 % or adopt a lower SCL of 0.1% to uniform the two classification systems. In the opinion of the DS both options are scientifically justified.

#### **RAC evaluation of skin sensitisation**

##### **Summary of the Dossier submitter's proposal**

Glutaraldehyde is already classified as Skin Sens. 1 – H317. The CLH report included one guinea pig maximisation test (GPMT) (Blaszczak, 1993), three mouse local lymph node assays (LLNA) (Kimber, 1994; Basketter, 2000 and 2003) and one guinea pig open epicutaneous test (Zeller, 1975). The four studies were used as key studies while the latter was reported as supportive information. In addition, the CLH report included short summaries of two human studies, one indicating sensitisation in human volunteers (Marzulli et al., 1974) and one indicating allergic contact dermatitis in health-care workers (Shaffer et al., 2000).

All animal studies were positive for skin sensitisation. In the GPMT study, an intradermal induction dose of 0.1% produced positive reactions in 68% of tested animals. In two LLNA studies, measured EC3 values were 0.07% and 0.2%. In Kimber (1994), the EC3 was not determined. The DS proposed sub-categorisation into Skin Sens. 1A – H317. As the GCL for subcategory 1A is 0.1%, the DS proposes removal of the SCL for skin sensitisation

##### **Comments received during public consultation**

Two MSCAs agreed with the sub-categorisation into category 1A and the removal of the SCLs. One company disagreed with the classification, arguing that the data are insufficient for sub-categorisation and that glutaraldehyde is not of significant concern in the "dermatological community". The DS disagreed and argued that the clear evidence from several independent animal studies justify classification in Skin Sens. 1A – H317. More details can be found in the RCOM.

##### **Assessment and comparison with the classification criteria**

As the result from the GPMT test was  $\geq 60\%$  with an induction dose at 0.1% together

with the results from the LLNA test (EC3 values; 0.07% and 0.2% both  $\leq 2\%$ ) are within the criteria for Skin Sens 1A, RAC agrees to classify glutaraldehyde as Skin Sens 1A – H317 and to remove the SCL (0.5%) and retain the GCL (0.1%) which is justified by the available data.

## 4.6.2 Respiratory sensitisation

### 4.6.2.1 Non-human information

**Table 21: Summary table of a respiratory sensitisation study**

| Species                      | Method  | Number of animals sensitised/total number of animals<br><br>(or description of other results)  | Result                           | Reference                              |
|------------------------------|---|--|----------------------------------|--|
| Mouse, BALB/c<br>(6 ♀/group) | Mouse IgE test<br><br>No guideline, no GLP<br><br>50 % aqueous GA diluted in acetone to final GA concentrations of 0, 2.5, 5 and 12.5 % | Dose-dependent increase in serum IgE, $\mu\text{g/ml}$ , mean $\pm$ SE: 0.304 $\pm$ 0.024 (acetone only), 0.516 $\pm$ 0.038, 0.640 $\pm$ 0.195 and 1.280 $\pm$ 0.193<br><br><u>Negative control</u> (non-respiratory sensitizer DNCB): 0.212 $\pm$ 0.042 $\mu\text{g/ml}$<br><br><u>Positive control</u> (trimellitic anhydride): 1.991 $\pm$ 0.160 $\mu\text{g/ml}$ | Potential respiratory sensitizer | Kimber, I. (1994)<br><br>Dow A6.1.5/02 |

A mouse IgE test was performed to assess the potential for respiratory sensitising (Kimber, 1994, Dow A6.1.5/02). The test is based on measuring the elevation of IgE levels, which do not change in skin sensitisation but rise during respiratory sensitisation. Elevated IgE levels correlate with higher risk of asthma. Groups of six mice were shaved on flanks and dosed dermally with 50  $\mu\text{l}$  of test material. Seven days later 25  $\mu\text{l}$  of the same material at half of the initial concentration was applied to the dorsum of both ears. Fourteen days later the animals were sacrificed and blood was collected and serum prepared. The concentration of serum IgE was determined using ELISA and the results were compared to a positive (25 % trimellitic anhydride) or to a negative (1% DNCB; a known contact sensitizer that does not induce respiratory sensitisation) control. Glutaraldehyde gave a clear dose-dependent positive response indicating that it is a potential respiratory sensitizer.

### 4.6.2.2 Human information

**Table 22: Summary table of relevant information on respiratory sensitisation**

| Study | Study setup | Result with regard to sensitizing effects | Conclusions on sensitized/non-sensitized population |
|-------|-------------|---|---|
|       |             |   |   |

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| Study  | Study setup   | Result with regard to sensitizing effects   | Conclusions on sensitized/non-sensitized population   |
|--|---|---|---|
| Teta <i>et al.</i> , 1995.   | 218 workers assigned to GA production or drumming<br>40-80 ppb in air (TWA)   | No clear evidence of sensitization to GA<br>6 cases of possible sensitization not attributable to a particular chemical   | <b>Conclusion: Relatively few people are sensitized at frequent exposures to GA concentrations of 10 to more than 100 ppb (TWA up to 80 ppb).</b> |
| BASF A6.12.1_01<br>Monitoring of manufacturing plant personnel, 2007 | Manufacturing plant<br>Up to 8 ppb in air   | No sensitization cases reported   | <b>Low GA concentration (<math>\leq 8</math> ppb) in the manufacturing plant air did not result in verified sensitization.</b>                    |
| Pałczyński <i>et al.</i> , 2001.                                     | A) 11 cases of asthma assumed to be due to GA<br>B) 10 atopic patients with perennial asthma and rhinitis<br>C) 10 healthy individuals<br>No data on exposure | In contrast to groups B and C, GA challenge resulted in strong increases in allergy and asthma markers in group A:<br><ul style="list-style-type: none"> <li>• 25-fold increase in the numbers and percentages of eosinophils</li> <li>• 27-fold increase in the numbers and percentages of basophils</li> <li>• 23-fold increase in ECP concentration</li> <li>• Increase in mast cell tryptase concentration (below LOQ before stimulus)</li> </ul> | No conclusions can be made with regard to a possible sensitization threshold.   |

ANNEX 1 - BACKGROUND DOCUMENT TO RAC OPINION ON GLUTARALDEHYDE

| Study                           | Study setup  | Result with regard to sensitizing effects  | Conclusions on sensitized/non-sensitized population   |
|---------------------------------|--|--|---|
| Gannon <i>et al.</i> , 1995     | <p>Eight workers whose asthmatic symptoms improved when away from work</p> <p><b>Endoscopy suites:</b> personal samples, short term median 39 ppb (range 27 to 230 ppb)</p> <p><b>Darkrooms:</b> all short term levels below detection limit of 2.2 ppb</p>            | <p>Occupational asthma was confirmed in 7 cases, all of whom had 1) peak expiratory flow (PEF) records suggestive of occupational asthma and 2) gave positive results in specific bronchial challenge tests to GA</p> <p>Exposure data on the sensitized cases:</p> <ul style="list-style-type: none"> <li>• Three endoscopy nurses had repeated short-term exposure to at least 27 ppb GA</li> <li>• One darkroom technician was exposed to GA-containing developers regularly during 23 years. Static air GA concentrations were less than 2.2 ppb, but no personal measurements were made</li> </ul> <p>No exposure data is available for two cases, and one further case (secretary) was reportedly only exposed to newly developed X-ray films.</p> | <p>The endoscopy nurses that became sensitized had experienced repeated short-term exposure to concentrations of at least 27 ppb GA</p> <p>The concentration that the darkroom technician was exposed to is probably lower than this, but the measured level of 2.2 ppb is not a personal measurement and is probably an underestimation. Furthermore, exposure had taken place during 23 years and peak exposure levels have most likely been significantly higher.</p> <p><b>Conclusion: Three of the four cases with exposure data had exposure to at least 27 ppb GA. The fourth case is difficult to interpret with regard to the concentration that caused sensitization.</b></p> |
| Pisaniello <i>et al.</i> , 1997 | <p>135 endoscopy nurses and 132 unexposed nurses in the same hospitals</p> <p>Highest and lowest geometric mean values:</p> <ul style="list-style-type: none"> <li>• 93 ppb in endoscopy areas without LEV</li> <li>• 14 ppb in operating theatres with LEV</li> </ul> | <p>No information on asthma or respiratory sensitization</p> <p>Wheezing (23 vs. 20.5 %) and cough (17 vs. 13.6 %) were more prevalent in the exposed nurses, but without statistical significance</p> <p>Headache, lethargy and symptoms in the skin, eye and throat were connected with combined inhalation and dermal exposure to GA</p>  | <p>No conclusions can be made with regard to a possible sensitization threshold.</p>  |

ANNEX 1 - BACKGROUND DOCUMENT TO RAC OPINION ON GLUTARALDEHYDE

| Study                           | Study setup  | Result with regard to sensitizing effects  | Conclusions on sensitized/non-sensitized population   |
|---------------------------------|--|--|---|
| Di Stefano <i>et al.</i> , 1999 | 24 health care workers with presumed occupational asthma due to GA exposure<br>Mean GA in air: 51 ppb (range 15 to 205 ppb)  | 8 subjects studied by specific bronchial provocation test (SBPT); all positive<br>16 studied by serial PEFr monitoring; 13/16 positive<br>7/24 had GA-specific IgE antibodies  | The lowest measured concentration in the short-term samples was 15 ppb and the mean value was 51 ppb "during activities likely to produce peak levels".<br><b>Conclusion: The sensitized workers have experienced repeated short-term exposure to concentrations of at least 15 ppb GA.</b> |
| Vyas <i>et al.</i> , 2000       | Survey of 348 current and 18 ex-nurses in 59 endoscopy units in UK (ex-nurses having left for health reasons)<br><br>• Peak concentration range ND to 263 ppb; geometric mean 14.6 ppb<br><br>• Peak concentrations above 50 ppb in 8/59 units | <u>Lower respiratory tract symptoms:</u><br><br>• 27/318 current nurses exposed to GA (altogether 30/348)<br><br>• 12/18 ex-workers<br><br><u>1-month PEFr results:</u><br><br>• 17 analysable of those with lower respiratory tract symptoms; 3/17 positive<br><br><u>Mean % predicted FEV<sub>1</sub>:</u><br><br>• Current workers with no lower respiratory tract symptoms: 104.5<br><br>• Current workers with lower respiratory tract symptoms: 99.3<br><br>• Ex-workers: 93.8 | Lower respiratory tract symptoms were not linked to sensitization.  |
| Stenton <i>et al.</i> , 1994    | A single endoscopy nurse with symptoms of occupational asthma connected with GA exposure<br>No data on exposure  | Initial exposure: entering the workplace; marked asthmatic response<br>After 7 and 8 months of no exposure, double-blind challenges gave inconsistent results in FEV <sub>1</sub><br>No clear immediate or late asthmatic reactions in the second series   | <b>No conclusions can be made with regard to a possible sensitization threshold.</b>  |

ANNEX 1 - BACKGROUND DOCUMENT TO RAC OPINION ON GLUTARALDEHYDE

| Study   | Study setup  | Result with regard to sensitizing effects  | Conclusions on sensitized/non-sensitized population  |
|---|--|--|--|
| Curran <i>et al.</i> , 1996                             | 20 GA-exposed workers (13 diagnosed with occupational asthma)<br>Control group of 21 unexposed workers<br>No data on exposure  | No clear evidence of correlation between IgE levels and occupational asthma<br>12 of the 20 patients were without GA exposure 6 months prior to testing, allowing IgE decrease   | <b>No conclusion with regard to possible threshold.</b><br><b>Asthma was associated with GA exposure, but no information on exposure duration/level is available.</b>  |
| Sutton <i>et al.</i> , 2007                             | 600 workers in two companies producing bioprosthetic heart valves <ul style="list-style-type: none"> <li>• Company A: 3 to 100 ppb</li> <li>• Company B: ND to 830 ppb</li> </ul> Exposure was > 50 ppb in 23/58 different tasks   | 2 cases of new-onset work-related asthma associated with GA during the 5-year period (likely to underestimate the true incidence)  | Exposure to GA has taken place continuously over each work shift for several years. Exposure has frequently occurred to GA levels above 50 ppb.<br><b>Conclusion: Relatively few people are sensitized even at frequent exposures to above 50 ppb GA.</b>  |
| Havics & Bucherl, unpublished/submitted for publication | 400 workers in the production area of a company producing bioprosthetic heart valves. Latex gloves were worn but no respiratory protection was used. Some of the workers have almost constant hand (in glove) contact with GA. Personal short-term samples: <ul style="list-style-type: none"> <li>• Range 1 to 970 ppb</li> <li>• Yearly arithmetic means 29 to 232 ppb</li> <li>• Yearly medians 12 to 85 ppb</li> <li>• 20 % of samples above 80 ppb and 5 % above 325 ppb</li> </ul> | 1 substantiated case of work aggravated asthma (exposure conditions: 20 % of samples were above 80 ppb; 5 % of samples above 314 ppb)<br>2 further cases insufficiently described or analysed to make conclusions<br>No new-onset asthma<br>No significant complaints by the workers were reported during 10 years regardless of the high GA concentrations in the air.<br>Only 6 respiratory-related cases were reported during 10 years in a facility of 400 workers with high exposure to GA. | Exposure to high GA concentrations has taken place. This study is not yet published, and overall the results indicate a surprisingly low level of effects regardless of the high exposure levels.<br><b>No conclusions can be made with regard to a possible sensitization threshold.</b><br><b>Note: Surprisingly few workers are affected and the results may be doubted.</b> In other studies, lower levels of GA have caused symptoms like headache, lethargy, cough, pharynx irritation and pain in the eyes. The lack of any such complaints might suggest a systematic error in the study setup, although this cannot be verified. The healthy survivor effect may be involved.<br><i>The RMS received this unpublished work on February 9, 2012. It has apparently not been published by November 8, 2012.</i> |

ANNEX 1 - BACKGROUND DOCUMENT TO RAC OPINION ON GLUTARALDEHYDE

| Study                       | Study setup   | Result with regard to sensitizing effects   | Conclusions on sensitized/non-sensitized population   |
|-----------------------------|---|---|---|
| Waters <i>et al.</i> , 2003 | <ul style="list-style-type: none"> <li>• 38 nurses exposed to GA</li> <li>• 38 nurses not exposed to GA</li> </ul> <p>Various tasks in endoscopy units and operating theatres</p> <ul style="list-style-type: none"> <li>• Highest reading &gt; 100 ppb in all but one task</li> <li>• Maximum 150 ppb</li> <li>• Detection of aldehydes; not specific to GA</li> </ul> | <p>Sensitization or asthma was not considered</p> <p>Modest reductions in cross-shift FEV<sub>1</sub> (mean 30 ml) and FVC (mean 50 ml) in the exposed group. Peak exposure was the only independent predictor of reduction</p> <p>Exposure duration or total dose seemed to have no effect</p>   | <p><b>Conclusion: the results support the suggestion that avoiding peak exposures may be the key to reducing GA sensitization.</b> Conversely, low GA concentrations might be less likely to produce sensitization.</p> |
| Arif & Delclos, 2012        | <p>Questionnaire sent to 5600 healthcare professionals; 3650 responded</p> <p>No data on exposure</p>   | <p>Work-related asthma symptoms: 132/3650</p> <p>Work-exacerbated asthma: 41/3650</p> <p>Occupational asthma: 33/3650</p> <p>Odds ratios for GA and ortho-phthalaldehyde combined; 95 % CI:</p> <ul style="list-style-type: none"> <li>• Work-related asthma symptoms: 2.18 (1.17 to 4.07)</li> <li>• Work-exacerbated asthma: 1.57 (0.58 to 4.27)</li> <li>• Occupational asthma: 1.03 (0.29 to 3.58)</li> </ul> | <p><b>No conclusions can be made with regard to a possible sensitization threshold.</b></p> <p>Asthma was related to GA exposure, but no information on exposure duration/level is available.</p>                       |

ANNEX 1 - BACKGROUND DOCUMENT TO RAC OPINION ON GLUTARALDEHYDE

| Study  | Study setup   | Result with regard to sensitizing effects   | Conclusions on sensitized/non-sensitized population   |
|--|---|---|---|
| Katagiri <i>et al.</i> , 2006                          | 31 exposed women; 101 unexposed control women<br>6 hospitals, 8 rooms with endoscope washing and disinfection<br>Geometric means: 1.3 to 19.6 ppb<br>Personal measurements: up to 94 and 85 ppb | Self-reporting (exposed vs. control):<br><ul style="list-style-type: none"> <li>• Asthma (2/31 vs. 0/101)</li> <li>• Cough (9/31 vs. 5/101)</li> <li>• Pharynx irritation (3/31 vs. 1/101)</li> <li>• Pain in the eyes (8/31 vs. 0/101)</li> </ul>        | The asthma results are based on self-reporting and are not trustworthy. Exposure to up to 94 ppb had taken place.<br><br><b>No conclusions can be made with regard to a possible sensitization threshold.</b> |
| Pechter <i>et al.</i> , 2005                           | Surveillance data from California, Massachusetts, Michigan, and New Jersey<br>No data on exposure   | GA exposure was associated with 8.9 % (27 cases) of work related asthma among health care workers during 1993-1997  | <b>No conclusions can be made with regard to a possible sensitization threshold.</b>  |
| McDonald <i>et al.</i> , 2000                          | SWORD project; UK: occupational physicians reporting voluntarily new cases of occupational asthma<br>No data on exposure  | Cases suspected to be due to GA:<br><ul style="list-style-type: none"> <li>• 30 (1989-1991)</li> <li>• 128 (1992-1994)</li> <li>• 133 (1995-1997)</li> </ul> GA was associated with 291 cases out of the estimated 7387 occupational asthma cases (3.9 %) | <b>No conclusions can be made with regard to a possible sensitization threshold.</b>  |
| BASF A6.14_04 Monitoring of laboratory personnel, 2007 | Pathology laboratory; GA used as fixative<br>Five employees with exposure to GA<br>0.17 ppb to 3.3 ppb<br>Maximum peak concentration 20 ppb   | No adverse health effects related to GA exposure reported during 20 years   | <b>The number of people affected was too low for conclusions with regard to a possible sensitization threshold.</b>   |
| Diar Bakerly <i>et al.</i> , 2008                      | Physicians in West Midlands, UK, reporting newly diagnosed cases of occupational asthma between 1991 and 2005<br>No data on exposure  | 1461 occupational asthma cases (85 % verified by confirmatory test; 94 % improved on holidays)<br>Glutaraldehyde associated with 84 cases (6 %)<br>Annual incidence of occupational asthma: 42/1000.000 in working population<br>No consistent time trend | <b>No conclusion with regard to possible threshold.</b><br>Asthma was associated with GA exposure, but no information on exposure duration/level is available.  |

ANNEX 1 - BACKGROUND DOCUMENT TO RAC OPINION ON GLUTARALDEHYDE

| Study                         | Study setup   | Result with regard to sensitizing effects   | Conclusions on sensitized/non-sensitized population  |
|-------------------------------|---|---|--|
| Liss <i>et al.</i> , 2011     | Retrospective analysis of successful claims filed 1998-2002 and classified as occupational asthma or work-exacerbated asthma in the health care sector<br>No data on exposure   | GA was given as the sensitizing agent in 3 of the 5 cases of occupational asthma<br>GA was given as the exposure agent in 1 of the 115 cases of work-exacerbated asthma<br>The record is assumed to be incomplete | <b>No conclusion with regard to possible threshold.</b><br>Asthma was associated with GA exposure, but no information on exposure duration/level is available. |
| Perdelli <i>et al.</i> , 2008 | GA concentration measurements in hospital rooms where instrument disinfection/washing took place<br>Maximum concentration 8 ppb<br>No personal samplers   | -   | <b>No conclusions can be made with regard to a possible sensitization threshold.</b>   |
| Leinster <i>et al.</i> , 1993 | GA concentration measurements during cold sterilisation and x-ray development in 6 hospitals, 14 locations in South East England<br>Personal samplers:<br><ul style="list-style-type: none"> <li>• Mean values 1.2 to 41 ppb</li> <li>• Range 0.73 to 41 ppb</li> </ul> | -   | <b>No conclusion with regard to possible threshold.</b>  |

## ANNEX 1 - BACKGROUND DOCUMENT TO RAC OPINION ON GLUTARALDEHYDE

| Study            | Study setup  | Result with regard to sensitizing effects  | Conclusions on sensitized/non-sensitized population  |
|------------------|--|--|--|
| Nayebzadeh, 2007 | Exposure to GA was measured in 19 locations, 5 hospitals<br>Personal sampling during 5 to 15 min<br>Work practices were classified and resulted in: <ul style="list-style-type: none"> <li>• "appropriate": mean 12 ppb, max 68 ppb</li> <li>• "poor": mean 51 ppb, max 150 ppb</li> <li>• "unsafe": mean 80 ppb, max 150 ppb</li> </ul> Quantity of GA used did not correlate with exposure<br>General ventilation systems were inefficient in controlling exposure, even at > 10 air changes/h | Irritant effects (eyes, nose) and headache correlated with work practices.<br>The study concerns exposure levels; sensitization was not studied. | <b>Conclusion: No conclusions can be made with regard to a possible sensitization threshold.</b> |

In the following short summaries of the studies listed in the table 16 are presented

### Manufacturing plant personnel

- **Teta M.J. et al., Absences of sensitisations and cancer increases among glutaraldehyde workers. Toxic Substance Mechanisms 14: 293-305, 1995.**

Plant medical records, work restrictions, and clinic visits for accidental exposures between 1959 and 1992 were reviewed to determine the incidence of skin sensitisation, respiratory sensitisation, and allergic blepharoconjunctivitis among 218 workers assigned to glutaraldehyde production or drumming at a Union Carbide plant in the U.S. A mortality analysis of workers assigned to glutaraldehyde production from its start-up to 1959 through 1988 was conducted, and cancer incidences were compared with local population. In addition to glutaraldehyde, the workers handled other chemicals including known sensitizers. Glutaraldehyde concentrations in the air during the measurement years 1977-1992 were consistently below the OELs at the time, time-weighted averages being 40 to 80 ppb (currently the lowest OEL is 50 ppb) and the highest measured concentration 340 ppb in 1990 (not including the data from 1982 where new methodology and measurement problems resulted in figures up to 12.11 ppm). There was no evidence of sensitisation for 199 workers (95 %); five had documented cases related to chemicals other than glutaraldehyde, and six (3 %) had symptoms that may have indicated sensitisation but were not attributable to a particular chemical. These symptoms occurred in the nose (sinus discomfort, irritation,

inflammation, bleeding), the eye (e.g. itching/irritation, conjunctivitis) and on the skin (rash and contact dermatitis). Some of these may have been related to accidental glutaraldehyde exposure. Some of the effects were considered as fungal infections, but the cause-effect relationship is unclear. Mortality and cancer incidence were lower than in the local control population. **Conclusion:** There was no clear evidence of sensitization to glutaraldehyde, and no effect was seen on cancer or mortality.

- **BASF report “Monitoring of manufacturing plant personnel”, 8 June 2007 (BASF A6.12.1\_01).**

In a manufacturing plant of BASF in Germany, no cases of adverse health effects related to glutaraldehyde exposure were reported during 15 years. In regular measurements over 20 years, the highest measured glutaraldehyde concentration in the air was 0.032 mg/m<sup>3</sup> (8 ppb). This data is based on the company statement whose reliability the RMS cannot evaluate. Conclusion: The very low exposure concentrations (up to 8 ppb) did not cause any adverse health effects. No further toxicological conclusions can be made due to the low concentrations to which workers have been exposed.

### **Cohort studies and case reports**

- **Palczyński et al., Occupational asthma and rhinitis due to glutaraldehyde: changes in nasal lavage fluid after specific inhalatory challenge test. Allergy 55: 1186-1191, 2001.**

Three study groups were compared: A) 11 health-care workers with occupational asthma assumed to be due to glutaraldehyde, B) 10 atopic patients with perennial asthma and rhinitis, and C) 10 healthy individuals. In an inhalatory challenge test with glutaraldehyde, subjects in group A were positive, and those in groups B and C negative. Groups B and C had no previous occupational exposure to glutaraldehyde. A “nasal pool” technique was used to evaluate the cellular response and the changes in eosinophil cationic protein (ECP; also known as ribonuclease 3) and mast-cell tryptase concentration in nasal lavage fluid before and after (30 min, 4 h and 24 h) an inhalatory provocation with glutaraldehyde and placebo. Results. In group A, there was a significant increase in the numbers and percentages of eosinophils (25-fold) and basophils (27-fold), and in ECP (23-fold) and mast cell tryptase (below LOQ before stimulus) concentrations. In groups B and C, there was a moderate increase in the basophil percentages (highest in group B, 3.5-fold), eosinophil percentages (highest in group B, 4-fold), while the response with regard to ECP and mast cell tryptase was either minimal or non-existent. Group A did not produce a response to placebo. Other possibly sensitising chemicals were not tested. Conclusion: Using two cellular and two molecular markers for allergy and asthma, the subjects that were assumed to have glutaraldehyde-induced occupational asthma reacted strongly to a glutaraldehyde challenge, while healthy controls and atopic patients with perennial asthma and rhinitis did not.

- **Gannon P.F.G. et al., Occupational asthma due to glutaraldehyde and formaldehyde in endoscopy and x ray departments. Thorax 50: 156-159, 1995. Dow 6.12.2(2); BASF 6.12.4\_05**

Eight workers were studied who had a history of asthmatic symptoms that improved when away from work, and had exposure to glutaraldehyde. They were investigated by measuring peak expiratory flow (PEF) with 2-hour intervals during 4 weeks, and using specific bronchial provocation tests using 0.9 % saline, 1 % formaldehyde and 2 % glutaraldehyde in the challenge. The diagnosis of occupational asthma was confirmed in seven workers, all of whom had PEF

records suggestive of occupational asthma and gave positive results in specific bronchial challenge tests to glutaraldehyde. Three of these gave positive results in the specific bronchial challenge to formaldehyde as well, while three others were negative and one was not tested. Two of those positive to formaldehyde used also formaldehyde at work. The mean level of glutaraldehyde in air during the challenge tests was 0.068 mg/m<sup>3</sup> (16 ppb), which is lower than the concentrations measured in 13 endoscopy suites but higher than in six x-ray darkrooms. During decantation in endoscopy suites, median short term levels were 0.16 mg/m<sup>3</sup> (39 ppb) with a range of 0.11 to 0.94 mg/m<sup>3</sup> (27 to 230 ppb). In darkrooms all the short term levels were below the apparent (not mentioned specifically) detection limit of 0.009 mg/m<sup>3</sup> (2.2 ppb). The duration of exposure to glutaraldehyde was 6 months to 23 years before the onset of symptoms suggestive of occupational asthma. It should be noted that there was no control group, and of the possible confounding substances used at work, only formaldehyde was tested in addition to glutaraldehyde. Conclusion: Seven workers had occupational asthma whose symptoms were triggered by glutaraldehyde.

- **Pisaniello et al.: Glutaraldehyde exposures and symptoms among endoscopy workers in South Australia. Appl. Occup. Environ. Hyg. 12: 171-177, 1997. Dow 6.12.4(4); BASF 6.12.4\_3**

Glutaraldehyde-exposed 135 endoscopy nurses and 132 unexposed nurses in the same hospitals were interviewed and their worksites were inspected. Inhalational exposure while using glutaraldehyde was determined and dermal exposure was assessed with skin pads. The measured overall geometric mean inhalational exposure concentration was 32 ppb, the highest mean of 93 ppb being in endoscopy areas with no local exhaust ventilation. Nurses exposed to glutaraldehyde reported more headache, lethargy and symptoms in the skin, eye and throat than the control group. The throat symptoms were mostly itching or tingling (10 vs. 4 % in the control group) and an unpleasant taste (9 vs. 3 %). No information is given on asthma or respiratory sensitization. Conclusion: Headache, lethargy and symptoms in the skin, eye and throat were connected with combined inhalation and dermal exposure to glutaraldehyde.

- **Di Stefano F. et al.: Glutaraldehyde: an occupational hazard in the hospital setting. Allergy 54:1105-1109, 1999.**

A group of 24 health care workers were identified with respiratory symptoms suggestive of occupational asthma due to glutaraldehyde exposure. Asthmatic symptoms were investigated with peak expiratory flow rate (PEFR) monitoring. During PEFR monitoring the glutaraldehyde concentrations in workplace air were measured by samplers worn by the operator. Short-term measurements gave a mean concentration of 0.21 mg/m<sup>3</sup> (51 ppb) and a range of 0.06 to 0.84 mg/m<sup>3</sup> (15 to 205 ppb). For eight of the subjects, the specific bronchial provocation test (SBPT) was performed with a mean glutaraldehyde concentration of 0.075 mg/m<sup>3</sup> (18 ppb; range 0.065-0.084 mg/m<sup>3</sup>), and all subjects gave a positive response indicating occupational asthma (late reaction in five and dual reaction in three subjects). In 13 out of the 16 remaining workers, the serial PEFR monitoring showed a work-related effect, while for three workers occupational asthma was not confirmed. Measurements of specific IgE antibodies to glutaraldehyde-modified proteins were positive in seven patients (29 %). The results are suggestive of glutaraldehyde being the causative agent of occupational asthma in the group of health care workers that were identified in a surveillance scheme. There was no control group and a direct cause-effect relationship cannot be demonstrated. Conclusion: Respiratory symptoms were suggestive of occupational asthma caused by glutaraldehyde. Occupational asthma was demonstrated by at least one of the methods in 21 out of 24 patients. Seven patients had glutaraldehyde-specific IgE antibodies, suggesting but not proving that occupational asthma was caused by glutaraldehyde.

- **Vyas et al.: Survey of symptoms, respiratory function and immunology, and their relation to glutaraldehyde and other occupational exposures among endoscopy nursing staff, Occupational and Environmental Medicine 57: 752-759, 2000**

Endoscopy nurses (348 nurses in 59 endoscopy units) in the United Kingdom and 18 ex-employees who had left their job for health reasons were surveyed. Any work-related symptoms were surveyed using questionnaires. Exposure measurements included personal airborne biocide sampling for peak and background concentrations. All ex-employees and 91 % of the current nurses were primarily exposed to glutaraldehyde, while the rest were exposed to a succinaldehyde-formaldehyde composite. Work related contact dermatitis was reported by 44 % of current workers exposed to glutaraldehyde and 44 % of ex-employees. The prevalence of work related symptoms in current glutaraldehyde exposed workers was 14 % for the eyes, 20 % for the nose, and 9 % for the lower respiratory tract, while these were all at least 50 % among the ex-employees. There were 30 current nurses with lower respiratory tract symptoms. For these, peak expiratory flow rates were recorded during one month and analysed using the OASYS-2 analysis program. The program revealed three cases of possible asthma, but re-evaluation of the data by two physicians concluded that none of these showed evidence of bronchial asthma. The RMS cannot verify these conclusions, which were also questioned in the journal as a response to the publication (BASF A6.12.4\_01a). The mean percentage of the predicted FEV1 was 104.5 % for the current workers with no lower respiratory tract symptoms and 99.3 % for those with lower respiratory tract symptoms; for ex-employees it was 93.8 %. Exposures were above the maximum exposure limit of 0.2 mg/m<sup>3</sup> (50 ppb) in eight of the units investigated. There was a clear relation between peak glutaraldehyde concentrations and work related chronic bronchitis and nasal symptoms but not to other symptoms. Conclusion: Glutaraldehyde caused clear irritant effects in the skin, eyes, nose and the lower respiratory tract, but asthma was not demonstrated. The results concerning asthma have been questioned in the journal where the article was published. There were few FEV1 results for the ex-employees but the significantly lower value for this group may be indicative of the reason for leaving the workplace where exposure to glutaraldehyde had occurred.

- **Stenton et al., Glutaraldehyde, asthma and work – a cautionary tale. Occup. Med. 44: 95-98, 1994. Dow 6.12.2(1); BASF 6.12.2\_01**

A single endoscopy nurse had symptoms of occupational asthma connected with glutaraldehyde exposure. An initial exposure was arranged by entering the workplace, resulting in a marked asthmatic response. Seven and eight months after cessation of glutaraldehyde exposure, two series of double-blind challenges were performed on nine different days each, using various glutaraldehyde concentrations and saline as control. Reactions to glutaraldehyde challenge were inconsistent, as measured from the forced expiratory volume. No clear immediate or late asthmatic reactions were seen in the second series, which was performed due to inconclusiveness of the first series. Conclusion: The initial assumption of glutaraldehyde clearly being the cause of occupational asthma was questioned. Glutaraldehyde was not excluded from being the causative agent, but it was shown that there is no clear evidence of it.

- **Curran A.D. et al., Clinical and immunologic evaluation of workers exposed to glutaraldehyde, Allergy 51: 826-832, 1996. Dow 6.12.2(3); BASF 6.12.4\_08**

Sera from 20 glutaraldehyde-exposed workers, 13 of whom had been diagnosed as having occupational asthma, and the control group of 21 unexposed workers were analysed for IgE antibodies in a radioallergosorbent test (RAST). Bovine and human serum albumin were modified

by incubating them with glutaraldehyde, and used in RAST. Positive results were defined as the control group mean proportion of binding plus  $2.5 \times$  standard deviation (99 % confidence level), and total IgE levels above 150 kU/l. There were however false positives at IgE levels above this limit, and therefore positive results could not be verified using the predefined conditions. When testing only the sera with less than 150 kU/l, the glutaraldehyde-exposed group had a significantly elevated binding percentage in the RAST analysis ( $p = 0.026$ ). The study failed to provide clear evidence of correlation between the specific analytical results and occupational asthma. This could at least partially be explained by the fact that 12 of the 20 patients had not been exposed to glutaraldehyde during at least 6 months prior to testing, which could have allowed the IgE levels to decrease. In further investigation of one of the patients, it was shown in a RAST inhibition assay that both GA-modified bovine and human serum albumin inhibited RAST binding, while there was no inhibition for two control sera. It was concluded that the one patient studied had specific IgE for GA-modified albumin despite the inability to clearly identify the asthma with the criteria on RAST and total IgE. No information is given on the workplace exposure concentrations. Conclusion: It was shown that a patient may have specific IgE antibodies while this is not evident in IgE testing.

- **Sutton P.M. et al., Glutaraldehyde exposures among workers making bioprosthetic heart valves. *Journal of Occupational and Environmental Hygiene* 4: 311-320, 2007.**

Exposure to glutaraldehyde was measured in two companies by personal air monitoring in a variety of tasks where glutaraldehyde exposure took place. In one company, the range of exposure concentrations in the air was 3 to 100 ppb, and in the other company it was from below the detection limit to 830 ppb. When sorted by different tasks, 40 % of the 58 different tasks involved exposure to more than 50 ppb glutaraldehyde in the air. The workers are reported to be continuously exposed to glutaraldehyde in the air during their work shift. During the 5-year period 1999 to 2003 there were 2 cases of new-onset work-related asthma associated with glutaraldehyde in these two companies, but this is reported to be likely to underestimate the true incidence. The tasks or presumed exposure levels of these two persons are not given. There were a total of 600 workers with potential exposure to glutaraldehyde.

- **Havics A.A. & Bucherl S., An evaluation of asthma risk due to glutaraldehyde at a medical device manufacturing facility. Unpublished/submitted for publication.**

Data was analysed from a company in California that produces bioprosthetic heart valves. Exposure data from years 1996 to 2005 indicated that personal 20-min samples and 240-min samples correlated poorly, as did also personal samples and area samples. The 20-min personal samples were considered more relevant as better representing peak exposures. The methodology of exposure measurements is not described. The values ranged from 1 ppb to 970 ppb, with yearly arithmetic means ranging from 29 to 232 ppb and medians of 12 to around 85 ppb. Altogether, 20 % of the 20-min samples were above 80 ppb and 5 % above 325 ppb. Only one substantiated case of work aggravated asthma was identified among the approximately 400 workers, and two further cases were insufficiently described or analysed to make conclusions (Cases 4 and 5). No cases of new-onset asthma were reported. The authors consider 325 ppb in the air as the threshold for no adverse effects for non-sensitised individuals and between 80 and 314 ppb for sensitized or pre-disposed individuals.

- **Waters A. et al., Symptoms and lung function in health care personnel exposed to glutaraldehyde. *American Journal of Industrial Medicine* 43: 196-203, 2003.**

## ANNEX 1 - BACKGROUND DOCUMENT TO RAC OPINION ON GLUTARALDEHYDE

Exposure to glutaraldehyde was measured in various tasks in endoscopy units and operating theatres in Australia. Nurses were selected among those who were exposed to glutaraldehyde (38) and those who worked in areas where glutaraldehyde was not used (38). These subjects answered questionnaires concerning symptoms, and their FVC (forced vital capacity) and FEV1 (forced expiratory volume in one second) were measured. Detailed information on glutaraldehyde concentrations in the air is not given. In all but one task the highest reading in the breathing zone exceeded 100 ppb, and the overall maximum was 150 ppb. The measuring system detected aldehydes and was not specific to glutaraldehyde.

There were modest reductions in cross-shift FEV1 (mean reduction 30 ml) and cross-shift FVC (mean reduction 50 ml) in the exposed group. Linear regression modelling suggested the peak exposure to be the only significant independent predictor of the reduction, while other possible factors such as duration of exposure or the total dose did not seem to have an effect. In the questionnaire only skin symptoms were clearly associated with glutaraldehyde exposure, and these were clarified to concern local effects in the hands and forearms. Sensitization or asthma was not considered.

- **Arif A.A. & Delclos T.L., Association between cleaning-related chemicals and work-related asthma and asthma symptoms among healthcare professionals. *Occupational & Environmental Medicine* 69 (1): 35-40, 2012.**

A questionnaire was sent to 5600 healthcare professionals, and 3650 responded. The information included asthma conditions that were divided into 1) work-related asthma symptoms, 2) work-exacerbated asthma, 3) occupational asthma and 4) none (mutually exclusive categories). The use and use frequencies of various substances as either cleaning agents or instrument disinfectants/sterilants were inquired. Of the 3650 responders, 132 reported work-related asthma symptoms, 41 work-exacerbated asthma and 33 occupational asthma. The odds ratio (OR) for glutaraldehyde and ortho-phthalaldehyde (OPA) combined was 2.18 (95 % confidence interval 1.17 to 4.07) for work-related asthma symptoms, 1.57 (0.58 to 4.27) for work-exacerbated asthma and 1.03 (0.29 to 3.58) for occupational asthma. The large confidence intervals of the latter two are explained by the relatively low numbers of responders reporting work-exacerbated or occupational asthma. The strongest effects were seen for bleach in cleaning (respective ORs of 3.72, 3.13 and 3.22) and chloramines in instrument cleaning/sterilation (3.81, 2.02 and 4.81). The study has obvious shortcomings due to self-reporting and because of an unavoidable healthy worker survival effect which is also seen as the lowest prevalence in the highest age quartile.

- **Katagiri H. et al., Indoor glutaraldehyde levels in the endoscope disinfecting room and subjective symptoms among workers. *Industrial Health* 44: 225-229, 2006.**

Exposure to glutaraldehyde in the air was measured at 6 hospitals in a total of 8 rooms where endoscope washing and disinfection took place. The subjective symptoms of 31 exposed women were compared to those of 101 unexposed control women using a questionnaire. Glutaraldehyde concentrations in the air had geometric means of 1.3 to 19.6 ppb, while personal measurements showed exposure levels of up to 94.2 and 84.9 ppb during the changing of the glutaraldehyde solution in the automatic washers. This high-exposure task is performed every 2 to 4 weeks. The women that were exposed to glutaraldehyde reported a variety of symptoms more frequently than those in the control group. These included asthma (2/31 vs. 0/101 in the control group), cough (9/31 vs. 5/101), pharynx irritation (3/31 vs. 1/101) and pain in the eyes (8/31 vs. 0/101). No attempts were made to clarify or verify the claimed symptoms.

- **Koda S. et al., Environmental monitoring and assessment of short-term exposures to hazardous chemicals of a sterilization process in hospital working environments. Acta Med Okayama 53 (5): 217-223, 1999.**

Glutaraldehyde concentrations in the air were measured in two hospitals in Japan. The detection limit was 200 ppb, and concentrations higher than this were only recorded in an endoscope unit lacking general ventilation. The two interviewed workers in the endoscope unit complained of headache and irritated eyes, nose and throat.

### **Surveillance data**

- **Pechter E. et al., Work-related asthma among health care workers: surveillance data from California, Massachusetts, Michigan, and New Jersey, 1993-1997. American Journal of Industrial Medicine 47: 265-275, 2005.**

Surveillance data that was collected on a mandatory basis from California, Massachusetts, Michigan, and New Jersey revealed 1879 diagnosed cases of work related asthma, 305 of these being health care workers. Among the health care workers, 27 cases (8.9 %) were reported to be related to glutaraldehyde while 5 % were related to formaldehyde. Glutaraldehyde was the substance most commonly reported after “cleaning products” and “natural rubber latex”. There was no information on the tests performed in each case. Conclusion: Glutaraldehyde exposure was associated with 8.9 % of work related asthma among health care workers.

- **McDonald J.C. et al., Reported incidence of occupational asthma in the United Kingdom, 1989-97, Occup. Environ. Med 57: 823-829, 2000.**

In the SWORD (Surveillance of Work Related and Occupational Respiratory Disease) project in the UK, chest and occupational physicians reported voluntarily new cases of occupational asthma. The number of cases suspected to be due to glutaraldehyde were 30 (1989-1991), 128 (1992-1994) and 133 (1995-1997). Reporting was voluntary and was based on the expert opinion of the physician, without any attempts to verify the causes of asthma in the reported cases. Conclusion: This study gives an indication of the frequency of occupational asthma that is connected with glutaraldehyde exposure, but does not give any evidence of causality.

- **BASF report “Monitoring of laboratory personnel”, 8 June 2007 (BASF A6.14\_04).**

Glutaraldehyde concentrations were measured in a pathology laboratory where glutaraldehyde is routinely used as a fixative. Judging by the data available, the concentrations in the air mostly ranged between 0.0007 and 0.014 mg/m<sup>3</sup> (0.17 ppb to 3.3 ppb), with maximum peak concentration of 0.085 mg/m<sup>3</sup> (20 ppb). No cases of adverse health effects related to glutaraldehyde exposure were reported during 20 years. Conclusion: The very low exposure concentrations did not cause any adverse health effects. No further toxicological conclusions can be made due to the low concentrations to which workers have been exposed.

- **Diar Bakerly N. et al., Fifteen-year trends in occupational asthma: data from the Shield surveillance scheme. Occupational Medicine 58: 169-174, 2008.**

Physicians in West Midlands, UK, were asked to provide details of newly diagnosed cases of occupational asthma. There were 1461 cases reported between 1991 and 2005, of which 85 % were verified by a confirmatory test and 94 % were reported to improve on holidays. The annual

incidence of occupational asthma was 42 per million in the working population, and there was no consistent trend in the incidence over time. Glutaraldehyde was associated with 84 of the cases (6 %).

- **Liss G.M. et al., Work-related asthma in health care in Ontario. American Journal of Industrial Medicine 54: 278-284, 2011.**

A retrospective analysis was made of the successful claims filed between 1998 and 2002 to the Workplace Safety & Insurance Board (WSIB) and classified as occupational asthma or work-exacerbated asthma in the health care sector. There were 5 cases of sensitizer-induced occupational asthma and 115 cases of work-exacerbated asthma. Glutaraldehyde was given as the sensitizing agent for 3 of the 5 occupational asthma cases, one of these classified as 'possible' and two as 'definite'. For work-exacerbated asthma, glutaraldehyde was given as the exposure agent in only one of the 115 cases. The authors mention several reasons why the record might be incomplete: it contains those cases that the claimant has been willing to file, and the requested information and possible examinations have been successfully performed.

### Other information

- **Perdelli F. et al., Evaluation of environmental contamination by glutaraldehyde in an outpatient facility for digestive endoscopy in an Italian hospital, International Journal of Environmental Health Research 18(1): 73-78, 2008.**

Glutaraldehyde concentrations in the air were measured in a hospital in static positions in the centre of each room at normal breathing height. Glutaraldehyde was detected in rooms where instrument disinfection and washing took place. These activities resulted in similar concentrations in the air, and the highest concentration measured was 0.0327 mg/m<sup>3</sup> (8.0 ppb). This study suffers from the lack of personal samplers and thus localised higher glutaraldehyde concentrations may have occurred. No connection is made between the exposure and any health effects.

- **Leinster P. et al., An assessment of exposure to glutaraldehyde in hospitals: typical exposure levels and recommended control measures, British Journal of Industrial Medicine 50: 107-111, 1993.**

Glutaraldehyde concentrations in the air during cold sterilisation and x-ray development were measured in six hospitals and a total of 14 locations in South East England. Using personal samplers, the mean concentrations were between 0.005 and 0.17 mg/m<sup>3</sup> (1.2 and 41 ppb) and the overall range was 0.003 to 0.17 mg/m<sup>3</sup> (0.73 to 41 ppb) although the highest value is not available as the range is not given for the activity producing highest air concentrations (cleaning suction bottles). When static monitoring was used, the mean concentrations were at the same range and the maximum concentration was 0.23 mg/m<sup>3</sup> (56 ppb). In 9 out of the 14 locations there was no mechanical ventilation, and windows were closed in all 14 locations.

- **Nayebzadeh A., The effect of work practices on personal exposure to glutaraldehyde among health care workers, Industrial Health 45: 289-295, 2007.**

Air samples were taken in 19 locations in five hospitals in the breathing zone by personal sampling to measure exposure to glutaraldehyde during 5 to 15 min. The work practices were monitored and classified as "appropriate", "poor" and "unsafe", and resulted in mean exposure rates of 12, 51 and 80 ppb, and maximum concentrations of around 68, 150 and 150 ppb, respectively. Irritant effects (burning or itchy eyes; itchy nose) and headache were found to correlate with the work practices

and consequently with peak exposure to glutaraldehyde. Correlation could not be established between work practices and cough/sneezing/runny nose. Although there was no control group without exposure to glutaraldehyde, it should be noted that even in the group with "appropriate" work practices 14 of the 27 cases reported headache and 11-22 % reported various irritant effects (but it is not mentioned whether e.g. "burning eyes" and "itchy eyes" were mutually exclusive categories). The quantity of glutaraldehyde solution used did not correlate with exposure. General ventilation systems were inefficient in controlling the exposure rates even when there were more than 10 air changes per hour. Local exhaust ventilation is recommended. Conclusion: Work practices determine the exposure rate to a large extent, while even appropriate practices may result in exposure rates above the OEL of 50 ppb. The quantity of glutaraldehyde solution or the efficiency of general ventilation do not correlate with exposure.

### **4.6.2.3 Summary and discussion of respiratory sensitisation**

Both animal and human evidence imply that glutaraldehyde is respiratory sensitizer. However, despite the abundance of data on respiratory sensitisation potential of glutaraldehyde, a number of uncertainties remain with respect to both the actual concentrations that have caused sensitization and the frequency of sensitization among the exposed populations. In general the data indicates that only a small proportion of the exposed population develop sensitization, and that sensitization seems to occur where relatively high GA concentrations have been detected (see Gannon et al., 1995; Di Stefano et al., 1999; Sutton et al., 2007; Waters et al., 2003). This interpretation is in line with the current understanding that there is a dose-response relationship for respiratory sensitization.

Also one case of sensitization after exposure to a very low GA concentration has been described (Gannon et al., 1995). An X-ray secretary was reportedly exposed to GA only through newly developed X-ray films, and reacted equally to GA and to formaldehyde in a special bronchial provocation test. No GA concentration measurements were made, and the workspace was not described (ventilation, proximity to the darkroom, etc.). Furthermore, it should be noted that respiratory hypersensitivity may also follow from a dermal challenge (see e.g. REACH Guidance on Information Requirements and Chemical Safety Assessment; Chapter R.7a), which might be the case here. Overall there is insufficient information to consider this as an example of a very low GA concentration in the air causing sensitization. In conclusion, no verified sensitization cases have been found where peak GA concentration in the air would have been below around 20-30 ppb.

It is considered likely that sensitization to glutaraldehyde is to a large extent connected to the peak exposure rates. Conversely, exposure to low concentrations of GA will most probably rarely lead to sensitization. The available studies where exposure has been low and no sensitization has occurred (see e.g. BASF A6.12.1\_01; BASF A6.14\_04) concern few human subjects and do not allow the conclusion that these GA levels were to be considered as safe. Other studies (e.g. Teta et al., 1995) have failed to identify the sensitizing agent, but this does not allow the conclusion that GA was not responsible for any of the cases.

The available evidence supports the general principle that sensitization occurs in workplaces where high exposure rates take place either regularly or as high peak concentrations. The available data seem to suggest that where sensitization has occurred, exposure has occurred to at least 20-30 ppb, and often much higher.

There is also mounting evidence of occupational asthma among health care workers, and this is often connected with glutaraldehyde exposure (e.g. Pechter et al. 2005, McDonald et al. 2000). The studies show that a number of health care workers that have been exposed to glutaraldehyde become asthmatic and the symptoms are triggered by glutaraldehyde (e.g. Gannon et al. 1995, Di

Stefano et al. 1999, Pałczyński et al. 2001). There are however also counterarguments and one report (Stenton et al. 1994) describes a single case where initial strong opinion on glutaraldehyde-triggered asthma fails to be demonstrated either correct or incorrect. The question is therefore whether the evidence is sufficient to demonstrate that glutaraldehyde is a causative agent in the cases where asthmatic symptoms are triggered by glutaraldehyde.

Glutaraldehyde appears to be one of the known substances for which molecular diagnosis of asthma cannot easily be based on specific IgE measurements due to poor correlation with clinical symptoms. One of the studies (Curran et al. 1996) showed that a glutaraldehyde-related asthma patient with IgE levels too low for diagnosis nevertheless had specific IgE to glutaraldehyde-modified proteins. This is however only indicative evidence and firm conclusions cannot be based on this study.

Nasal lavage fluids were analysed for several asthma indicators after glutaraldehyde challenge (Pałczyński et al. 2001). Eosinophils and basophils are granulocytes that respond to parasitic infections, and are also associated with allergy and asthma. Following activation by an immune stimulus, eosinophils degranulate and release cytotoxic proteins, including eosinophil cationic protein (ECP). Increased levels of ECP are associated with inflammation and asthma. Serum ECP measurement is used for assessing asthma severity. Mast cell tryptase is a serine proteinase that is used as a marker of mast cell activation and is involved with allergic response. A significant increase was found in the numbers and percentages of eosinophils and basophils, as well as in the concentrations of ECP and mast cell tryptase. The difference was statistically significant when compared to the reactions of healthy controls and of atopic patients with perennial asthma and rhinitis, and to the study group reactions to placebo. All cellular and molecular indicators for asthma were therefore very clearly elevated as a response to glutaraldehyde challenge, while atopic patients showed a mild reaction.

There could be two explanations to the findings presented above: either glutaraldehyde causes asthma or another substance causes asthma and glutaraldehyde is capable of triggering an asthmatic response once asthma has been induced. Health care workers are exposed to a number of chemicals that might cause sensitisation, and it cannot be excluded that glutaraldehyde might trigger asthmatic symptoms even if asthma was not caused by glutaraldehyde. The DS considers that this explanation is unlikely to explain all the demonstrated cases for the following reasons: 1) glutaraldehyde is associated with a large portion of the asthmatic symptoms among the health care workers (Pechter et al. 2005, McDonald et al. 2000), 2) the most closely related chemical that also produces asthmatic symptoms is formaldehyde, and cross-reactivity appears to exist only in few cases (e.g. Gannon et al. 1995), and 3) none of the ten atopic patients reacted to glutaraldehyde challenge, nor gave a weak response that was not comparable to that of the main test group (Pałczyński et al. 2001). The lack of cross-reactivity between glutaraldehyde and formaldehyde has also been demonstrated in skin sensitisation (Shaffer & Belsito 2000). In conclusion, the DS considers that although it is conceivable that glutaraldehyde could have been a triggerer of symptoms of the asthma patients, it is likely that glutaraldehyde is also a causative agent.

#### **4.6.2.4 Comparison with criteria**

According to the CLP Regulation substances shall be classified as respiratory sensitisers in category 1 if there is evidence in humans that the substance can lead to specific respiratory hypersensitivity; and /or if there are positive results from an appropriate animal test. According to the 2<sup>nd</sup> ATP of the CLP Regulation (286/2011) sub-categorization of the substances in sub-category 1A (strong sensitizers) or in sub-category 1B (other respiratory sensitisers) shall be carried out if there is

sufficient data. Substances classified into 1A should show a high frequency of occurrence in humans; or a probability of occurrence of a high sensitisation rate in humans based on animal or other tests. Severity of reaction may also be considered. Substances classified into 1B should show a low to moderate frequency of occurrence in humans; or a probability of occurrence of a low to moderate sensitisation rate in humans based on animal or other tests. Severity of reaction may also be considered. At present there are no recognized and validated animal models for the testing of respiratory hypersensitivity. Under certain circumstances data from animal studies may provide valuable information in a weight of evidence assessment.

According to the draft updated version of the CLP guidance on application of criteria, there is currently no clear way of establishing sub-categories for respiratory sensitisation. However, if there were compelling evidence available such as observations in the workplace it may be possible to determine a sub-category. Furthermore, classification into sub-categories is only allowed if data are sufficient, and care should be taken when classifying substances into category 1B when category 1A cannot be excluded.

DS is of the view that in the light of the presented data, the criteria described above mean that the evidence is sufficient for classification of glutaraldehyde for respiratory sensitisation but not for sub-categorisation. The potential for respiratory sensitisation has not been directly demonstrated, but the overall evidence is based on 1) the mouse IgE test (Dow A6.1.5/02), 2) human data showing asthma in relation to glutaraldehyde exposure and 3) the known skin sensitisation.

Despite the abundance of data on respiratory sensitisation potential of glutaraldehyde, a number of uncertainties remain with respect to both the actual concentrations that have caused sensitization and the frequency of sensitization among the exposed populations. Although the presented human data might be considered pointing towards subcategory 1B, strictly speaking category 1A cannot be excluded and thus sub-categorization is not possible.

#### **4.6.2.5 Conclusions on classification and labelling**

Glutaraldehyde is currently classified as Resp Sens. 1; H334 under the CLP Regulation. No change is proposed to the existing classification since classification into sub-categories is not possible. Under DSD glutaraldehyde is currently classified as R42 and no change is proposed to the existing classification.

In conclusion, it is proposed to classify glutaraldehyde as follows:

**CLP: Resp. Sens. 1; H334**

**DSD: R42**

#### **4.7 Repeated dose toxicity**

Not evaluated in this dossier.

#### **4.8 Specific target organ toxicity (CLP Regulation) – repeated exposure (STOT RE)**

Not evaluated in this dossier.

**4.9 Germ cell mutagenicity (Mutagenicity)**

Not evaluated in this dossier.

**4.10 Carcinogenicity**

Not evaluated in this dossier.

**4.11 Toxicity for reproduction**

Not evaluated in this dossier.

**4.12 Other effects**

Not evaluated in this dossier.

## **5 ENVIRONMENTAL HAZARD ASSESSMENT**

Environmental fate properties and environmental hazard assessment are based on studies and summaries belonging to the assessment of glutaraldehyde under Directive 98/8/EC performed by the Finnish Competent Authority as part of the Review Programme. The Document II-A (Draft, June 15<sup>th</sup>, 2012) of the Competent Authority Report (CAR), and study summaries (belonging to the Document III-A of the CAR) concerning the most relevant studies in terms of environmental hazard classification, are provided in section 13 of the IUCLID file.

## 5.1 Degradation

**Table 23: Summary of relevant information on degradation**

| Method  | Results   | Remarks  | Reference                    |
|---|---|--|------------------------------|
| Hydrolysis<br>US EPA FIFRA N 161-1<br>GLP.  | DT <sub>50</sub> (12 °C): pH 5 = 1437 d, pH 7 = 288 d, pH 9 = 130d<br>Hydrolytically stable in environmentally relevant conditions  |  | Jalali-Araghi et al. (1992a) |
| Hydrolysis. US EPA FIFRA N 161-N<br>GLP   | DT <sub>50</sub> (12 °C), pH 5 = 1777 d, pH 7 = 1115 d, pH 9 = 180 d<br>Hydrolytically stable   |  | Levine (1991)                |
| Photolysis<br>US EPA FIFRA 161-2<br>GLP. Direct phototransformation   | DT <sub>50</sub> 196 d<br>Photolytically stable at pH 5   | DT <sub>50</sub> in dark 355 d   | Jalali-Araghi et al. 1992b   |
| Biological degradation<br>OECD guideline 301 A<br>GLP   | Readily biodegradable   |  | Schaefer (2000)              |
| Biological degradation<br>OECD guideline 301 A<br>GLP.  | Readily biodegradable   |  | Taeger (1993)                |
| Biodegradation in seawater<br>OECD 306<br>GLP   | Potential to biodegrade in the marine environment   |  | Doi (2000)                   |
| Biodegradation in seawater<br>ISO 16221<br>GLP  | Potential to biodegrade in the marine environment   |  | Schwarz (2002)               |
| US EPA Pesticide Assessment N 162-4<br>GLP<br><br>Water/Sediment Simulation Study.<br>Addition of <sup>14</sup> C-glutaraldehyde. | Water:<br>DT <sub>50</sub> 10.6 h (25 °C)<br>DT <sub>50</sub> 1.25 d (12 °C)<br><br>For the whole water-sediment system, degradation DT <sub>50</sub> was 11 h (25 °C). A part of the added <sup>14</sup> C was found in the sediment phase and was counted as glutaraldehyde in the calculation of degradation rate. | Mineralization 67.9% (based on <sup>14</sup> CO <sub>2</sub> production).                          | Esser (1994a)                |
| US EPA Pesticide Assessment N 162-3<br>GLP<br>Water/Sediment Simulation Study<br>Addition of <sup>14</sup> C-glutaraldehyde.      | Water:<br>DT <sub>50</sub> 7.7 h (25 °C)<br>DT <sub>50</sub> 0.91 d (12 °C)   | Primary biodegradation. Three metabolites identified. CO <sub>2</sub> production was insignificant | Esser (1994b)                |

**Table 24: Summary of biological degradation tests**

| Guide-line /Test method             | Test type                      | Test parameter                                       | Inoculum             |  |            | Additional substrate | Test substance conc.    | Degradation       |  | Reference       |
|-------------------------------------|--------------------------------|--|----------------------|--|------------|----------------------|-------------------------|-------------------|--|-----------------|
|                                     |                                |  | Type                 | Conc   | Adaptation |                      |                         | Incubation period | Degree [%]                               |                 |
| OECD 301A GLP                       | Ready biodegradability         | DOC  | Activated sludge     | 20.6 mg solids/L (2.21 x 10 <sup>5</sup> CFU/mL) | No         | No                   | 15 mg TOC/L             | 9 d               | 73%                                      | Schaefer (2000) |
| OECD 301A GLP                       | Ready biodegradability         | DOC  | Activated sludge     | 30 mg suspended solids/L                         | No         | No                   | 20 mg DOC/L             | 28 d              | 90-100%                                  | Taeger (1993)   |
| OECD 306 GLP                        | Biodegradation in seawater     | BOD  | Sea-water            | 1.34 x 10 <sup>3</sup> CFU/mL                    | No         | No                   | 3 mg /L                 | 28 d              | 73.4%                                    | Doi (2000)      |
| ISO 16221 GLP                       | Biodegradation in seawater     | CO <sub>2</sub>                                      | Sea-water            | 1494 mL sea water/ test vessel                   | No         | No                   | 10 mg TOC/L             | 70 d              | 90-100%                                  | Schwarz (2002)  |
| US EPA Pesticide Assessment N 162-4 | Aerobic water/sediment test    | Radioactivity (added <sup>14</sup> C-glutaraldehyde) | River water/sediment | 20gdw sediment , 100 ml water                    | No         | No                   | 9.45 µg/l (water phase) | 30 d              | 100% (mainly due to mineralisation)      | Esser (1994a)   |
| US EPA Pesticide Assessment N 162-3 | Anarerobic water/sediment test | Radioactivity (added <sup>14</sup> C-glutaraldehyde) | River water/sediment | 20gdw sediment , 100 ml water                    | No         | No                   | 9.45 µg/l (water phase) | 123 d             | 100% (mainly due to primary degradation) | Esser (1994b)   |

### 5.1.1 Stability

#### Abiotic degradation

#### Hydrolysis

##### References:

Levine AM 1991. Hydrolysis of 14 C-Glutaraldehyde in aqueous solutions buffered at pH 5, 7 and 9. Centre for Hazardous Materials Research, Pittsburgh, Laboratory Project ID 003/0037001/89. GLP, Unpublished.

Jalali-Araghi, K., Ruzo, L.O. and Shepler, K. 1992a. Hydrolysis of [1,5-14C] glutaraldehyde at pH 5, 7 and 9 PRTL West, Inc. K-020301-016

Glutaraldehyde was stable to hydrolysis or hydrolysed slowly at pH 5 and pH 7 at room temperature (DT<sub>50</sub> 102-628 d at 25°C and 288-1777 d at 12°C). None of the hydrolysis products exceeded 10% of applied radioactivity. Hydrolysis was faster at higher temperature and pH. The hydrolytical half-life of glutaraldehyde was 46-64 d at pH 9 at 25°C (130-180 d at 12°C). One hydrolysis product accounting more than 10% of applied radioactivity was formed in both studies at pH 9. The hydrolysis rate constants and half-lives were calculated assuming pseudo-first order kinetics. The studies are summarized in Table 25.

**Conclusion:** Glutaraldehyde is hydrolytically stable in the environmentally relevant conditions.

**Table 25: Hydrolysis**

| Guideline / Test method  | pH | Temperature [°C] | Initial TS concentration, C <sub>0</sub> | Reaction rate constant, K <sub>h</sub> [d] | Half-life, DT <sub>50</sub> [d] (12°C) | Coefficient of correlation, r <sup>2</sup> | Reference                    |
|--------------------------|----|------------------|--|--|--|--|------------------------------|
| US EPA FIFRA N 161-1 GLP | 5  | 24.5-25.5        | 0.1 mmol/L (10 mg/L)                     | 4.82 x 10 <sup>-4</sup>                    | 1437                                   | 0.74                                       | Jalali-Araghi et al. (1992a) |
|                          | 7  |                  |  | 2.41 x 10 <sup>-3</sup>                    | 288                                    | 0.78                                       |                              |
|                          | 9  |                  |  | 5.33 x 10 <sup>-2</sup>                    | 130                                    | 0.84                                       |                              |
| US EPA FIFRA N 161-1 GLP | 5  | 25               | 111.47 ppm                               | 3.90 x 10 <sup>-4</sup>                    | 1777                                   | 0.0966*                                    | Levine (1991)                |
|                          | 7  |                  | 109.39 ppm                               | 6.22 x 10 <sup>-4</sup>                    | 1115                                   | 0.3222*                                    |                              |
|                          | 9  |                  | 109.09 ppm                               | 3.85 x 10 <sup>-3</sup>                    | 180                                    | 0.9670                                     |                              |

\* In the Competent Authority Report according to Directive 98/8/EC, the following footnote is presented: "As the correlation coefficients correlate the change in the dependent variable with a corresponding change in the independent variable, it is not a reliable statistic to use for lines with low slopes. Therefore, this correlation coefficient should not be interpreted to mean the data are unreliable".

## Photolysis

Reference:

Jalali-Araghi, K., Ruzo, L.O. and Shepler, K. 1992b. Sunlight photodegradation of [1,5-14C] glutaraldehyde in a buffered aqueous solution at pH 5. PTRL West, Inc. K-020301-014

Glutaraldehyde did not degrade appreciably in a buffer system at pH 5. The half-lives of glutaraldehyde at 25°C were extrapolated for light exposed and dark samples and were 196 days and 355 days, respectively. The study is summarized in Table 26.

**Conclusion:** Glutaraldehyde is photolytically stable in aqueous solutions in the environmental relevant conditions.

**Table 26: Photolysis in water**

| Guideline / Test method | Initial molar TS concentration | Total recovery of test substance [% of appl.a.s.] | Photolysis rate constant ( $k_p^c$ ) | Direct photolysis sunlight rate constant ( $k_{pE}$ ) | Reaction quantum yield ( $\phi_{E}^c$ ) | Half-life ( $t_{1/2E}$ )  | Reference                    |
|-------------------------|--------------------------------|---|--------------------------------------|---|---|---|------------------------------|
| US EPA FIFRA 161-2 GLP  | 0.1 mmol/L (10 mg/L)           | 94.4±2.8% (overall material balance)              | 4.09 x 10 <sup>-3</sup>              | Not determined  | Not determined                          | Light-exposed samples = 196 days ( $R^2 = 0.861$ )<br>Dark samples = 355 days ( $R^2 = 0.688$ ) | Jalali-Araghi et al. (1992b) |

## Photo-oxidation in air

If glutaraldehyde is present in ambient air it is expected to exist to a great extent in the vapour phase, based on a vapour pressure of 44 Pa at 20°C (Table 11). Therefore photochemical reactions in air may be important. No experimental information is available for glutaraldehyde on photodegradation in air. The rate constant for the atmospheric, gas-phase reaction between photochemically produced hydroxyl radicals and organic chemicals was estimated using the model EPIWIN Version 3.20 including Aopwin (Atmospheric Oxidation Program) Version 1.92 (Environmental Protection Agency). The estimation methods used by the Aopwin are based upon the structure-activity relationship (SAR) methods. The Atkinson calculation method sums up the reactivity towards OH radicals of all structural elements. Using a 24-hours day and a mean daily OH concentration of 5.0 x 10<sup>5</sup> OH/cm<sup>3</sup> a half-life of 8.2 hours was assessed (overall OH rate constant: 46.89 E-12 cm<sup>3</sup>/molecule sec).

The rapid reactivity of glutaraldehyde in the atmosphere indicated by SAR results is also supported by analogy with the homologous dialdehyde glyoxal (photolytic half-life in air: 0.7 d). Glutaraldehyde would be expected to degrade rapidly by photolytic reaction in air. Since the glutaraldehyde absorbs ultraviolet radiation maximally at wavelength of 280 nm this is the most important wavelength area for the direct photolysis of glutaraldehyde in the atmosphere.

**Conclusion:** Since the photochemical half-life of glutaraldehyde in air is 8.2 hours it is expected to degrade rapidly by photolytic reaction in air.

## 5.1.2 Biodegradation

### 5.1.2.1 Biodegradation estimation

Experimental data is available and therefore estimation is not needed.

### 5.1.2.2 Screening tests

Ready biodegradability of glutaraldehyde was demonstrated in two tests performed according to OECD 301A. This test is considered appropriate as glutaraldehyde is not expected to evaporate from aqueous solution due to its high water solubility ( $\geq 51.3$  g/100 ml) and low Henry's law constant ( $0.0086$  Pa m<sup>3</sup> mol<sup>-1</sup>). OECD 301 guideline (page 5) states: "Unless adsorption of the test substance has been ruled out beforehand, tests which measure biodegradation as the removal of DOC, especially with activated sludge inocula, should include an abiotic control which is inoculated and poisoned". According to the adsorption test (see chapter 5.2.1) glutaraldehyde is mobile in sandy sediment and moderately mobile in soils. One of the two ready biodegradability tests reviewed here included an abiotic control, which is expected to show the potential for adsorption to activated sludge during the experiment.

#### Test 1:

Reference: Schaefer 2000. Ucarcide 250 Antimicrobial: Ready biodegradability by the dissolved organic carbon die-away test method, Wildlife International Ltd. DR-0222-1070-027

The biodegradability of glutaraldehyde (UCARCIDE® 250 antimicrobial, Batch number IS 782609; 50.9% glutaraldehyde, remainder water, impurities listed in confidential IUCLID) was tested using activated sludge from a municipal wastewater treatment plant as inoculum. Glutaraldehyde was applied at concentration of 15 mgTOC/L (OECD 301 requirement 10-40 mgDOC/l). Sodium benzoate was used as a reference substance at a concentration of 15 mgTOC/L. Inoculum blank test was also conducted and it was used to subtract the DOC concentration due to inoculum alone from those of the test and reference substances. The cell density of bacteria in the inoculum was  $3.3 \times 10^6$  (CFU/ml) (307 mg solids/L). Abiotic control assay was not performed.

Three test vessels per concentration were used (test volume = 2L). An aqueous mineral salts medium was used for the preparation of test suspensions to provide nutrients and trace elements. Test vessels were not closed. The test batches were stirred/mixed on 15-minute on-off cycles. pH of 7.1-7.2 is reported as test condition; however, it is not mentioned at which time point it was measured and whether pH changed during the experiment. The incubation temperature was 18 – 21 °C. There were small deviations from the test guideline concerning, e.g., pH and temperature, but these were not considered critical. DOC concentration was measured at 0, 1, 2, 3, 4, 5, 6, 9 days using a Shimadzu analyzer or equivalent and, for each sample, the average for duplicate analyses was reported. The percent degradation of test material based on DOC removal was determined.

The results are presented in Figure 2. An average of 13% DOC removal was observed on day 2. The DOC levels in the test material decreased markedly during days 3-5 and remained constant thereafter until the end of experiment (day 9). The biological degradation of glutaraldehyde was 74% after 9 days of incubation. Therefore, the pass level (70% of DOC removal within the 10 day window) was reached.

The reference substance, sodium benzoate, was utilised effectively as there was a 96% DOC removal in less than 9 days, indicating sufficient activity of the inoculum.

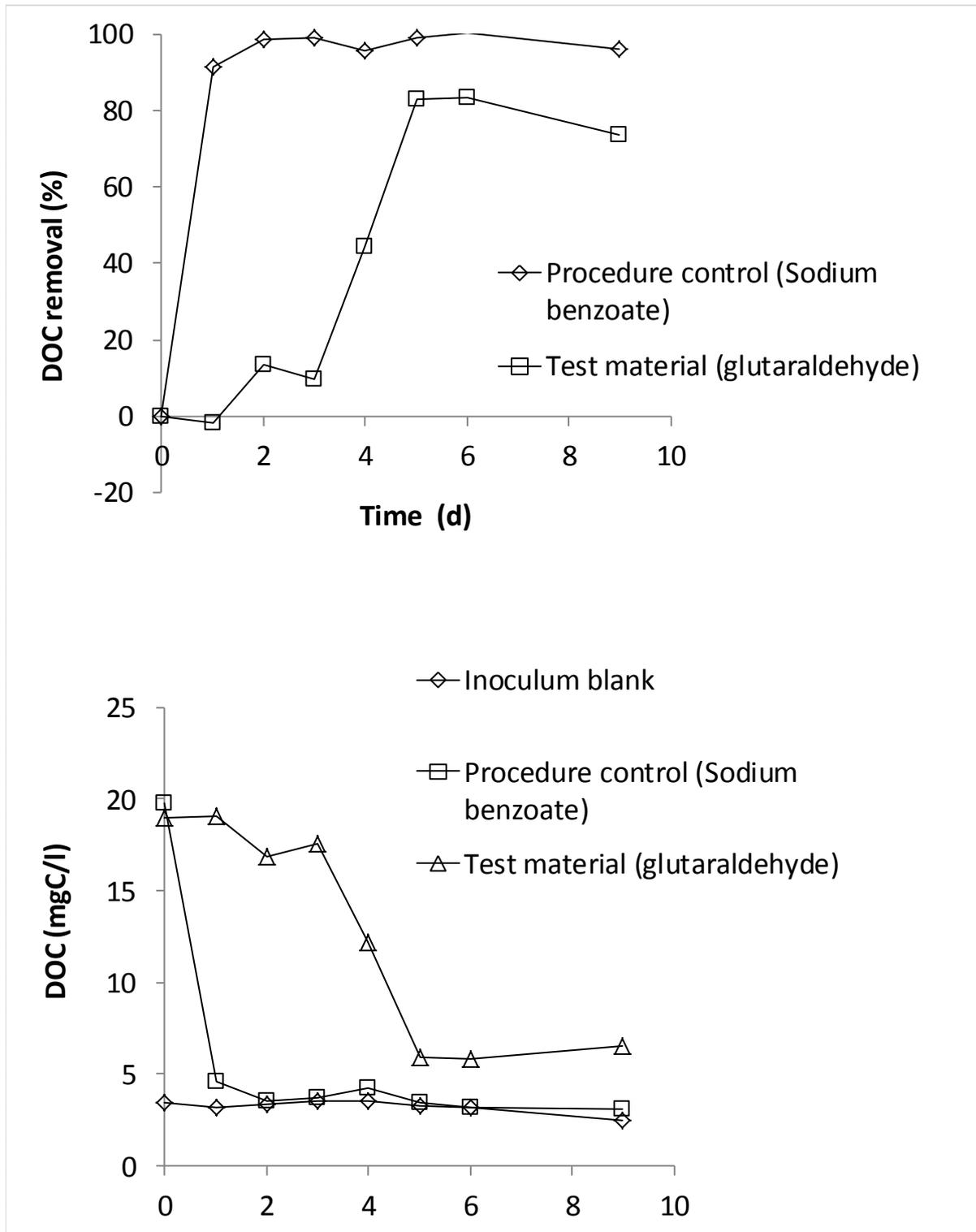


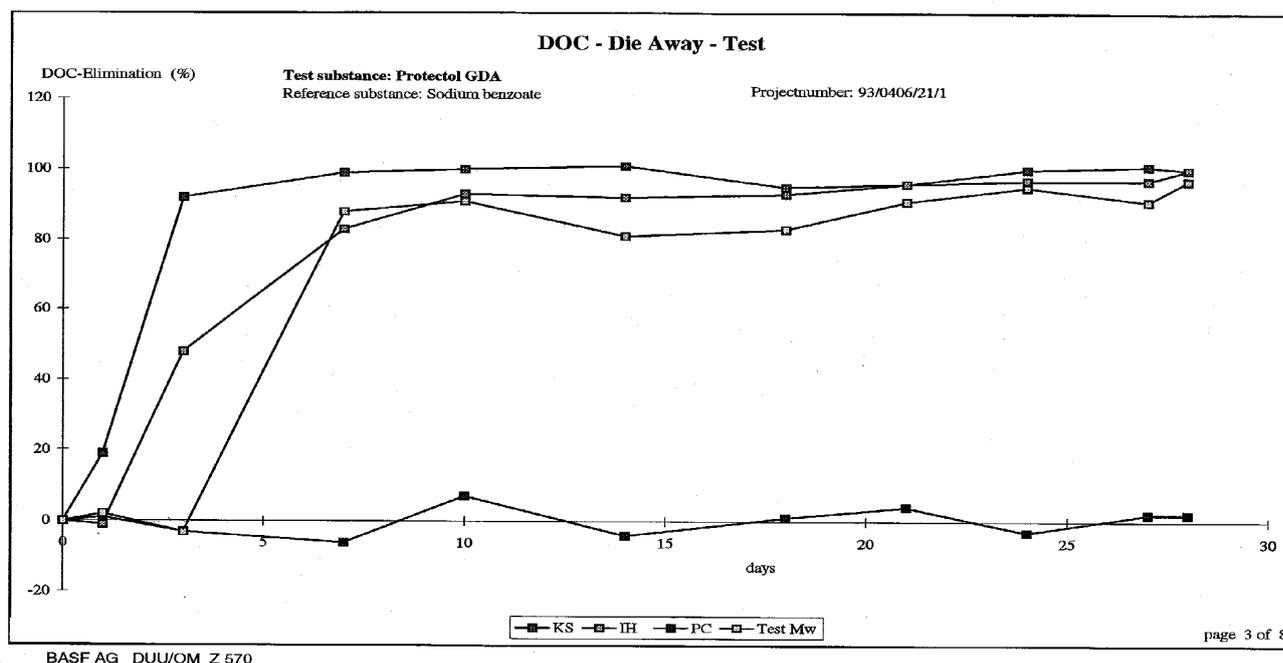
Figure 2: Percentage DOC removal (above) as calculated from the measured DOC levels (below) in ready biodegradability test 1

Test 2

Reference: Taeger K (1993) Determination of the Biodegradability or the Elimination of Protectol GDA in the DOC Die Away (ISO 7827)-Test. BASF AG, Department of Ecology, Ludwigshafen/Rhein, Germany, Report No: 93/0406/21/1 (Unpublished).

The biodegradability of glutaraldehyde (Protectol GDA (1,5-pentandial); batch number not specified, 50% glutaraldehyde; impurities listed in confidential luclid) was tested using activated sludge (from laboratory-scale waste water treatment plants fed with municipal and synthetic sewage) as inoculum. Glutaraldehyde was applied at concentration of 20 mgDOC/L (two replicates per concentration. Sodium benzoate was used as a reference substance at a concentration of 20 mgDOC/l. Inoculum blank test was also conducted and it was used to subtract the DOC concentration due to inoculum alone from those of the test and reference substances. The initial concentration of the inoculum was 30 mg suspended solids/l, which is the maximum allowed in OECD 301A instructions. Two replicates per concentration were used (test volume not specified). Abiotic control assay was performed.

Test vessels were not closed. pH was not specified. The incubation temperature was 20 – 25 °C. DOC concentration was measured at 0, 1, 3, 7, 10, 14, 18, 21, 24, 27, and 28 days by a Shimadzu 5000 DOC analyzer according to DIN 38409 Part 3 (1983). For each sample, the average for duplicate analyses was reported. The percent degradation based on DOC removal was determined. It is not mentioned what type or size of flasks were used and whether the flasks were shaken.



**Figure 3: Percentage DOC removal in ready biodegradability test 2. KS = reference substance, IH = toxicity control, PC = abiotic control, MW = test substance (mean value)**

The results are presented in Figure 3. The removal of DOC in the glutaraldehyde test started after 3-day lag period and increased to 88% removal by day 7. The DOC removal at the end of the experiment was 97%. Therefore, the pass level (70% DOC removal within the 10 day window) was reached.

No toxicity was indicated by the toxicity control.

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The reference substance, sodium benzoate, was metabolised effectively as there was a 96% DOC removal in less than 9 days, indicating sufficient activity of the inoculum.

Abiotic degradation was in the range of 2-7%. The low DOC removal values (and lack of trend in DOC removal during the experiment) in the abiotic control test showed that abiotic degradation was negligible and that the DOC removal in the glutaraldehyde test was due to biodegradation.

**Conclusion on ready biodegradability of glutaraldehyde:** According to the CLP criteria glutaraldehyde is considered readily biodegradable. Both tests fulfilled the validity criteria of OECD 301 and the pass level (70% of DOC removal within 10 day window) was reached in both tests.

### 5.1.2.3 Simulation tests

#### Aerobic water/sediment test

Reference: Esser, T. (1994a) Aerobic Aquatic Metabolism of <sup>14</sup>C- Glutaraldehyde in River Water and Sediment, PTRL West, Inc., The Dow Chemical Company Report No: K-020301-015, GLP, Unpublished, 25 May 1994

The aerobic water/sediment study was carried out under GLP and according to US EPA Pesticide Assessment N 162-4. Glutaraldehyde dissipated with a half-life of 10.6 hours at 25 °C (corresponding to 1.25 d at 12 °C) from the aqueous phase, as estimated using glutaraldehyde concentrations in the aqueous phase and pseudo-first order kinetics. In the aqueous phase, the major metabolites that exceeded 10% were identified as glutaric acid (maximum of 20.2% detected at 12 hours) and carbon dioxide (CO<sub>2</sub>) (Table 27). The metabolic pathway proposed is proposed in Figure 4. Glutaraldehyde was detected in the aquatic phase during the first 48 hours but was below detection in the measurements on the day 7 and beyond. It is noted in the report that serious losses of CO<sub>2</sub> occurred in sample treatment in measurements beyond the day 7 and therefore the results of those measurements were not tabulated. It is indicated, however, that CO<sub>2</sub> was the sole metabolite in the water beyond the day 7. At the end of the 30-day experiment 12% of the applied <sup>14</sup>C was found in aqueous phase and 14% in sediment phase. The aqueous radiocarbon loss during the experiment was 81.2% (difference between average <sup>14</sup>C percentages in water at days 0 and 30; calculated from values in Table 28), corresponding to the sum of the percentages of <sup>14</sup>C converted to CO<sub>2</sub> (67.9%; average of replicate values in Table 28) and <sup>14</sup>C found in the sediment phase at the end of the experiment (14%). A majority of the radiocarbon in sediment could not be extracted and its identity could not be ascertained (Table 29). The amount of non-extractable radioactivity in sediment at the end of the 30d experiment was 12.6% of applied radioactivity and 90% of the total radioactivity detected in the sediment phase at the same time point (Table 29). Total mean recovery of applied radioactivity was 93.3 ± 9.8% (Table 28).

**In conclusion,** glutaraldehyde dissipated in the aerobic water/sediment system with the half-life of 1.25 d (12 °C). The corresponding rate constant is 0.555 d<sup>-1</sup>.

During the assessment of glutaraldehyde under Directive 98/8/EC it was questioned whether it is appropriate to use the dissipation half-life in exposure calculations. It was considered whether it is possible to calculate the degradation half-lives for water, sediment and the whole system according to the FOCUS guidance developed within the plant protection registration framework. It was concluded that it is not possible to derive a degradation rate in the sediment phase because glutaraldehyde is typically not sorbed to sediment but it rather reacts with functional groups and is incorporated into the organic matter in the sediment. For the entire water-sediment- system, a

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degradation half-life of 11 hours was obtained; however, this is conservative value based on the assumption that the entire radioactivity extracted from the sediment phase is glutaraldehyde. The actual rate of degradation of glutaraldehyde for the entire system is likely to be higher due to the reactivity of glutaraldehyde. However, because the degradation rate in the entire water-sediment system (corresponding to a half-life of 11 hours) is similar to the dissipation rate in water (half-life 10.6 hours), the water dissipation rate can be used for risk assessment.

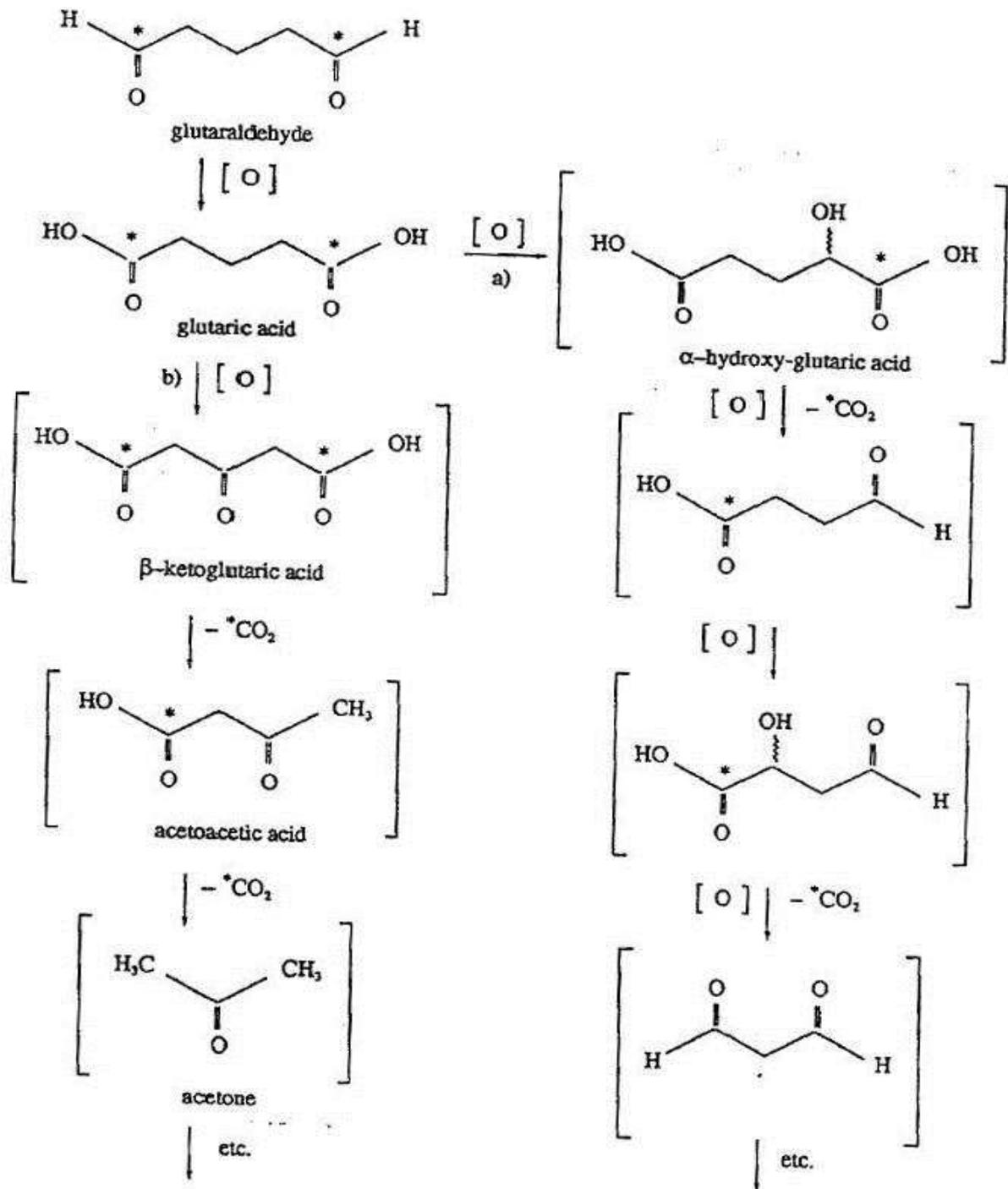


Figure 4: Proposed metabolic pathway for glutaraldehyde under aerobic conditions

**Table 27: Composition of aqueous phase under aerobic conditions**

| Sampling Time & Replicate |   | Products Detected as Percentage of Applied Radioactivity |         |               |         |                 |         |
|---------------------------|---|--|---------|---------------|---------|-----------------|---------|
|                           |   | Glutaraldehyde   | Average | Glutaric acid | Average | CO <sub>2</sub> | Average |
| 0-hour                    | A | 90.8   | 88.85   | 0             | 0       | 0               | 0       |
|                           | B | 86.9   |         | 0             |         | 0               |         |
| 4-hour                    | A | 82   | 75.7    | 12.9          | 12.3    | 0               | 0       |
|                           | B | 69.4   |         | 11.7          |         | 0               |         |
| 12-hour                   | A | 43.4   | 44.65   | 21.5          | 20.2    | 13              | 13.7    |
|                           | B | 45.9   |         | 18.9          |         | 14.4            |         |
| 24-hour                   | A | 13.9   | 18.95   | 11            | 10.55   | 32.6            | 33.8    |
|                           | B | 24   |         | 10.1          |         | 35              |         |
| 48-hour                   | A | 0.3  | 0.15    | 0             | 0       | 52.9            | 51.35   |
|                           | B | 0  |         | 0             |         | 49.8            |         |
| 7-day                     | A | 0  | 0       | 0             | 0       | 37.1            | 35.75   |
|                           | B | 0  |         | 0             |         | 34.4            |         |

**Table 28: Radiocarbon material balance (expressed as percent of applied radioactivity) under aerobic conditions**

| Sampling Time & Replicate |    | <sup>14</sup> C in Sediment |      | <sup>14</sup> C in Water |      | <sup>14</sup> CO <sub>2</sub> |       | Total %    |
|---------------------------|----|-----------------------------|------|--------------------------|------|-------------------------------|-------|------------|
|                           |    | %                           | ppm  | %                        | ppm  | %                             | ppm   |            |
| 0-hour                    | A  | 8.4                         | 0.79 | 93.4                     | 8.83 | -                             | -     | 101.8      |
|                           | B  | 6.8                         | 0.64 | 93.7                     | 8.85 | -                             | -     | 100.5      |
| 4-hour                    | A  | 9.0                         | 0.85 | 97.3                     | 9.19 | 0.1                           | <0.01 | 106.4      |
|                           | B  | 8.1                         | 0.76 | 90.6                     | 8.57 | 0.0                           | <0.01 | 98.7       |
| 12-hour                   | A  | 15.7                        | 1.49 | 84.1                     | 7.95 | 0.6                           | 0.06  | 100.4      |
|                           | B  | 17.6                        | 1.67 | 85.0                     | 8.03 | 0.4                           | 0.04  | 103.0      |
| 24-hour                   | A  | 22.2                        | 2.10 | 63.3                     | 5.99 | 0.6                           | 0.06  | 86.2       |
|                           | B  | 18.6                        | 1.75 | 71.2                     | 6.73 | 0.4                           | 0.04  | 90.2       |
| 48-hour                   | A* | -                           | -    | -                        | -    | -                             | -     | -          |
|                           | B  | 25.3                        | 2.39 | 49.8                     | 4.71 | 10.3                          | 0.97  | 85.3       |
| 7-day                     | A  | 20.0                        | 1.89 | 38.6                     | 3.64 | 20.4                          | 1.93  | 78.9       |
|                           | B  | 23.7                        | 2.24 | 26.1                     | 3.32 | 19.5                          | 1.84  | 78.3       |
| 14-day                    | A* | -                           | -    | -                        | -    | -                             | -     | -          |
|                           | B  | 17.1                        | 1.62 | 18.6                     | 1.75 | 48.1                          | 4.54  | 83.8       |
| 30-day                    | A  | 11.9                        | 1.12 | 11.1                     | 1.05 | 69.4                          | 6.56  | 92.4       |
|                           | B  | 16.1                        | 1.52 | 13.6                     | 1.29 | 66.3                          | 6.27  | 96.0       |
| Average                   |    |                             |      |                          |      |                               |       | 93.3 ± 9.8 |

\* Measurements for replicate A are not included. These samples revealed serious losses of radioactive material upon storage probably due to <sup>14</sup>CO<sub>2</sub> formation with only 0 % (48 hr-A) and 2.6 % (14 day-A) recovered.

**Table 29: Total, extractable and non-extractable radioactivity in sediment as a percentage of the applied radioactivity under aerobic conditions**

| Sampling Time & Replicate |   | Total C-14 | Average | Extractable C-14 | Average | Not Extractable C-14 | Average |
|---------------------------|---|------------|---------|------------------|---------|----------------------|---------|
| 0-hour                    | A | 8.4        | 7.6     | 3.0              | 3.0     | 4.0                  | 4.4     |
|                           | B | 6.8        |         | 2.9              |         | 4.7                  |         |
| 4-hour                    | A | 9          | 8.6     | 3.8              | 3.8     | 5.8                  | 5.8     |
|                           | B | 8.1        |         | 3.8              |         | 5.7                  |         |
| 12-hour                   | A | 15.7       | 16.7    | 3.5              | 3.8     | 7.9                  | 7.0     |
|                           | B | 17.6       |         | 4.1              |         | 6.1                  |         |
| 24-hour                   | A | 22.2       | 20.4    | 1.2              | 1.8     | 2.6                  | 3.4     |
|                           | B | 18.6       |         | 2.3              |         | 4.3                  |         |
| 48-hour                   | A | 21         | 23.2    | 2.6              | 2.3     | 11.5                 | 12.1    |
|                           | B | 25.3       |         | 2.1              |         | 12.8                 |         |
| 7-day                     | A | 20         | 21.9    | 1.6              | 1.8     | 14.9                 | 19.1    |
|                           | B | 23.7       |         | 2.1              |         | 23.3                 |         |
| 14-day                    | A | 15.2       | 16.2    | 2.1              | 1.7     | 19.6                 | 17.7    |
|                           | B | 17.1       |         | 1.3              |         | 15.8                 |         |
| 30-day                    | A | 11.9       | 14.0    | 2.1              | 1.7     | 10.4                 | 12.6    |
|                           | B | 16.1       |         | 1.4              |         | 14.8                 |         |

### Anaerobic water/sediment test

Reference: Esser, T. (1994b) Anaerobic Aquatic Metabolism of <sup>14</sup>C-Glutaraldehyde, PTRL West, Inc., The Dow Chemical Company Report No: K-020301-013, GLP, Unpublished, 2 June 1994

The anaerobic water/sediment study of Dow was carried out under GLP and according to US EPA Pesticide Assessment N 162-3. Under anaerobic conditions only primary biodegradation was observed, with the production of three metabolites that exceeded 10% of applied radioactivity. After 3 days of application only 0.1% of applied radioactivity attributed to glutaraldehyde could be detected in the water phase (Table 30). Concurrently, 3 radioactive metabolic fractions could be detected (Table 30) and were identified as:

-Compound A (2-hydroxy-3,4,4a,7,8,8a-hexahydro-2H-chromene-6-carbaldehyde) (maximum of 17.7% detected at Day 90)

-5-hydroxy-pentanal (5-hydroxyvaleraldehyde) (maximum of 37.0% at Day 1)

-1,5-pentanediol (pentane-1,5,-diol) (maximum of 76.1% detected at Day 14)

Compound A and 1,5-pentanediol are considered persistent because they were present >10% throughout the experiment. Radioactivity assigned to 5-hydroxy-pentanal exceeded 10% only on day 1 and thereafter decreased continuously until day 30. After that it was not detected. Thus, 5-hydroxypentanal is not considered persistent. These three observed metabolites are characterized below. The metabolic pathway is proposed in Figure 5. The production of <sup>14</sup>CO<sub>2</sub> was insignificant. The radioactivity in the water phase remained at a fairly constant level throughout the study being 91.4% at the end of incubation (Day 123). The radioactivity in the sediment reached a maximum of 8.4% of the applied radioactivity at the study termination (Day 123) Table 31). Total mean recovery

of applied radioactivity was  $98.7 \pm 2.5\%$  (Table 32). The non-extractable radioactivity ranged from 17% (0 hour) to 37% (Day 3) of total radioactivity in sediment (values calculated from Table 31). This is equivalent to 1.0-2.3% of applied radioactivity as calculated using the total recovered radioactivity percentage (Table 32). A half-life of 7.7 hours at 25 °C (corresponding to 0.91 d at 12 °C) was calculated based on the observed concentration of glutaraldehyde in the aqueous phase using pseudo-first order kinetics.

**In conclusion**, glutaraldehyde is transformed to two persistent metabolites (Compound A and 1,5-pentanediol) and one intermediate metabolite (5-hydroxy-pentanal) under anaerobic conditions. All three metabolites exceeded 10% of applied radioactivity. The dissipation half-life was 0.91 d (12 °C). The corresponding rate constant is  $0.76 \text{ d}^{-1}$ .

### **Significance of the metabolites observed in the anaerobic water/sediment test for classification of glutaraldehyde**

Although persistent metabolites were detected in the anaerobic water/sediment tests, these are not considered relevant for classification purposes. In CLP classification, degradation data is required to show whether or not the substance in question is rapidly degradable. In the ECHA Guidance on the application of the CLP criteria (ECHA, 2012) it is stated that "anaerobic degradation tests (OECD 311/ISO 11734 and analogous tests) do not qualify because of the specificity of the anaerobic compartments.". Moreover, in Annex II of the guidance, it is stated that "Data regarding anaerobic degradation cannot be used in relation to deciding whether a substance should be regarded as rapidly degradable, because the aquatic environment is generally regarded as the aerobic compartment where the aquatic organisms, such as those employed for aquatic hazard classification, live.". Therefore, the dossier submitter concludes that anaerobic biodegradation data, including any data concerning the formation of metabolites (whether these fulfill the criteria for classification as hazardous to the aquatic environment or not) in anaerobic conditions must not be considered in the evaluation of fulfillment of the rapid degradability criterion in this case. However, for completeness' sake, the available information relevant for environmental hazard classification of the three degradation products is reviewed below.

### **Characterisation of the metabolites observed in anaerobic water/sediment test**

#### 5-hydroxy-pentanal (5-Hydroxyvaleraldehyde)

In the assessment of glutaraldehyde under Directive 98/8/EC, 5-hydroxy-pentanal (5-hydroxyvaleraldehyde) was identified as a possible metabolite using a skin metabolism simulator and mechanistic profiling indicated potential toxicity (Doc II-A, Chapter 3.1)

5-hydroxy-pentanal is included in the European Chemical Agency's C&L Inventory (5-Hydroxyvaleraldehyde; CAS 4221-03-8) with classification Skin Irrit. 2, Eye Irrit. 2., STOT SE3, while for other hazard categories it is mentioned that data is lacking.

QSAR prediction using BIOWIN models suggests that the substance is readily biodegradable and not persistent (Table 33). The QSAR predicted Log Kow suggests that the substance is not bioaccumulative. The predicted ecotoxicity values suggest that the substance should not be classified for environmental hazards according to CLP (2.ATP) (Table 33).

#### 1,5-pentanediol (pentane-1,5,-diol)

In the Doc II-A under Directive 98/8/EC, 1,5-pentanediol is mentioned only in the context of this anaerobic water/sediment test but not elsewhere in the report.

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1,5-pentanediol is included in the European Chemical Agency's C&L Inventory with the name pentane-1,5,-diol (CAS: 111-29-5). The hazard class is "Not classified" in the case of 294 notifiers whereas 3 notifiers have not assigned hazard categories to the substance but have still included the following hazard statement codes: "H302 Harmful if swallowed", "H315 Causes skin irritation", "H319 Causes serious eye irritation", and "H335 May cause respiratory irritation". In addition, one notifier classifies the substance as Acute Tox. 4.

1,5-pentanediol is included in the ECHA database of registered substances (pentane-1,5,-diol; CAS: 111-29-5) with the status "not classified". According to the information available in the database 1,5-pentanediol is readily biodegradable and its ecotoxicity does not warrant a classification for environmental hazards (Table 33). QSAR prediction using BIOWIN models suggests that the substance is readily biodegradable and not persistent (Table 33). According to the registration data, the substance is not bioaccumulative, which is supported by the experimentally determined and QSAR predicted Log Kow values (Table 33).

### Compound A (2-hydroxy-3,4,4a,7,8,8a-hexahydro-2H-chromene-6-carbaldehyde)

In the Doc II-A under Directive 98/8/EC, Compound A is mentioned only in the context of this anaerobic water/sediment test but not elsewhere in the report.

Compound A could not be found in any of the European Chemical Agency's databases. No CAS number could be found for this substance. Smiles code C1CC(OC2C1C=C(CC2)C=O)O was obtained from The Pubchem Compound Database (National Center for Biotechnology Information, 2013) (CID 42632221) and this Smiles code was used for QSAR predictions.

QSAR prediction using BIOWIN models suggests that the substance is readily biodegradable and not persistent (Table 33). The QSAR predicted Log Kow suggests that the substance is not bioaccumulative (Table 33). The QSAR predicted ecotoxicity values suggest that the substance should be classified as Aquatic Acute 1 with an M factor of 1 and Aquatic Chronic 2 (no M factor) (Table 33).

**Table 30: Composition of aqueous phase under anaerobic conditions**

| Sampling Time & Replicate |   | Products Detected as Percent of Dose (ppm) |            |                    |                 |
|---------------------------|---|--|------------|--------------------|-----------------|
|                           |   | Glutaraldehyde                             | Compound A | 5-Hydroxy-pentanal | 1,5-Pentanediol |
| 0-hour                    | A | 78.6                                       | 2.89       | 5.22               | 0.00            |
|                           | B | 67.6                                       | 3.64       | 9.30               | 0.00            |
| 1-day                     | A | 4.9  | 10.50      | 38.97              | 34.75           |
|                           | B | 4.0  | 13.24      | 35.11              | 34.79           |
| 3-day                     | A | 0.0  | 8.59       | 7.02               | 67.16           |
|                           | B | 0.2  | 14.64      | 10.58              | 54.33           |
| 7-day                     | A | 0.0  | 12.46      | 0.79               | 69.25           |
|                           | B | 0.0  | 11.75      | 2.92               | 62.98           |
| 14-day                    | A | 0.0  | 12.76      | 0.38               | 77.86           |
|                           | B | 0.0  | 13.33      | 2.18               | 74.34           |
| 30-day                    | A | 0.0  | 16.47      | 0.84               | 62.17           |
|                           | B | 0.0  | 11.49      | 1.46               | 70.14           |
| 60-day                    | A | 0.0  | 15.14      | 0.0                | 71.17           |
|                           | B | 0.0  | 10.49      | 0.0                | 74.78           |
| 90-day                    | A | 0.0  | 22.86      | 0.0                | 66.74           |
|                           | B | 0.0  | 12.62      | 0.0                | 75.39           |
| 123-day                   | A | 0.0  | 18.35      | 0.0                | 67.51           |
|                           | B | 0.0  | 14.81      | 0.0                | 71.64           |

**Table 31: Total, extractable and not-extractable radioactivity in sediment as a percentage of the applied radioactivity under anaerobic conditions**

| Sampling Time & Replicate |   | Total C-14 | Average | Extractable | Average | Not-extractable | Average |
|---------------------------|---|------------|---------|-------------|---------|-----------------|---------|
| 0-hour                    | A | 5.40       | 5.70    | 3.45        | 3.75    | 1.14            | 0.97    |
|                           | B | 6.00       |         | 4.06        |         | 0.80            |         |
| 1-day                     | A | 6.10       | 6.30    | 5.04        | 4.77    | 2.03            | 1.53    |
|                           | B | 6.50       |         | 4.51        |         | 1.03            |         |
| 3-day                     | A | 6.10       | 6.05    | 4.54        | 4.13    | 2.18            | 2.24    |
|                           | B | 6.00       |         | 3.73        |         | 2.30            |         |
| 7-day                     | A | 7.70       | 7.05    | 4.94        | 4.59    | 1.59            | 1.77    |
|                           | B | 6.40       |         | 4.24        |         | 1.96            |         |
| 14-day                    | A | 6.90       | 7.00    | 4.10        | 4.40    | 1.75            | 1.91    |
|                           | B | 7.10       |         | 4.70        |         | 2.07            |         |
| 30-day                    | A | 8.90       | 8.25    | 4.44        | 5.09    | 3.37            | 2.58    |
|                           | B | 7.60       |         | 5.74        |         | 1.79            |         |
| 60-day                    | A | 7.80       | 7.20    | 4.14        | 4.20    | 2.96            | 2.59    |
|                           | B | 6.60       |         | 4.26        |         | 2.22            |         |
| 90-day                    | A | 7.40       | 7.40    | 3.96        | 3.79    | 2.70            | 2.44    |
|                           | B | 7.40       |         | 3.62        |         | 2.18            |         |
| 123-day                   | A | 9.20       | 8.40    | 4.96        | 5.05    | 2.56            | 2.64    |
|                           | B | 7.60       |         | 5.15        |         | 2.72            |         |

**Table 32: Radiocarbon material balance (expressed as percent of applied radioactivity) under anaerobic conditions**

| Sampling Time & Replicate |   | <sup>14</sup> C in Sediment |      | <sup>14</sup> C in Water |      | <sup>14</sup> CO <sub>2</sub> |      | Total %    |
|---------------------------|---|-----------------------------|------|--------------------------|------|-------------------------------|------|------------|
|                           |   | %                           | ppm  | %                        | ppm  | %                             | ppm  |            |
| 0-hour                    | A | 5.4                         | 0.51 | 92.4                     | 8.73 | --                            | --   | 97.8       |
|                           | B | 6.0                         | 0.57 | 91.3                     | 8.63 | --                            | --   | 97.3       |
| 1-day                     | A | 6.1                         | 0.58 | 95.6                     | 9.03 | 0.1                           | 0.01 | 101.8      |
|                           | B | 6.5                         | 0.62 | 94.5                     | 8.93 | 0.1                           | 0.01 | 101.1      |
| 3-day                     | A | 6.1                         | 0.58 | 90.7                     | 8.57 | 0.2                           | 0.02 | 97.0       |
|                           | B | 6.0                         | 0.57 | 88.5                     | 8.36 | 0.3                           | 0.03 | 94.8       |
| 7-day                     | A | 7.9                         | 0.75 | 88.2                     | 8.34 | 0.0                           | 0.00 | 96.1       |
|                           | B | 6.4                         | 0.61 | 89.7                     | 8.48 | 0.0                           | 0.00 | 96.1       |
| 14-day                    | A | 6.9                         | 0.65 | 94.0                     | 8.88 | 0.1                           | 0.01 | 101.0      |
|                           | B | 7.1                         | 0.67 | 95.1                     | 8.97 | 0.1                           | 0.01 | 102.3      |
| 30-day                    | A | 8.9                         | 0.84 | 86.8                     | 8.20 | 0.1                           | 0.01 | 95.8       |
|                           | B | 7.6                         | 0.72 | 87.1                     | 8.23 | 0.1                           | 0.01 | 94.8       |
| 60-day                    | A | 7.8                         | 0.74 | 90.8                     | 8.58 | 0.2                           | 0.02 | 98.8       |
|                           | B | 6.6                         | 0.62 | 92.3                     | 8.72 | 0.2                           | 0.02 | 99.1       |
| 90-day                    | A | 7.4                         | 0.70 | 94.3                     | 8.91 | 0.2                           | 0.02 | 101.9      |
|                           | B | 7.4                         | 0.70 | 92.5                     | 8.74 | 0.3                           | 0.03 | 100.2      |
| 123-day                   | A | 9.2                         | 0.87 | 91.1                     | 8.61 | 0.3                           | 0.03 | 100.6      |
|                           | B | 7.6                         | 0.72 | 91.7                     | 8.67 | 0.3                           | 0.03 | 99.6       |
| Average                   |   |                             |      |                          |      |                               |      | 98.7 ± 2.5 |

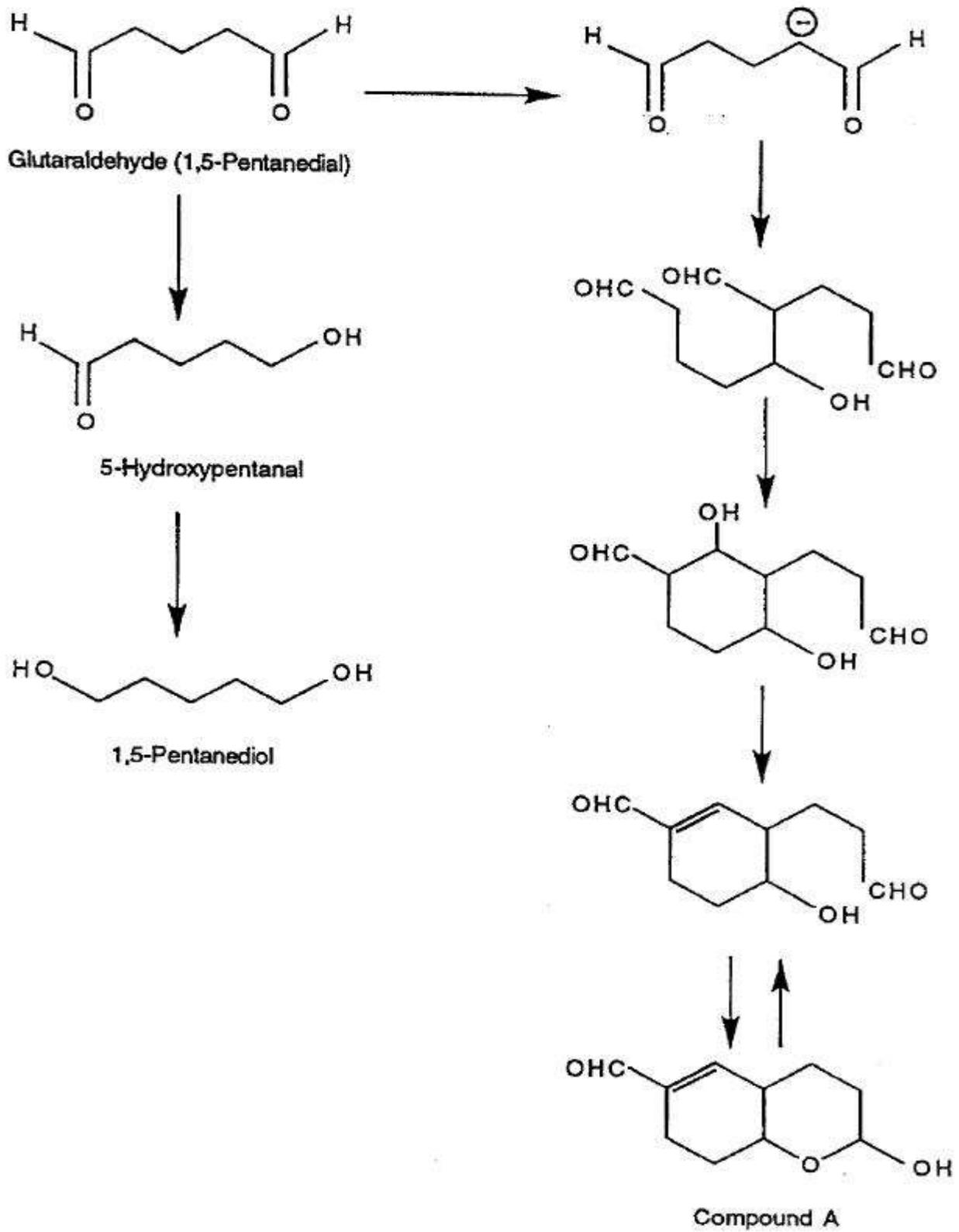


Figure 5: Proposed metabolic pathway for glutaraldehyde under anaerobic conditions

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Table 33: Summary of data relevant for the environmental hazard classification of the metabolites detected in the anaerobic water/sediment test.<sup>a</sup>

| Substance (CAS No:)   | Occurrence in the anaerobic water/sediment test (US EPA Pesticide Assessment N 162-3) | Degradation  | Log Kow and bioaccumulation  | Aquatic toxicity <sup>b</sup>   | Suggested environmental hazard classification according to CLP 2. ATP <sup>c</sup>                                    |
|---|---|--|--|---|---|
| 5-hydroxy-pentanal (CAS No: 4221-03-8)                                    | Intermediate metabolite   | Readily biodegradable <sup>d</sup> (QSAR)  | Log Kow: -0.16 (QSAR); low bioaccumulation potential   | Acute hazards: 64.7 mg/l (fish, QSAR)<br><br>Chronic hazards: 5.2 mg/l (fish, QSAR)   | <b>Not classified for environmental hazards<sup>e</sup></b>   |
| 1,5-pentandiol (CAS No: 111-29-5)   | Persistent metabolite   | Readily biodegradable (REACH registration data)<br><br>Readily biodegradable (QSAR) <sup>d</sup> | Log Kow: -0.49 (REACH registration data); low bioaccumulation potential<br><br>Log Kow: 0.27 (QSAR); low bioaccumulation potential | Acute hazards: >500 mg/l (crustacea and algae), 4640 mg/l (fish), 260 mg/l (algae, QSAR)<br><br>Chronic hazards: 74.5 mg/l (algae, QSAR), >500 mg/l (algae) | <b>Not classified for environmental hazards<sup>e</sup></b>   |
| 2-hydroxy-3,4,4a,7,8,8a-hexahydro-2H-chromene-6-carbaldehyde (Compound A) | Persistent metabolite   | Readily biodegradable (QSAR) <sup>d</sup>  | Log Kow: 0.10 (QSAR); low bioaccumulation potential  | Acute hazards: 0.41 mg/l (fish, QSAR)<br><br>Chronic hazards: 0.04 mg/l (fish, QSAR)  | <b>Aquatic Acute 1 with an M factor of 1, and, (assuming rapid degradability), Aquatic Chronic 2 with no M factor</b> |

<sup>a</sup> All QSAR predictions were conducted by the dossier submitter (DS) using US EPA Epi Suite vers 4.00. The models used were: ECOSAR Computer program, v1.00 (2009), KOWWIN v1.76a (2008) and BIOWIN v 4.10 (2009).

<sup>b</sup> For all three metabolites, the Chronic Values (ChV) obtained from the ECOSAR QSAR models have been used here similarly as NOEC for comparison with the classification criteria. In the ECOSAR documentation, ChV is defined as the geometric mean of the no observed effect concentration (NOEC) and the lowest observed effect concentration (LOEC). This can be mathematically represented as:  $ChV = 10^{([\log(LOEC \times NOEC)]/2)}$  (Methodology Document for the ECOlogical Structure-Activity Relationship Model (Ecosar). EPA, 2012)

**5-hydroxy-pentanal:** Ecosar QSAR results for class "Aldehydes (Mono)": the lowest EC/LC value is 64.7 mg/l (fish (SW), 96-hr LC50), and the lowest ChV value is 5.2 mg/l (fish (SW))<sup>f</sup>. Ecosar QSAR results for class "neutral organics": the lowest EC/LC value is 416.4 mg/l (green algae, 96-hr LC50) and the lowest ChV value is 101.6 mg/l (green algae).

**1,5-pentandiol:** In the ECHA database of registered substances, short-term aquatic toxicity data for fish, invertebrates, algae and bacteria is presented. The reported EC/LC values relevant for classification are:

>500 mg/l (*Daphnia magna*, 48-hr EC50, nominal) (highest tested concentration 500 mg/l)

>500 mg/l (green algae *Scenedesmus subspicatus* (new name: *Desmodesmus subspicatus*), 72-hr EC50) (highest tested concentration 500 mg/l)

4640 mg/l (fish (*Leuciscus idus*), 96-hr LC50, nominal)

One experimental long-term aquatic toxicity value is available (the same test result is also used for the short-term toxicity above): green algae *S. subspicatus* (>500 mg/l, 72-hr EC50, highest tested concentration 500 mg/l). Ecosar QSAR results for class "neutral organics": lowest EC/LC value is 260 mg/l (green algae, 96-hr EC50). The lowest ChV value is 74.5 mg/l (green algae).

**2-hydroxy-3,4,4a,7,8,8a-hexahydro-2H-chromene-6-carbaldehyde:**

Ecosar QSAR results for class "Vinyl /Allyl Aldehydes": lowest acute toxicity concentration is 0.41 mg/l (fish, 96-hr LC50) and the

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lowest ChV value is 0.04 mg/l (fish, ChV)<sup>f</sup>. For the class "neutral organics the lowest EC/LC value is 519.3 mg/l (green algae, 96-hr EC50) and the lowest ChV value is 132.7 mg/l (green algae).

<sup>c</sup>This is a tentative environmental hazard classification as evaluated by the dossier submitter based on the available data (physical and health hazard classification was not evaluated). There are no harmonized classifications for these substances within the EU.

<sup>d</sup>On the basis of BIOWIN results the substance is not likely to fulfill the persistence screening criteria in ECHA guidance R.11 ("Table R11-2 Screening criteria for P and vP". Guidance for information requirements and chemical safety assessment. Chapter R.11: PBT Assessment. ECHA. May 2008 (page 14)) and is likely to fulfill the ready biodegradability criteria mentioned in ECHA guidance R.7b ("Ready biodegradability prediction: yes or no". Guidance for information requirements and chemical safety assessment. Chapter R.7b: Endpoint specific guidance. ECHA. May 2008 (version 1.1). (pp. 170-171)). It is noted, however, that BIOWIN 2 and BIOWIN 3 results should be used cautiously because the compounds contain one or more fragments that are not included in the training sets of the models BIOWIN 2 and BIOWIN 3. Therefore, the structure is only partially taken into account in the prediction.

<sup>e</sup>The predicted effect concentrations are above the classification criteria for acute aquatic category 1 ( $\leq 1$  mg/l) or chronic aquatic category 3 ( $\leq 1$  mg/l for substances which are rapidly degradable and not bioaccumulative).

<sup>f</sup>The Ecosar output included a note "The toxicity value was determined from a predicted SAR using established acute-to-chronic ratios and ECOSAR regression techniques which are documented in the supporting Technical Reference Manual. When possible, this toxicity value should be considered in a weight of evidence approach".

### Biodegradation in seawater

#### Test 1:

Reference: Doi, J. (2000) Biodegradability in Seawater Study- Closed Bottle Method, Amended Final Report Including Page 3a, Aqua Survey, Inc., The Dow Chemical Company, Report No: 0222-100-028, Unpublished, 28 March 2000.

This seawater biodegradation test was performed according to the closed bottle method described in OECD306, with no deviations from the guideline stated in the report or protocol. The tested glutaraldehyde product was Ucarcide<sup>®</sup> 250 Antimicrobial (Lot and/or Batch number IS 782609; purity 50.9% glutaraldehyde). No additional inoculum other than those microorganisms already in the natural seawater was added to the treatment bottles. The extent of biodegradation was determined as biological oxygen demand (BOD) as a percentage of theoretical oxygen demand (%ThOD). BOD of test substance was calculated from dissolved oxygen concentrations; oxygen consumption due to seawater alone was measured separately and subtracted from oxygen consumption of test substance and seawater to obtain BOD due to test substance. The initial concentration of test substance in test solution was 3.0 mg/l. Sodium benzoate was used as the reference control at 2.0 mg/L. The dissolved oxygen was determined in the BOD bottles on days 0, 1, 3, 5, 8, 11, 15, 19, 23, and 28.

The test showed that after five days lag period 73% biodegradation was attained by the 28 d, thus fulfilling the level of 60% defined in the OECD 306 guideline. Therefore, glutaraldehyde has a potential to biodegrade in the marine environment.

Validity of test: The validity criteria listed in the OECD 306 were fulfilled. According to the OECD 306 the test substance can be considered inhibitory to bacteria as the BOD of the toxicity control was less than the sum of BOD from test and procedure control. However, it was noted that the extent of degradation in the toxicity controls could not be reliably quantified because the dissolved oxygen concentrations in the toxicity controls decreased to below 1 mg/L within 11 days. The decrease in dissolved oxygen was attributed to the large quantity of carbon added to the reaction mixtures in the toxicity control assay. Due to extensive degradation observed in both test and procedural control treatments, inhibition of the microbial inoculum by glutaraldehyde in the test is considered negligible and therefore the validity criteria are considered to be met despite the low biodegradation in the toxicity control.

#### Test 2:

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Reference: Schwarz, H. (2002) Protectol GA (50% glutaraldehyde), Determination of the Biodegradability in the marine CO<sub>2</sub>-Evolution Test. BASF AG, Department of Experimental Toxicology and Ecology, Ludwigshafen/Rhein, Germany, Report No: 01/0411/32/1 (Unpublished).

This seawater biodegradation test was performed according to ISO 16221-2001, with GLP. The extent of biodegradation was determined as carbon dioxide (CO<sub>2</sub>) evolution as a percentage of theoretical CO<sub>2</sub> evolution. Test substance was Protectol GA (1,5-Pentanedial), batch Nr. 50-4402, substance Nr. 01/0411-1, date of production 16 Feb 1999, product Nr. 004181, purity 50.3% (water 46%, impurities listed in confidential IUCLID).

The biodegradation of Protectol GA was evaluated at a concentration of 32 mg test substance/l (corresponding to 10 mg/l TOC). A blank control (seawater and inorganic medium without test substance), a reference substance (aniline) and a toxicity control (reference and test substances) were considered in this test. Evolved CO<sub>2</sub> was trapped in NaOH absorber flasks. CO<sub>2</sub> was determined 17 times during the 71-day experiment). The relation of the determined CO<sub>2</sub> evolution to the calculated theoretical CO<sub>2</sub> value is the measure for the marine biodegradation of Protectol GA. 100 mg TS/l showed a decreased level of degradation in the toxicity control assay (with initial concentrations of 100 mg TS/l test substance and 100 mgTS/l reference substance) therefore only the measurements of the lowest test substance concentration were used for biodegradability estimation.

The percentage of degradation of Protectol GA at 10 mg/l TOC was determined to be 90-100% at the end of incubation (71 days). At a test concentration of about 100 mg/l (equivalent to 30 mg TOC/l) biodegradation was decreased (30% degradation), apparently due to toxic effects as indicated by the toxicity control. Biodegradation of the reference substance was > 60% on day 6 and > 90 % after 50 days. Since there were no indications for abiotic elimination processes Protectol GA can be regarded as biodegradable in this test system.

Glutaraldehyde degraded steadily achieving the 95% degree of degradation after 70 d. After 30 d the degree of degradation was 41%.

Validity of test: Validity criteria can be considered fulfilled. It was noted, however, that until day 17 the replicates deviated from each other more than 20% (22-55%), after that day the deviation was less than 10%. No plateau could be identified.

### **Conclusions on biodegradation in seawater:**

According to both of the two tests, glutaraldehyde has a potential to biodegrade in the marine environment.

### 5.1.3 Summary and discussion of degradation

Glutaraldehyde is readily biodegradable. In the ready biodegradability tests, the pass level (70% of DOC within the 10 day window) was reached.

Glutaraldehyde has the potential to biodegrade in the marine environment. An OECD 306 test showed that after five days lag period 73% biodegradation was attained after 28 d, thus fulfilling the level of 60% defined in the guideline. In an ISO 16221-2001 test, glutaraldehyde degraded steadily achieving the 95% degree of degradation after 70 d.

In aerobic water/sediment simulation test, glutaraldehyde dissipated from the aqueous phase with a half-life of 1.25 d (12°C). Major metabolites were glutaric acid and carbon dioxide (CO<sub>2</sub>). A majority of glutaraldehyde was mineralized as indicated by the 67.9% of radiocarbon recovered as CO<sub>2</sub>. At the end of the 30-d experiment, glutaraldehyde was not detected and 12% of the applied <sup>14</sup>C was found in aqueous phase and 14% in sediment phase.

In anaerobic water/sediment simulation test, glutaraldehyde dissipated from the aqueous phase with a half-life of 0.91 d at 12°C, with three metabolites identified, two of which (1,5-pentanediol and 2-hydroxy-3,4,4a,7,8,8a-hexahydro-2H-chromene-6-carbaldehyde; the latter is referred in this report as Compound A) were persistent and one (5-hydroxy-pentanal) non-persistent. Production of <sup>14</sup>CO<sub>2</sub> was insignificant. A maximum of 9.4% of radioactivity was detected in the sediment and >90% of <sup>14</sup>C remained in the aqueous phase throughout the experiment. In this case the metabolites formed in anaerobic water/sediment simulation tests are not relevant for classification as explained in chapter 5.1.2.3. However, a brief characterisation of the properties of these metabolites was presented.

Glutaraldehyde can be considered hydrolytically and photolytically stable in the aquatic environment. In the atmosphere, glutaraldehyde is likely to be photochemically degraded with an estimated half-life of 8.2 hours.

## 5.2 Environmental distribution

### 5.2.1 Adsorption/Desorption

#### Soil adsorption study

Reference: Skinner, W., Shepler, K. and Estigoy, L. (1994), Soil adsorption/desorption of [<sup>14</sup>C] glutaraldehyde by the batch equilibrium method, PTRL West, Inc., The Dow Chemical Company Report No: K-020301-081, Unpublished, 29 March 1994.

This adsorption/desorption study was carried out in accordance with US EPA Guideline 163-1. Freundlich K values for adsorption ranged from 0.59 (sediment with 24.9% of total radioactivity adsorbed) to 4.94 (silty clay loam with 43.1% of total radioactivity adsorbed). Freundlich K values for desorption were not calculated, this was due to rapid degradation of glutaraldehyde which could not be measured in the desorption supernatants. Further details of the test are provided in Table 34.

**Conclusion:** Glutaraldehyde is mobile in sandy sediment and moderately mobile in the four studied soils.

**Table 34: Adsorption/desorption in four soils and one sediment**

| Guideline /Test method          | Soil                      | Adsorbed a.s. [%] | $K_a$ <sup>1</sup> | $K_{aOC}$ <sup>2</sup> | $K_d$ <sup>3</sup><br>$K_{dOC}$ <sup>4</sup><br>$K_a/K_d$ <sup>5</sup> | Degradation products  |             | Reference                |
|---------------------------------|---------------------------|-------------------|--------------------|------------------------|--|---|-------------|--------------------------|
|                                 |                           |                   |                    |                        |  | Name  | [%] of a.s. |                          |
| US EPA<br>FIFRA<br>163-1<br>GLP | Soil 1<br>Sandy loam      | 38.4              | 2.06               | 210                    | NR*  | Glutaric acid<br>(8 other trans-formation products but these were not identified as they formed less than 10% of applied radioactivity) | 0 - 4.8%    | Skinner et al.<br>(1994) |
|                                 | Soil 2<br>Silty clay loam | 43.1              | 4.94               | 500                    |  |   |             |                          |
|                                 | Soil 3<br>Silt loam       | 42.7              | 4.83               | 340                    |  |   |             |                          |
|                                 | Soil 4<br>Loamy sand      | 40.2              | 1.10               | 460                    |  |   |             |                          |
|                                 | Sediment<br>Sand          | 24.9              | 0.59               | 120                    |  |   |             |                          |

<sup>1</sup>  $K_a$  = Adsorption coefficient

<sup>2</sup>  $K_{aOC}$  = Adsorption coefficient based on organic carbon content

<sup>3</sup>  $K_d$  = Desorption coefficient

<sup>4</sup>  $K_{dOC}$  = Desorption coefficient based on organic carbon content

<sup>5</sup>  $K_a / K_d$  = Adsorption / Desorption distribution coefficient

NR\* = Not required. Due to the rapid degradation of glutaraldehyde desorption isotherms could not be determined.

### 5.2.2 Volatilisation

Glutaraldehyde is a volatile substance, with vapour pressure of 44 Pa at 20 °C (Table 11). Therefore, photochemical reactions in air may be important (see 5.1.1). However, based on the Henry's constant (0.0086 Pa×m<sup>3</sup>/mol), glutaraldehyde is not very volatile from a water solution.

### 5.2.3 Distribution modelling

Not relevant for this dossier.

### 5.3 Aquatic Bioaccumulation

#### 5.3.1.1 Bioaccumulation estimation

The estimation of bioaccumulation of glutaraldehyde was done on the basis of n-octanol/water partition coefficient, log K<sub>ow</sub> (Table 35). Glutaraldehyde has a low potential for bioaccumulation, as indicated by measured and calculated log K<sub>ow</sub> values. Glutaraldehyde is highly hydrophilic and lipophobic and therefore would not be expected to bioaccumulate. Log K<sub>ow</sub> values are -0.33 in one test (pH not reported) and -0.41 (pH 5), -0.36 (pH 7) and -0.80 (pH 9) in another. A calculation with the EPISUITE program is also available. The calculation method supported low bioaccumulation potential of glutaraldehyde. The calculated log K<sub>ow</sub> value is -0.18 (SRC KOWWIN v1.67).

**Table 35: Partition coefficient of glutaraldehyde**

| pH           | Temperature | result (log K <sub>ow</sub> ) | Reference       |
|--------------|-------------|-------------------------------|-----------------|
| 5            | 23 ± 1 °C   | -0.41                         | Sametschek 2002 |
| 7            | 23 ± 1 °C   | -0.36                         |                 |
| 9            | 23 ± 1 °C   | -0.80                         |                 |
| not reported | 25°C        | -0.33                         | Shepler 1996    |

#### 5.3.1.2 Measured bioaccumulation data

No experimental bioaccumulation data is available.

### 5.3.2 Summary and discussion of aquatic bioaccumulation

Glutaraldehyde is not expected to bioaccumulate in aquatic organisms.

### 5.4 Aquatic toxicity

The aquatic toxicity studies show that the concentration of glutaraldehyde in test water does usually not remain in range of 80 to 120 % of the nominal concentration. In some available ecotoxicity tests no analytical measurements were performed. In these cases deviation of more than 20% from the nominal concentration cannot be excluded because glutaraldehyde is known to be readily biodegradable and relatively reactive. Glutaraldehyde has the ability to react with proteins and as a result of this “chemisorption,” glutaraldehyde is likely bound by covalent chemical bonds to proteinaceous material and loses its identity as glutaraldehyde. Consequently studies without any analytical monitoring of test substance concentrations were considered as invalid and were not used for this report.

In most studies with measured concentrations glutaraldehyde was demonstrated to be very unstable during the test. This was considered to be related to the instability of the test substance in aqueous

media and/or adsorption of the test material in the test system (algal cells, *Daphnia*, glassware surfaces etc.). In addition, it was thought that yeast might have reacted with glutaraldehyde and further reduced glutaraldehyde concentrations. The oxidation sensitivity of the test substance was also speculated to be in relation to the reduction of the test concentrations.

In those studies where concentrations of glutaraldehyde did not remain 80-120% of nominal, the effect concentrations were expressed relative to geometric mean or arithmetic mean concentrations depending on the test conditions (static/semi-static/flow-through) as instructed in the OECD Guidance Document on Aquatic Toxicity Testing of Difficult Substances and Mixtures (OECD, 2000).

**All ecotoxicological studies have been performed with an aqueous solution of glutaraldehyde (appr. 50 %). To the best of knowledge the results are considered as 100 % glutaraldehyde for this report.**

**Table 36: Summary of relevant information on aquatic toxicity**

| Method  | Results   | Remarks  | Reference                   |
|---|---|--|-----------------------------|
| Short-term toxicity to fish<br>US EPA FIFRA 72-3<br>GLP                                     | LC <sub>50</sub> 32 mg active substance<br>(a.s.)/L             | Marine species   | Machado, M.W.<br>1993a      |
| Long-term toxicity to fish<br>ASTM method, Non-GLP  | NOEC 1.0 mg a.s./L  |  | Sano et al. 2005            |
| Short-term toxicity to aquatic<br>invertebrates<br>UK Proposal to ISO<br>TC147/SC5/W92, GLP | <b>LC<sub>50</sub> 0.07 mg a.s./L</b>                           | Marine species<br>Results based on the<br>geometric mean of the<br>measured<br>concentrations. | Wetton and<br>Bartlett 1997 |
| Long-term toxicity to aquatic<br>invertebrates<br>OECD 211, GLP                             | NOEC 0.26 mg a.s./L   | Results based on the<br>arithmetic mean.   | Migchielsen,<br>M.H.J. 2003 |
| Growth inhibition on algae<br>92/69/EEC C.3, GLP  | <b>NOECr 0.025 mg a.s./L</b><br>ErC <sub>50</sub> 0.6 mg a.s./L | Results based on the<br>geometric mean of<br>the measured<br>concentrations.                   | Maisch, R. 1997             |

## 5.4.1 Fish

### 5.4.1.1 Short-term toxicity to fish

Only one 96-h acute fish test with measured concentration is available. It was carried out with the marine fish species Sheepshead Minnow giving LC<sub>50</sub> value of 32 mg active ingredient (a.i.) /l for acute fish toxicity indicating Glutaraldehyde to be harmful to marine fish (Sheepshead Minnow).

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### Test 1

Reference: Machado, M. W., 1993a Glutaraldehyde - Acute Toxicity to Sheepshead Minnow (*Cyprinodon variegatus*) Under Flow-Through Conditions, Springborn Laboratories Inc., The Dow Chemical Company Report No: K-020301-010, Unpublished, 13 April 1993

The acute toxicity of glutaraldehyde (purity 51%, remainder water, batch number 566756) to the marine species Sheepshead minnow (*Cyprinodon variegatus*) was determined under flow-through conditions for 96 hours. The test was carried out in compliance with GLP and according to US EPA FIFRA 72-3 guideline. Fish were acclimated to test conditions for a minimum of 14 days. Immature individuals with mean wet weight of 0.31 (0.14-0.51) g and mean length of 24 (19-28) mm were used in the test. All treatment levels and the controls were maintained in duplicate and 10 fish/vessel were used. Mean analytical concentrations based on analyses in the beginning and at the end of the test were 2.9, 4.9, 9.2, 14, 24 and 41 mg a.i./L (averaging 99 % of nominal dose). Dissolved oxygen varied 5.8-7.1 mg/L (81-100 %) in vessels. Test temperature ranged 21-23 °C and pH 7.9-8.2. LC<sub>50</sub> 96 h was determined to be 32 mg a.i./l based on the mean measured concentrations (95 % confidence interval 24-52 mg a.i./L).

**Table 37: Acute toxicity to fish**

| Guideline Test method | Species  | Endpoint  | Exposure     |          | Results mg a.s./L |                  |                   | Remarks                           | Study owner Reference |
|-----------------------|--|-----------|--------------|----------|-------------------|------------------|-------------------|-----------------------------------|-----------------------|
|                       |  |           | design       | duration | LC <sub>0</sub>   | LC <sub>50</sub> | LC <sub>100</sub> |                                   |                       |
| US EPA FIFRA 72-3 GLP | Sheepshead minnow <i>Cyprinodon variegatus</i> | Mortality | Flow-through | 96 h     | 24                | 32               | 41                | Key study Meas. conc. Marine spec | Machado, M.W. 1993a   |

### 5.4.1.2 Long-term toxicity to fish

#### Effects on reproduction and growth rate in fish

Three long-term studies are available in fish, all carried out with freshwater species. NOEC values derived from the three studies are close to each other, ranging from 1.0 to 1.6 mg a.s./L. The study with the lowest test result is chosen as the key study giving NOEC value of 1.0 a.i. mg /l indicating glutaraldehyde to be slightly toxic to fish (*Oncorhynchus mykiss*) in long-term. The studies are summarized in Table 38.

### Test 1

Reference: Sano, L.L., Krueger, A.M. and Landrum, P.F. (2005) Chronic toxicity of glutaraldehyde: different sensitivity of three freshwater organisms, *Aquatic Toxicity*, 71:283-296

Long-term toxicity of glutaraldehyde (purity 50 %, remainder water) to the early-life stages of Rainbow trout (*Oncorhynchus mykiss*) was investigated under semi-static conditions according to ASTM (1998c) method. The experiment lasted 62 days and it was not carried out in compliance with GLP. Initial nominal test concentrations of test substance were 0, 0.6, 1.3, 2.5, 5.1, 13.6 mg/l and the actual concentrations were measured both prior to and after renewing test solution which was done daily (24-hour weighted averages -0.1, 0.6, 1.3, 2.5, 5.1 and 13.6 mg/l). Four vessels per concentration were used and 30 embryos were placed in each vessel. Dissolved oxygen

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concentration was not specified and the water temperature ranged 9-13°C and therefore the temperature range was higher than the maximum range ( $\pm 1.5$  °C) recommended in the guideline. Daily observations were made on embryo condition (alive/dead/deformed) and hatching time. Glutaraldehyde concentrations fluctuated substantially both over the 24-h period between solution renewals and over the 62-day exposure period. For the embryonic period (through hatch-out, day 34) the initial renewing solution was close to the nominal concentration but by the end of the 24-h period, most concentrations had decreased by an average of 20 %. After day 35, test solutions declined on an average of 65 % over the 24-h period between renewals. In addition, the concentration in the renewed solution was often much lower than the nominal value (usually about 50 % less). The results are separated out by the two different exposure periods, pre-hatch (embryonic) and post-hatch (sac-fry and larval). Survival rates of embryos, up until day 25, were comparable for all concentrations tested including the controls. Although most of the embryos survived the initial embryonic period, the majority of organisms at the 2.5 mg/l treatment level and higher were not able to hatch from the embryo stage into the sac-fry stage. After the 10-day post-hatch period (up to day 35), only 3 % of the surviving embryos treated at 2.5 mg/l had successfully emerged from the chorion and none of the embryos at the higher concentrations had survived. Even at concentrations as low as 1.3 mg/l embryos had difficulty emerging from the chorion. The survival rates were estimated separately due to the large effect of glutaraldehyde exposure on hatching success and due to differences in measured glutaraldehyde concentrations over the experimental period. Larval fish were followed for 27 days after hatching, through the alevin and the fry stages. At the end of this period, there was no significant difference between survival in the controls and the two remaining treatments (0.4 and 1.0 mg/l). The overall estimated NOEC for this experiment (embryo to fry stage) was 1.0 mg/l, and the LOEC was 2.5 mg/l.

### Test 2

Reference: Roberts, C.A., Drottar, K.R., Swigert, J.P. and Krueger, H.O. (1999) Ucarcide® 250 Antimicrobial: An early life-stage toxicity test with the Fathead minnow (*Pimephales promelas*), Wildlife International Ltd., Unpublished, 22 January 1999

Effects of glutaraldehyde (purity 50.9%, remainder water, batch number IS-720843) on early life-stage of Fathead minnow was studied according to FIFRA 72-4 and OECD 210 during 32 days. The test was conducted under flow-through conditions and in compliance with GLP. Two replicates were used per concentration and 40 embryos per replicate were placed (80 totals per dose level). Initial nominal concentrations of test substance were 0.38, 0.77, 1.5, 3.0 and 6.0 mg/l. The mean measured concentrations were 81-98% of the nominal concentrations except in the lowest test concentration where the mean measured concentration was 76% of the nominal concentration. The temperature ranged during the test from 24.5°C to 26.0°C. Effects parameters were time to hatch, hatching success, survival and growth. There were no significant differences in time of hatching or hatching success between the control and any treatment groups. The survival was the most sensitive parameter. It was statistically reduced at the level of 2.9 and 5.9 mg a.i./l. Post-hatch growth was also reduced in the same groups when compared to the negative controls. NOEC of glutaraldehyde to Fathead minnow was determined to be 1.4 mg a.i./l (survival and growth) based on the measured concentrations.

### Test 3

Reference: Zok, S. (2000) Protectol GDA (50 % Glutaraldehyde) - Early Life-Stage toxicity test on the Rainbow trout (*Oncorhynchus mykiss*). BASF AG, Department of Product Safety, Ludwigshafen/Rhein, Germany, Report No: 52F0447/975114 (Unpublished).

The toxicity of glutaraldehyde (purity 48.15 %, remainder water, batch number 40-2699) to early life-stage of Rainbow trout was assessed in a 97 days study under flow-through conditions. The test was run according to FIFRA 72-4 and OECD 210 (1992) and it was done in compliance with GLP. Initial nominal test concentrations were 0, 0.32, 1.0, 3.2 and 10 mg/, mean analytically determined test concentrations were 0.28 (0.1-0.44), 0.79 (0.3-1.27), 3.41 (2.8-4.0) and 10.58 (9.4-12.5) mg/l. Four replicates for each test concentration and control were used (25 fertilized eggs in each test vessel) and two replicates as viable control for the first 14 days. For monitoring test substance concentration samples were taken on day zero and then generally at weekly intervals and generally alternating from all test aquaria generally before the replacement of the stock solutions. The lower concentrations were near the analytical detection limit. A reliable analytical determination was therefore difficult. The dilution system was checked regularly and no technical problems occurred which could explain the deviation from the theoretical concentration values. The relevant concentrations for the determination of the effect concentrations were within the range of  $\pm 20\%$  of the nominal concentrations, with the only exception: in one week values of 125% of the nominal concentrations were determined. Dissolved oxygen was maintained in a range between 8.3 and 11.3 mg/l, corresponding to 70-100% of the saturation at the test temperature. Test temperature maintained at the  $10 \pm 1$  °C throughout the study in all aquaria. Survival, time to hatch and swim-up, toxic signs and abnormalities, body weight and length were evaluated. NOAEC and LOAEC for survival was determined to be 1.6 mg a.i./l and 5 mg a.i./l, respectively based on the measured concentrations.

**Table 38: Long-term toxicity to fish**

| Guideline / Test method        | Species  | Endpoint / Type of test                              | Exposure     |          | Results mg a.s./L | Remarks                  | Study owner Reference |
|--------------------------------|--|--|--------------|----------|-------------------|--------------------------|-----------------------|
|                                |  |  | design       | duration | NOEC              |                          |                       |
| ASTM method<br>Non-GLP         | Rainbow trout<br>( <i>Oncorhynchus mykiss</i> )  | Embryo larval survival and growth                    | Semi-static  | 62 d     | 1.0               | Key study<br>Meas. conc. | Sano et al. 2005      |
| FIFRA 72-4/<br>OECD 210<br>GLP | Fathead minnow<br>( <i>Pimephales promelas</i> ) | Time to hatch, hatching success, survival and growth | Flow-through | 32 d     | 1.4               | Meas. conc.              | Roberts et al. 1999   |
| OECD 210<br>GLP                | Rainbow trout<br>( <i>Oncorhynchus mykiss</i> )  | Time to hatch, hatching success, survival and growth | Flow-through | 97 d     | 1.6               | Meas. conc.              | Zok S. 2000           |

## 5.4.2 Aquatic invertebrates

### 5.4.2.1 Short-term toxicity to aquatic invertebrates

In total five acute tests on invertebrates with measured concentrations are available. All of them were performed on marine species. The most sensitive species was a marine copepod, *Acartia tonsa*, with  $LC_{50}$  of 0.07 mg a.s./L. The toxicity value for *Acartia tonsa* was an order of magnitude lower than that for the next most sensitive species, the Eastern oyster. For other species, the test result exceeded 1 mg/L. This test was chosen as the key study. The result indicated glutaraldehyde to be acutely very toxic to marine copepod *Acartia tonsa*. All tests are summarized in Table 39.

#### Test 1

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Reference: Wetton, P.M. and Bartlett, A.J. (1997) Ucarcide Antimicrobial 250: Acute Toxicity to *Acartia Tonsa*, Safepharm Laboratories Limited, The Dow Chemical Company Report No: DR-0222-1070-033, Unpublished, 24 April 1997

Acute toxicity of glutaraldehyde (purity 50.9, remainder water) to a marine crustacean, *Acartia tonsa*, was investigated in a 48 hours test under static condition. Test was indicated to be GLP compliant and done according to UK proposal to ISO TC147/SC5/WG92. Potassium dichromate was used as a reference substance, and an additional control group was maintained under identical conditions but not exposed to the test material. Four replicates per each test concentration were used and five copepods at least 14 days old were placed per test vessel. Initial nominal concentrations were 0.01, 0.018, 0.032, 0.056, 0.1, 0.18, 0.32, 0.56 and 1.0 mg/l. Actual concentrations were analysed for nominal concentration of 0.01, 0.032, 0.1, 0.32 and 1.0 at the initial of the test giving a mean average recovery of 99,6 %. At the termination of the test (48 h) analyses were conducted for all exposure levels. Measured concentrations were ranging then from 8-33 % of the nominal and measured initial test concentrations. Pre-study analysis of the test material (Ucarcide Antimicrobial 250) had showed it to be stable over the exposure period; hence the marked decline in glutaraldehyde concentrations during the experiment was thought to be result from biodegradation in the seawater. The water temperature was maintained at 20-22 °C. Dissolved oxygen (ranging from 7.8 to 8.5 mg/l) and pH (ranging from 8.1 to 8.2) were recorded at the start and end of the test. Test parameters were mortality and sublethal effects. Because of the substantial decline of test substance concentrations, LC<sub>50</sub> (48 h) value was calculated based on the geometric mean of the measured concentrations, resulting LC<sub>50</sub> to be of 0.07 mg a.i./l with confidence limits of 0.058-0.084 mg a.i./L.

### Test 2

Reference: Dionne, E. (1993) Glutaraldehyde - Acute Toxicity to Eastern oysters (*Crassostrea virginica*) Under Flow-Through Conditions, Springborn Laboratories, Inc., The Dow chemical Company, Report No: K-020301-011, Unpublished, 7 September 1993

Acute toxicity of glutaraldehyde to *Crassostrea virginica* was studied in a 96 h test under flow-through conditions. Test was carried out in compliance with GLP and according to US EPA FIFRA 72-3 with minor deviations. Two vessels per concentrations were used in the test and 20 animals were placed per vessel after 14-day acclimation. Nominal concentrations were 0.12, 0.19, 0.32, 0.54 and 0.90 mg a.i./l. Measured concentrations were consistent between replicate samples but decreased by an average of 35 % between 0 and 96 hours of exposure. Measured concentrations obtained at 96-hours for the lowest treatment level tested were below the established limit of quantification. This decrease was attributed to adsorption of the test material to the high concentration of organisms present in unfiltered salt water, combined with high density of algal cells added as food which accumulated over the exposure period. Based on the mean measured concentrations, the concentrations of glutaraldehyde tested were defined as 0.71, 0.33, 0.16, 0.11 and 0.068 mg/l, which averaged 61 % of the nominal. The water temperature varied 18-22 °C. Test parameters were shell growth and sublethal effects, The 96 hour EC<sub>50</sub> for *Crassostrea virginica* was 0.78 mg a.i./L based on mean measured concentrations and biological responses. The NOEC was determined to be 0.16 mg a.i./l.

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### Test 3

Reference: Sousa, J.V. (1995) Glutaraldehyde - Acute toxicity to Mysids (*Mysidopsis bahia*) under flow-through conditions. Springborn Laboratories Inc., Environmental Sciences Division, Wareham, Massachusetts, SLI Report No. 94-12-5603 (Unpublished)

Acute toxicity of glutaraldehyde (purity 50.2 %, remainder water) to marine invertebrates *Mysidopsis bahia* was investigated under flow-through conditions during 96 hours. The study was GLP compliant and was run according to FIFRA Guideline No: 72-3. US EPA (1985). Nominal concentrations were 0.62, 1.0, 1.7, 2.9, 4.8 and 8.0 mg a.i./l. Mean measured concentrations over the test period (measured at the test initiation and ending) were 0.38, 0.71, 1.1, 2.4, 4.5 and 76 mg a.i./l corresponding to 62-95% percentages of nominal concentrations. Two replicates were used per test concentration and 10 mysids were placed per chamber. Test temperature was maintained at 25 ±1 °C. Dissolved oxygen was >3 mg/l in all test vessels ranging between 89 - 102 % of saturation and pH varied between 7.75 and 7.9. Test parameters were mortality and biological observations (absence of mobility or response to gentle prodding). At the 4.5 mg a.i./l 10 % mortality was recorded after 72 hours. At the highest test concentrations of 7.6 mg a.i./l, mortality was 45 % after 48 hours and reached 100 % after 96 h. From 1.1 mg a.i./l sublethal effects were seen. LC<sub>50</sub> value (96h) was determined to be 5.5 mg a.i./l (95 % confidence limits 4.5-7.6 mg/l) based on the measured concentrations and NOEC was 0.71 mg a.i./l.

### Test 4

Reference: Machado, M.W. (1993b) Glutaraldehyde - Acute Toxicity to Mysid Shrimp (*Mysidopsis bahia*) Under Flow-Through Conditions, Springborn Laboratories, Inc., The Dow chemical Company, Report No: K-020301-018, Unpublished, 7 September 1993

Acute toxicity of glutaraldehyde to Mysid Shrimp (*Mysidopsis bahia*) was studied during 96 hours under flow-through conditions and according to US EPA FIFRA 72-3 with minor deviations. Two vessels were used at each of the five test concentrations and control and ten animals were placed per aquarium. Nominal concentrations were 0.78, 1.3, 2.2, 3.6, 6.0, 10 mg a.i./l and mean measured concentrations were 0.78, 1.5, 2.5, 3.9, 6.8 and 12 mg a.i./l, averaging 112 % of nominal concentrations. Dissolved oxygen ranged during the study from 6.9 to 7.3 mg/l and temperature varied between 25 and 26 °C. Mortality and sublethal effects were observed at the initiation of the test and at every 24 hour interval during the exposure period. LC<sub>50</sub> was established at 7.1 mg a.i./l with 95 % confidence interval 6.0-8.6 mg a.i./l and the NOEC was 0.78 mg a.i./l based on the mean measured concentrations.

### Test 5

Reference: Caferella, M.A. (2006): Glutaraldehyde - Acute Toxicity to White Shrimp (*Penaeus vannamei*) Under Flow-Through Conditions, Springborn Smithers Laboratories, The Dow Chemical Company Report No: K-020301-114, Unpublished, 27 February 2006

Acute toxicity of glutaraldehyde to White Shrimp (*Penaeus vannamei*) was investigated under flow-through conditions for 96 hours. Test was carried out according to EPA OPPTS 850.1045 and was indicated to be GLP compliant. Initial test concentrations were 0, 3.8, 7.5, 15, 30, 60 and 120 mg a.i./l. Actual mean measured concentrations were 0, 4.4, 6.2, 18, 31, 61, and 120 mg a.i./l. Two vessels were used at each test concentration including control and ten juvenile shrimps were placed in each vessel. Acclimatization for at least 14 days was reported. Oxygen content was 7.3-7.9 mg/l (96-104 % of saturation). Temperature maintained at 23 °C throughout the study and pH was at 8.0. Test parameters mortality and sublethal effects were observed at 0, 3, 6, 12, 24, 48, 72 and 96

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hours. LC<sub>50</sub> 96 h was 68 mg a.i./l based on the mean measured concentrations with 95 % confidence interval 52-96 mg a.i./l.

**Table 39: Acute toxicity to invertebrates**

| Guideline / Test method              | Species                                     | End-point | Exposure     |          | Results mg a.s./L |                    |                     | Remarks   | Study owner Reference    |
|--------------------------------------|---|-----------|--------------|----------|-------------------|--------------------|---------------------|---|--------------------------|
|                                      |   |           | design       | duration | E/LC <sub>0</sub> | E/LC <sub>50</sub> | E/LC <sub>100</sub> |   |                          |
| UK Proposal to ISO TC147/SC5/W92 GLP | <i>Acartia tonsa</i>                        | Mortality | Static       | 48 h     |                   | 0.07               | >0.18               | Key study Meas. conc. Marine spec. Results based on the geometric mean of the measured concentrations | Wetton and Bartlett 1997 |
| US EPA FIFRA 72-2 GLP                | Eastern oyster <i>Crassostrea virginica</i> | Growth    | Flow-through | 96 h     | 0.16              | 0.78               |                     | Meas. conc. Marine spec.  | Dionne, E. 1993          |
| FIFRA Guideline No: 72-3 GLP         | Mysid shrimp <i>Mysidopsis bahia</i>        | Mortality | Flow-through | 96 h     | ~4.5              | 5.5                | 7.6                 | Meas. conc. Marine spec.  | Sousa, JV. 1995          |
| US EPA FIFRA 72-3 GLP                | Mysid shrimp <i>Mysidopsis bahia</i>        | Mortality | Flow-through | 96 h     | 0.78              | 7.1                | >12                 | Meas. conc. Marine spec.  | Machado, M.W. 1993b      |
| EPA OPPTS 850.1045 GLP               | White shrimp <i>Penaeus vannamei</i>        | Mortality | Flow-through | 96 h     | 18                | 68                 | >120                | Marine spec. Meas. conc.  | Caferella, M.A. 2006     |

### 5.4.2.2 Long-term toxicity to aquatic invertebrates

#### Effects on reproduction and growth rate in invertebrates

One reproduction tests on *Daphnia magna* and a reproduction test on *Ceriodaphnia dubia* were available. The study with the lowest NOEC of 0.12 mg a.s./L was chosen as the key study which indicated glutaraldehyde to be toxic to *Daphnia magna* in long-term. The studies are summarized in

Table 40.

#### Test 1

Reference: Migchielsen, M.H.J. (2003) *Daphnia magna*, Reproduction Test with Glutaraldehyde 50 % (flow-through), Notox Safety Environmental Research, The Dow Chemical company Report No: K-020301-115, Unpublished, 10 April 2003

The effects of glutaraldehyde 50% on reproduction and growth of *Daphnia magna* was tested under flow-through conditions for 21 days. Test was run according to OECD 211 guideline and was indicated to be GLP compliant. For each test concentration including control there was one stainless steel vessel (1.5 l) with 4 mesh containers of stainless steel. Ten daphnids (<24 hours old) were placed in each mesh container. Nominal concentrations were 0.9, 1.3, 2.1, 3.3, 4.5 mg a.i./l. Measured concentrations were 88-106 % of target concentrations at the initiation of the test but dropped significantly on sampling days 7, 14 and 21, ranging from 7 to 25 % of nominal concentrations. Temperature ranged from 19.6 C° to 22.2 C° and pH was 7.4-8.1. The dissolved oxygen was reported to be 6.9-8.9. As instructed in the OECD Guidance Document on Aquatic Toxicity Testing of Difficult Substances and Mixtures (ENV/JM/MONO(2000)6) the effects concentrations used are based on the arithmetic mean concentrations resulting to the NOEC for reproduction is 0.26 mg/l.

#### Test 2

Reference: Jatzek H-J (1993) Determination of the chronic toxicity of Protectol GDA to *Daphnia magna*. BASF AG, Department of Ecology, Ludwigshafen/Rhein, Germany, Report No: 93/0406/51/2 (Unpublished)

The chronic toxicity of glutaraldehyde 50% (remainder water) to *Daphnia magna* was tested under semi-static conditions for 21 days. Ten daphnids (2-24 hours old) were used per concentration and one animal was placed individually per test vessel (ten vessels per concentrations). Test solutions were changed 2 times a week. Nominal test concentrations were 0, 0.039, 0.078, 0.156, 0.313, 0.625, 1.25, 2.5, 5, 10 and 20 mg/l. Analytical monitoring was performed for nominal concentrations of 0, 0.156, 1.25, 20 and 100 (stock solution) mg/l each week. For each concentration, the freshly prepared test solution and the corresponding 48 h or 72 h old test solution (with or without *Daphnia*) were analysed. For smaller concentrations (0.156, 1.25 mg/l) measured concentrations were significantly below the expected values but the actual values were not demonstrated. This reduction was speculated to be in relation to the oxidation sensitivity of the test substance. For the higher concentrations (20 and 100 mg/l), the measured concentrations were as expected (95-100% of the nominal values). Daphnids were examined daily for mortality and reproduction. No significant effects were observed on reproduction or offspring at the low concentrations, and no parental mortality was observed. In the 20 mg/l group 100% mortality was reached after 2 days. Temperature varied between 18.7-21.2 °C during the test. Oxygen content was in the range of 7.1 to 9.2 mg/l and pH 7.5-8.5. NOEC (21 d) was 5 mg/l based on the nominal concentrations.

**Table 40: Long-term toxicity to invertebrates**

| Guideline / Test method               | Species              | Endpoint /Type of test            | Exposure     |          | Results (mg a.s./L) | Remarks  | Study owner Reference    |
|---------------------------------------|----------------------|-----------------------------------|--------------|----------|---------------------|--|--------------------------|
|                                       |                      |                                   | design       | duration | NOEC                |  |                          |
| OECD 211<br>GLP                       | <i>Daphnia magna</i> | Survival, growth and reproduction | Flow-Through | 21 d     | 0.13                | Key study<br>Meas. conc.<br>Result based on arithmetic mean concentrations | Migchielsen, M.H.J. 2003 |
| Directive XI/681/86<br>Draft 4<br>GLP | <i>Daphnia magna</i> | Survival, growth and reproduction | Semi-static  | 21 d     | 5                   | Result based on nominal concentrations                                     | Jatzek, H-J. 1993        |

### 5.4.3 Algae and aquatic plants

#### Growth inhibition on algae

Two algae studies on freshwater species and one test on marine species are available. The three algal studies showed approximately equal toxicity to algae. The study with the green alga *Scenedesmus subspicatus* was chosen as a key study with the ErC<sub>50</sub> of 0.6 mg a.s./L and NOEC of 0.025 mg a.s./L. The results indicated glutaraldehyde to be very toxic to green alga (*Scenedesmus subspicatus*). The results of available studies in algae with Glutaraldehyde are summarised in Table 41.

#### Test 1

Reference: Maisch, R. (1997): Determination of the inhibitory effect of Basolon GDA 50 on cell multiplication of unicellular green algae. BASF AG, Department of Ecology, Ludwigshafen/Rhein, Germany, Report No: 97/0329/60/1 (Unpublished)

The effect of Basolon GDA 50 (glutaraldehyde 50%, remainder water) on the growth of green alga *Scenedesmus subspicatus* was determined in a 72 h test under static condition. Test was carried out according to Directive 92/69/EEC, C.3 (1992) and in compliance with GLP. Initial nominal test concentrations were 0.025, 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, and 12.8 mg/l. The analytical monitoring was performed to nominal concentrations of 0, 0.1, 1.6 and 12.8 mg/ which indicated a recovery rate > 80 % and therefore the effect concentrations were based on the nominal values. The initial cell density of *Scenedesmus subspicatus* was 104 cell/ml. Temperature during the test was 23 ±2 °C and pH in the range of 7.8-9.4. Fluorescence measurements were performed after 0, 24, 48 and 72 hours. NOEC<sub>r</sub> was determined to be 0.025 mg a.i./l and ErC<sub>50</sub> 0.6 mg a.i. /l.

#### Test 2

Reference: Mead, C. and Bartlett, A.J. (1997) Ucarcide Antimicrobial 250: Marine Algal inhibition Test, Safepharm Laboratories Limited, The Dow Chemical Company Report No: DR-0222-1070-032, Unpublished, 30 April 1997

The effect of glutaraldehyde, 50% (purity 50.9%, remainder water) on the growth of marine algae *Skeletonema costatum* was investigated in a 72 h test under static conditions according to ISO/DIS 10253 and in compliance with GLP. Target test concentrations were 0.625, 1.25, 2.5, 5.0 and 10 mg/l. The actual initial test concentrations were 0.607, 1.28, 2.54, 5.12 and 9.8 mg/l. At the end of

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the test (72 h) the actual concentrations were not detectable at the two lowest nominal concentrations of 0.625 and 1.25 mg/l. The remaining values were quantified at 0.935, 2.53 and 7.94 mg/l corresponding 37, 51 and 79 % of the nominal concentration, indicating that the test substance concentrations did not remain at > 80 % of initial concentrations during the test. Test temperature was  $24 \pm 1$  °C and pH was measured at the start of the test (ranging from 7.8 to 8.0) and at the end (ranging from 8.1 to 10.4). Results based on the geometric mean of the measured concentrations were: ErC<sub>50</sub> 0.61 mg a.i./l (72 h) with 95 % confidence limit 0.21-1.0 mg a.i./l and NOEC 0.071 mg a.i./l (72 h).

### Test 3

Reference: Migchielsen, M.H.J. (2001) Fresh water algae growth inhibition test with glutaraldehyde 50 %, NOTOX Safety and Environmental Research The Dow Chemical Company Report No: K-020301-095, unpublished, 19 June 2001

The inhibitory effect of glutaraldehyde 50 % (remainder water, Batch number 12863) on the growth of fresh water green algae *Selenastrum capricornutum* was studied in a 72 h test under static condition. Test was conducted to OECD 201 and indicated to be GLP compliant. Algal cell density was 104 cell/ml in the beginning of the test. Three replicates were used in each test concentration. Initial nominal test concentrations were 0.025, 0.05, 0.11, 0.24, 0.52, 1.14 and 2.5 mg a.i./l. Only four highest test concentrations (0.24, 0.52, 1.13 and 2.5 mg/l) were detectable at 0, 24, 48 and 72 hours. Mean measured concentrations were 0.054, 0.23, 0.69 and 1.81 mg/l, respectively. Temperature ranged between 22.0 and 23.5 °C during the test. pH increased towards the end of the study (at the start 7.6-7.8 and at the end 8.0-10.3). ErC<sub>50</sub> was determined to be 0.82 mg a.i./l with confidence limits 0.76-0.88 mg/l and NOEC was 0.108 mg a.i./l. The results are based on the geometric mean concentrations of measurements in test concentrations 0.24, 0.52, 1.14 and 2.5 mg/l.

**Table 41: Growth inhibition on algae**

| Guideline Test method | Species                          | Endpoint          | Exposure |          | Results mg a.s./L  |   |   | Remarks  | Study owner Reference    |
|-----------------------|----------------------------------|-------------------|----------|----------|--------------------|---|---|--|--------------------------|
|                       |                                  |                   | design   | duration | NOE <sub>r</sub> C | E <sub>b</sub> C <sub>50</sub> <sup>1</sup> | E <sub>r</sub> C <sub>50</sub> <sup>2</sup> |  |                          |
| 92/69/EEC C.3 GLP     | <i>Scenedesmus subspicatus</i>   | Growth inhibition | Static   | 72 h     | 0.025              | 0.38  | 0.6   | Key study Meas. conc, Results based on nominal | Maisch R. 1997           |
| ISO/DIS 10253 GLP     | <i>Skeletonema costatum</i>      | Growth inhibition | Static   | 72 h     | 0.071              | 0.19  | 0.61  | Meas. conc. geometric mean. Marine spec.       | Mead and Bartlett 1997   |
| OECD 201 GLP          | <i>Selenastrum capricornutum</i> | Growth inhibition | Static   | 72 h     | 0.108              | 0.52  | 0.82  | Meas. conc; geometric mean.                    | Migchielsen, M.H.J. 2001 |

<sup>1</sup> calculated from the area under the growth curve

<sup>2</sup> calculated from growth rate

#### **5.4.4 Other aquatic organisms (including sediment)**

Not evaluated in this dossier.

#### **5.5 Comparison with criteria for environmental hazards (sections 5.1 – 5.4)**

##### CLP (2nd ATP) criteria

Glutaraldehyde is rapidly degradable in the environment as shown by ready biodegradability tests. Glutaraldehyde does not have a tendency to bioaccumulate, as shown by Log Kow values. Based on aquatic acute toxicity tests, glutaraldehyde is classified as "Aquatic Acute 1" and M factor of 10 must be used for classification of mixtures on the basis of acute toxicity. Based on aquatic chronic toxicity tests, glutaraldehyde is classified as "Aquatic chronic 2".

##### DSD criteria

Glutaraldehyde is readily degradable in the environment as shown by ready biodegradability tests. Glutaraldehyde does not have a tendency to bioaccumulate, as shown by Log Kow values. Based on aquatic acute toxicity tests, glutaraldehyde is classified as "Dangerous for the environment; Very toxic to aquatic organisms".

**Table 42: Comparison of glutaraldehyde data with criteria for environmental hazards**

| Endpoint                 | Results   | Comparison with classification criteria  |
|--------------------------|---|--|
| Degradation              | Glutaraldehyde is <b>hydrolytically stable</b> at environmentally relevant conditions.<br>Glutaraldehyde is <b>readily biodegradable</b> under test conditions, as indicated by the DOC removals of 74 and 88% reached during 7-9 days from the start of the experiments. | According to CLP and DSD criteria, <b>Glutaraldehyde is readily/rapidly degradable in the environment</b> , based on ready biodegradation. According to both regulations, a substance is regarded as readily/rapidly degradable if DOC removal of 70% is reached fulfilling the 10-day window.   |
| Bioaccumulation          | Log K <sub>ow</sub> -0.80 to -0.36 (pH 5-9, 25°C)   | The measured log Kow values are below the two classification criteria: Log K <sub>ow</sub> < 4 (CLP) and Log K <sub>ow</sub> < 3 (DSD). Therefore, according to CLP and DSD criteria, <b>Glutaraldehyde does not have a tendency to bioaccumulate.</b>   |
| Acute aquatic toxicity   | <i>Acartia tonsa</i> EC <sub>50</sub> = 0.07 mg/L   | Glutaraldehyde fulfills the criteria for <b>N; R50</b> classification according to Directive 67/548/EEC (DSD) and the criteria for the proposed classification as <b>H400</b> according to Regulation EC 1272/2008 (CLP) (namely L(E)C <sub>50</sub> ≤ 1 mg/l). In the case of the H400 classification according to CLP, an <b>M-factor of 10</b> is applicable based on 0.01 < L(E)C <sub>50</sub> ≤ 0.1 mg/l. In the case of DSD classification, a specific concentration limit of C ≥ 2.5% shall be applied with the <b>N; R50</b> classification. It should be noted that N; R50-53 classification, however, is not applicable to glutaraldehyde, due to the ready biodegradability and the absence of bioaccumulation tendency. |
| Chronic aquatic toxicity | <i>Scenedesmus subspicatus</i> NOECr (72 h) = 0.025 mg/l<br><i>Skelatonema costatum</i> NOEC(72 h) = 0.071 mg/l   | According to CLP (2 <sup>nd</sup> ATP), in the case of rapidly degradable substances, <b>H411</b> classification is applicable based on 0.01 < NOEC ≤ 0.1 mg/l. Therefore, glutaraldehyde fulfills the criteria for H411 according to Regulation EC 1272/2008.   |

## 5.6 Conclusions on classification and labelling for environmental hazards (sections 5.1 – 5.4)

### Conclusion of environmental classification according to Directive 67/548/EEC

Glutaraldehyde should be classified Dangerous for the Environment with the following risk and safety phrases:

**N** Dangerous for the Environment

**R50** Very toxic to aquatic organisms

**S61** Avoid release to the environment. Refer to special instructions/safety data sheet

Specific concentration limit  $C \geq 2.5\%$  shall be applied with the N; R50 classification.

Conclusion of environmental classification according to Regulation EC 286/2011 (2<sup>nd</sup> ATP to EC 1272/2008)

Based on the CLP Regulation, Glutaraldehyde should be classified as:

|                           |   |
|---------------------------|---|
| Classification categories | aquatic <b>acute category 1, M factor 10</b>                  |
|                           | aquatic <b>chronic category 2</b>                             |
| Hazard Statement          | <b>H400</b> 'Very toxic to aquatic life',                     |
|                           | <b>H411</b> 'Toxic to aquatic life with long lasting effects' |

In the labelling H400 and H411 are combined resulting to Hazard Statement H410 'Very toxic to aquatic life with long lasting effects'

### RAC evaluation of environmental hazards

#### Summary of the Dossier submitter's proposal

The DS proposed to add the classification as aquatic chronic 2 for long-term aquatic hazard to the existing annex VI entry. Moreover, the DS proposed to add the acute M-factor = 10. Following the PC, the DS changed the proposal to acute M-factor = 1. The proposed additions were based on the following arguments:

- Glutaraldehyde is rapidly degradable in the environment as shown by two ready biodegradability tests conducted according to the OECD guideline 301 A, providing a biological degradation of 74% after 9 days and 88% after 7 days, respectively.
- Glutaraldehyde does not have a tendency to bioaccumulate, as shown by the Log Kow values (at pH 5: -0.41; at pH 7: -0.36; at pH 9: -0.80).
- The results of an aquatic acute toxicity test on marine invertebrates (*Acartia tonsa*) provided an  $EC_{50} = 0.07$  mg/L. Following the information submitted during the PC, the DS concluded that this value was no longer valid and should be substituted by the result of a new test on the same test organism ( $LC_{50} = 3.0$  mg/L (nominal)). As a consequence, the most sensitive species is the algae *Scenedesmus subspicatus*, with an  $ErC_{50}$  of 0.6 mg/L, which was used for updating the originally proposed M-factor.
- The result of the aquatic chronic toxicity test conducted on *Scenedesmus subspicatus*, providing a  $NOECr (72 h) = 0.025$  mg/L.

#### Comments received during public consultation

Two MSs supported the proposed classification. Two manufacturers recommended the modification of the proposed acute M-factor (M= 10) to M=1, according to new information on marine invertebrate toxicity. According to the commenting parties, the

newly executed acute toxicity test on the marine invertebrate *Acartia tonsa* gave a more realistic result compared to the previous study, conducted under static conditions and where measured concentrations declined significantly within 48 hours (values ranged from 8–33% of the nominal concentration and the results were based on geometric mean of the measured concentrations). The new test was carried out under semi-static conditions according to GLP and ISO 14669 (1999) guidelines. The measured concentrations were within the 80–120% range of the nominal concentrations (therefore within the range of 0.7–8.1 mg a.s./L). The  $LC_{50} = 3.0$  mg/L (nominal) corresponded to 2.7–3.3 mg/L based on measured concentrations. The test was qualified as reliable, acceptable and valid.

The newly executed test showed that marine invertebrate *Acartia tonsa* is less sensitive than was supposed based on the results of an earlier test of questionable quality. *A. tonsa* showed sensitivity similar to that of the freshwater *Daphnia*. The most sensitive species was therefore algae, with an  $ErC_{50}$  of 0.6 mg/L.

### Assessment and comparison with the classification criteria

- Glutaraldehyde is readily biodegradable
  - 74% and 88% DOC removal was measured within 7–9 days (a substance is readily biodegradable if a minimum of 70% DOC is removed within a 10-day time window, according to Regulation EC 1272/2008 (CLP)).
- Glutaraldehyde is not bioaccumulative
  - The log  $K_{ow}$  was between -0.80 and -0.36 (pH 5–9, 25°C). Comparing this with the CLP criterion of  $K_{ow} > 4$  for classification as bioaccumulative, glutaraldehyde does not fulfill the bioaccumulation criterion.
- Acute aquatic toxicity
  - Acute aquatic toxicity measured in the new marine invertebrate *Acartia tonsa* acute toxicity test (resulting in an  $LC_{50} = 3.0$  mg/L) does not fulfil the CLP criterion of  $L(E)C_{50} \leq 1$  mg/L for this hazard class. Consequently glutaraldehyde should be classified based on the algae toxicity test result. Acute aquatic toxicity measured in the algal growth test was  $LrC_{50} = 0.60$  mg/L, which is  $\leq 1$  mg/L, fulfilling the criterion of  $L(E)C_{50} \leq 1$  mg/L and based on that, glutaraldehyde is classified as Aquatic Acute 1, H400, with an M-factor of  $M=1$  (based on the CLP criterion of  $0.1 < L(E)C_{50} \leq 1$  mg/L).
- Chronic aquatic toxicity
  - Chronic aquatic toxicity measured by *Scenedesmus subspicatus*  $NOEC_r$  (72 h) = 0.025 mg/L results in a classification of Aquatic Chronic 2; H411, fulfilling the criterion of  $0.01 < NOEC \leq 0.1$  mg/L.
- Combined labelling
  - H400 and H411 are combined (in accordance with Table 4.1.6-a of the Guidance on the Application of the CLP Criteria) resulting in Hazard Statement H410 "Very toxic to aquatic life with long lasting effects".

### Supplemental information - In depth analyses by RAC

Key studies: methods, endpoints and values

| Method   | Results  | Remarks                       |
|--|--|-------------------------------|
| <b>Hydrolysis</b><br>US EPA FIFRA N 161-1 GLP                              | DT50 (12 °C), pH 5 = 1437 d; pH 7 = 288 d; pH 9 = 130d   | Hydrolytically stable         |
| US EPA FIFRA N 161-N GLP   | DT50 (12 °C), pH 5 = 1777 d; pH 7 = 1115 d; pH 9 = 180 d |                               |
| <b>Photolysis</b><br>US EPA FIFRA 161-2 GLP.<br>Direct phototransformation | DT50 =196 d (DT50 in dark = 355 d)                       | Photolytically stable at pH 5 |
| <b>Biodegradation</b>  |  |                               |

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|--|---|---|
| OECD guideline 301 A, GLP<br>In seawater: OECD 306 /ISO 16221, GLP   | Potential to biodegrade in the marine environment   | Readily biodegradable<br>Two different studies<br>Two standards: OECD and ISO   |
| Aerobic Water/Sediment Simulation<br>US EPA Pesticide Ass. N 162-4, GLP  | Water: DT <sub>50</sub> =10.6 h (25 °C), DT50 =1.25 d (12 °C)<br>Whole water-sediment system: DT <sub>50</sub> =11 h (25 °C)  | Addition of <sup>14</sup> C-glutaraldehyde<br>Mineralization: 67.9% ( <sup>14</sup> CO <sub>2</sub> )   |
| Anaerobic Water/Sediment Simulation<br>US EPA Pesticide Ass. N 162-3, GLP  | Water: DT <sub>50</sub> =7.7 h (25 °C) DT50 =0.91 d (12 °C)   | Primary biodegradation:<br>3 metabolites, insignificant CO <sub>2</sub>   |
| <b>Bioaccumulation</b>   | <b>Kow:</b> pH 5: -0.41; pH 7: -0.36; pH 9: -0.80<br>No experimental bioaccumulation data are available.  | Not bioaccumulative   |
| <b>Short-term toxicity to fish</b><br>US EPA FIFRA 72-3 GLP  | LC <sub>50</sub> 32 mg active substance (a.s.)/L  | Marine fish species:<br>sheepshead minnow   |
| <b>Long-term toxicity to fish</b><br>ASTM method, Non-GLP<br>FIFRA 72-4 and OECD 210 during 32 days<br>FIFRA 72-4 and OECD 210 (1992)                    | NOEC = 1.0 mg a.s./L LOEC = 2.5 mg/L<br>NOEC = 1.4 mg a.i./L (survival and growth)<br>NOAEC = 1.6 mg a.i./L LOAEC = 5 mg a.i./L   | 3 studies with fish<br><i>Oncorhynchus mykiss</i><br><i>Pimephales promelas</i><br><i>Oncorhynchus mykiss</i>   |
| <b>Short-term toxicity to aq. invertebrates</b><br>UK Proposal to ISO TC147/SC5/W92, GLP<br>US EPA FIFRA 72-3<br>US EPA FIFRA 72-3<br>EPA OPPTS 850.1045 | LC <sub>50</sub> = 3.0 mg a.s./L<br>LC <sub>50</sub> = 0.78 mg a.i./L<br>LC <sub>50</sub> = 5.5 mg a.i./L and LC <sub>50</sub> = 7.1 mg a.i./L<br>LC <sub>50</sub> = 68 mg a.i./L               | Results based on measured concentrations (within the 80–120% range of the nominal). Marine invertebrate:<br><i>Acartia tonsa</i><br><i>Crassostrea virginica</i><br>Two studies with <i>Mysidopsis bahia</i><br><i>Penaeus vannamei</i> |
| <b>Long-term toxicity to aq. invertebrates</b><br>OECD 211, GLP<br>Directive XI/681/86 Draft 4, GLP  | NOEC 0.13 mg a.s./L<br>NOEC = 5 mg a.s./L   | Results based on arithmetic mean.<br><i>Daphnia magna</i><br><i>Daphnia magna</i>   |
| <b>Growth inhibition on algae</b><br>92/69/EEC C.3, GLP<br><br>ISO/DIS 10253, GLP<br>OECD 201, GLP   | <b>ErC<sub>50</sub> = 0.6 mg a.s./L NOECr = 0.025 mg a.s./L</b><br><br>ErC <sub>50</sub> = 0.61 mg a.s./L NOECr = 0.071 mg a.s./L<br>ErC <sub>50</sub> = 0.82 mg a.s./L NOECr = 0.108 mg a.s./L | <i>Scenedesmus subspicatus</i><br>Geometric mean of measured conc.<br><i>Skeletonema costatum</i><br><i>Selenastrum capricornutum</i>   |

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| Liss G.M.,<br>Buyantseva<br>L., Luce<br>C.E.,<br>Ribeiro M.,<br>Manno M.<br>and Tarlo<br>S.M. | 2011  | Work-related asthma in healthcare<br>in Ontario<br><br>American Journal of Industrial<br>Medicine 54, 278-284  | No  | Public |  |
| Machado,<br>M.W.  | 1993a | Glutaraldehyde - Acute Toxicity to<br>Sheepshead Minnow ( <i>Cyprinodon<br/>variegatus</i> ) Under Flow-Through<br>Conditions<br>Springborn Laboratories Inc.<br>K-020301-010  | Yes                                       | Dow    | A7_4_1_1/01                            |
| Machado,<br>M.W.  | 1993b | Glutaraldehyde - Acute Toxicity to<br>Mysid Shrimp ( <i>Mysidopsis bahia</i> )<br>Under Flow-Through Conditions.<br>Springborn Laboratories, Inc.<br>K-020103-018  | Yes                                       | Dow    | A7_4_1_2/02                            |
| Maisch, R.  | 1997  | Determination of the inhibitory<br>effect of Basolon GDA 50 on cell<br>multiplication of unicellular green<br>algae.<br><br>BASF AG, Department of Ecology,<br>Ludwigshafen/Rhein, Germany,<br>Report No: 97/0329/60/1,<br><br>Unpublished | Yes                                       | BASF   | A7.4.1.3_01                            |
| Marzulli,<br>F.N. and<br>Maibach,<br>H.I.   | 1974  | The use of graded concentrations in<br>studying skin sensitizers:<br>experimental contact sensitization<br>in man<br><br>Food and cosmetics toxicology 12,<br>219-227  | No  | Public |  |

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| McDonald,<br>J.C.,<br>Keynes,<br>H.L. and<br>Meredith,<br>S.K.     | 2000  | Reported incidence of occupational<br>asthma in the United Kingdom,<br>1989-97<br><br>Occupational and Environmental<br>Medicine 57, 823-829                      | No  | Public |  |
| McKelvey<br>J.A.,<br>Anuszkiewi<br>cz C. M.<br>and Tallant<br>M.J. | 1985  | Skin Penetration and<br>Pharmacokinetics of<br>Glutaraldehyde in Rats and Rabbits,<br>Union Carbide Corporation, The<br>Dow Chemical Company Report<br>no. 47-197 | Yes                                       | Dow    | Dow A6.02/6                            |
| McKemie,<br>T.H.   | 2000a | Freezing point/melting point of<br>UCARCIDE 250 Antimicrobial<br>PTRL West, Inc.<br>DR-0222-1070-040  | Yes                                       | Dow    | A3__1/01                               |
| McKemie,<br>T.H.   | 2000b | Boiling Point of UCARCIDE 250<br>Antimicrobial<br>PTRL West, Inc.<br>DR-0222-1070-039   | Yes                                       | Dow    | A3_1_2/01                              |
| McKemie,<br>T.H.   | 2000c | Density of UCARCIDE 250<br>Antimicrobial<br>PTRL West, Inc.<br>DR-0222-1070-038   | Yes                                       | Dow    | A3_1_3/01                              |
| McKemie,<br>T.H.   | 2000e | Surface Tension of UCARCIDE<br>250 Antimicrobial<br>PTRL West, Inc.<br>DR-0222-1070-041   | Yes                                       | Dow    | A3_13/01                               |
| McKemie,<br>T.H.   | 2000f | Viscosity of UCARCIDE 250<br>Antimicrobial<br>PTRL West, Inc.<br>DR-0222-1070-037   | Yes                                       | Dow    | A3_14/01                               |
| Mead, C.<br>and Bartlett,<br>A.J.                                  | 1997  | Ucarcide Antimicrobial 250:<br>Marine Algal Inhibition Test<br>Safepharm Laboratories Limited<br>DR-0222-1070-032   | Yes                                       | Dow    | A7_4_1_3/02                            |

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| Mendrala,<br>A.L., Clark,<br>A.J. and<br>Sushynski,<br>J.M. | 2004 | Glutaraldehyde: pharmacokinetics<br>in Fischer 344 rats following oral<br>gavage or dermal application.<br><br>The Dow Chemical Company,<br>Department of Toxicology and<br>Environmental Research and<br>Consulting, Midland, Michigan<br>48674, USA, Report No: 021134,<br>(sponsor: The Dow Chemical<br>Company and BASF AG), BPD ID<br>A6.02_02<br><br>Unpublished | Yes                                       | BASF  | A6.02_02_a<br>A6.02_02_b<br>A6.02_02_c |
| Mendrala,<br>A.L., Clark,<br>A.J. and<br>Sushynski,<br>J.M. | 2004 | Glutaraldehyde: Pharmacokinetics<br>in Fischer 344 Rats Following Oral<br>Gavage or Dermal Application<br>The Dow Chemical Company<br>K-020301-003   | Yes                                       | Dow   | A6_2/02                                |
| Migchielsen<br>M.H.J.                                       | 2001 | Fresh water algal growth inhibition<br>test with glutaraldehyde 50%.<br>NOTOX Safety and Environmental<br>Research<br>K-020301-095   | Yes                                       | Dow   | A7_4_1_3/01                            |
| Migchielsen<br>M.H.J.                                       | 2003 | Daphnia magna, Reproduction Test<br>with Glutaraldehyde 50% (flow-<br>through)<br>Notox Safety and Environmental<br>Research<br>K-020301-115   | Yes                                       | Dow   | A7_4_3_4/01                            |
| Myers, R.C.   | 1981 | Glutaraldehyde dilutions:<br>Percutaneous toxicity and eye<br>irritation studies<br>Bushy Run Research Centre, Union<br>Carbide<br>44-65   | Yes                                       | Dow   | A6_1_2                                 |
| Myers, R.C.   | 1987 | 50% aqueous glutaraldehyde<br>samples, Primary eye irritancy<br>studies in the rabbit<br>Bushy Run Research Centre, Union<br>Carbide<br>50-104   | Yes                                       | Dow   | A6_1_4(e)                              |
| Myers, R.C.   | 1988 | 50% aqueous glutaraldehyde<br>samples, Primary dermal irritancy<br>studies in the rabbit<br>Bushy Run Research Centre, Union<br>Carbide<br>51-14   | Yes                                       | Dow   | A6_1_4(s)                              |

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| Myers, R.C.<br>and<br>Christopher,<br>S.M.                           | 1992 | Ucarcide Antimicrobial 250: Acute<br>peroral toxicity study in the rat<br>Bushy Run Research Centre, Union<br>Carbide<br>DR-0222-1070-013  | Yes                                       | Dow              | A6_1_1                                 |
| National<br>Center for<br>Biotechnolo<br>gy<br>Information<br>n.     | 2013 | PubChem Compound Database;<br>CID=42632221,<br><a href="http://pubchem.ncbi.nlm.nih.gov/summary/summary.cgi?cid=42632221">http://pubchem.ncbi.nlm.nih.gov/summary/summary.cgi?cid=42632221</a><br>(accessed Apr. 10, 2013) | No  | Public           |  |
| Nayebzadeh<br>, A.   | 2007 | The effect of work practices on<br>personal exposure to glutaraldehyde<br>among health care workers<br><br>Industrial Health,<br>45: 289-295   | No  | Public           |  |
| Norris J.C.,<br>and Kintigh<br>W.J.                                  | 1995 | Glutaraldehyde: Acute Vapour<br>Inhalation Toxicity Study in Rats,<br>Union Carbide Corporation, The<br>Dow Chemical Company Report<br>No: K-020301-089  | Yes                                       | Dow              | A6_1_3/02                              |
| OECD   | 2000 | Guidance Document on Aquatic<br>Toxicity Testing of Difficult<br>Substances and Mixtures<br><br>OECD Series on Testing and<br>Assessment, Number 23 /<br>ENV/JM/MONO(2000)6  | No  | Public<br>domain |  |
| Olson, J.D.  | 1998 | The vapour pressure of pure and<br>aqueous glutaraldehyde.<br><br>Fluid Phase Equilibria 150-151:<br>713-720, Published  | No  | Public           | A3.2_03                                |
| Olson, J.D.  | 1998 | The Vapor Pressure of Pure and<br>Aqueous Glutaraldehyde<br><br>Fluid Phase Equilibria<br>Vol. 150, p 713-720  | Yes                                       | Dow              | Olson, J.D.<br>(1998)                  |
| Palczynski,<br>C.,<br>Walusiak,<br>J., Ruta, U.<br>and Gorski,<br>P. | 2001 | Occupational asthma and rhinitis<br>due to glutaraldehyde: changes in<br>nasal lavage fluid after specific<br>inhalatory test.<br><br>Allergy 56: 1186-1191,   | No  | Public           |  |

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| Perdelli, F., Ottria, G., Cristina, M.L., Lombardi, R., Sartini, M., Spagnolo, A.M., Dalleria, M. and Orlando, P.   | 2008 | Evaluation of environmental contamination by glutaraldehyde in an outpatient facility for digestive endoscopy in an Italian hospital<br><br>International Journal of Environmental Health Research 18, 73-78 | No                               | Public |                                  |
| Pisaniello, D.L, Gun, R.T., Tkaczuk, M.N., Nitschke, M. and Crea, J.  | 1997 | Glutaraldehyde exposures and symptoms among endoscopy nurses in South Australia<br><br>Applied Occupational and Environmental Hygiene, 12: 171-177   | No                               | Public | 6.12.4(4); Dow 6.12.4_3; BASF    |
| Rick, D.L. and West, R.J.   | 2006 | A Critical Evaluation of Vapor Pressure Measurements for Aqueous Glutaraldehyde Formulations<br>The Dow Chemical Company Toxicology and Environmental Research and Consulting K-020301-122                   | Yes                              | Dow    | A3_2                             |
| Roberts, C.A., Drottar, K.R., Swigert, J.P. and Krueger, H.O.   | 1999 | Ucarcide Antimicrobial: An early life-stage toxicity test with the fathead minnow ( <i>Pimephales promelas</i> )<br><br>Wildlife International Ltd. DR-0222-1070-011   | Yes                              | Dow    | A7_4_3_2/01                      |
| Salway, J. G.   | 1994 | Metabolism at a glance, Blackwell Scientific Publications  | No                               | Public | Salway J. G. (1994)              |

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| Sametschek,<br>E.  | 2004 | Physico-chemical Properties of<br>"Protectol GA 50" for the<br>Notification in the Netherlands.<br>BASF AG, Ludwigshafen/Rhein,<br>Germany, Study 04L00165,<br><br>Unpublished   | Yes                                       | BASF             | A3.13_01                               |
| Sano, L.L.,<br>Krueger,<br>A.M., and<br>Landrum,<br>P.F. | 2005 | Chronic toxicity of glutaraldehyde:<br>differential sensitivity of three<br>freshwater organisms.<br><br>Aquatic Toxicology<br>71:283-296  | No  | Public<br>domain | A7_4_3_2/02                            |
| Schaefer,<br>E.C.  | 2000 | Ucarcide 250 Antimicrobial: Ready<br>biodegradability by the dissolved<br>organic carbon die-away test<br>method<br><br>Wildlife International Ltd.<br>DR-0222-1070-027  | Yes                                       | Dow              | A7_1_1_2_1                             |
| Schmidt, P.  | 2002 | Determination of the Melting<br>Temperature of "Protectol GA<br>(50% Glutaraldehyde)".<br>BASF AG, Ludwigshafen/Rhein,<br>Germany, Study 02L00155,<br><br>Unpublished  | Yes                                       | BASF             | A3.1.1_01                              |
| Schwarz, H.  | 2002 | Protectol GA (50%<br>Glutaraldehyde), Determination of<br>the Biodegradability in the marine<br>CO <sub>2</sub> -Evolution Test. BASF AG,<br>Department of Experimental<br>Toxicology and Ecology,<br>Ludwigshafen/Rhein, Germany,<br>Report No: 01/0411/32/1<br><br>Unpublished | Yes                                       | BASF             | A7.1.1.2.3_01                          |

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| Shepler, K.                                       | 1996 | Partition coefficient (n-<br>octanol/deionized water) of<br>[14C]glutaraldehyde<br>PTRL West, Inc.<br>96U1629   | Yes                                       | Dow    | A3_9/01                                |
| Siemann, L.                                       | 1999 | Product Chemistry for<br>Glutaraldehyde (50% Solution),<br>Series 63 - Physical and Chemical<br>Characteristics.<br><br>Midwest Research Institute,<br>Laboratory Project ID: 4217-F(02),<br>BASF MicroCheck Ltd.,<br>Nottingham, UK,<br>BASF No. BM99006,<br>Unpublished | Yes                                       | BASF   | A3.1.2_01                              |
| Simms, R.   | 2006 | Protectol GA 50 - Thermal<br>Decomposition.<br>BASF AG, Nottingham, UK,<br>Statement,<br><br>Unpublished  | Yes                                       | BASF   | A3.10_02                               |
| Skinner, W.,<br>Shepler, K.<br>and Estigoy,<br>L. | 1994 | Soil adsorption/desorption of [ <sup>14</sup> C]<br>glutaraldehyde by the batch<br>equilibrium method<br>PTRL West, Inc.<br>K-020301-081  | Yes                                       | Dow    | A7_2_3_1/01                            |
| Sousa, J.V.                                       | 1995 | Glutaraldehyde - Acute toxicity to<br>Mysids (Mysidopsis bahia) under<br>flow-through conditions.<br><br>Springborn Laboratories Inc. ,<br>Environmental Sciences Division,<br>Wareham, Massachusetts, SLI<br>Report No: 94-12-5603,<br><br>Unpublished                   | Yes                                       | BASF   | A7.4.1.2_04                            |

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| Stenton,<br>S.C., Beach,<br>J.R.,<br>Dennis,<br>J.H.,<br>Keaney,<br>N.P.,<br>Hendrick,<br>D.J.     | 1994 | Glutaraldehyde, asthma and work -<br>a cautionary tale.<br><br>Occupational Medicine 44, 95-98  | No  | Public |  |
| Sutton,<br>P.M., Quint<br>J.,<br>Prudhomme<br>J., Flattey J.,<br>Materna B.<br>and<br>Harrison, R. | 2007 | Glutaraldehyde exposure among<br>workers making bioprosthetic heart<br>valves.<br><br>Journal of Occupational and<br>Environmental Hygiene 4, 311-320   | No  | Public |  |
| Taeger, K.   | 1993 | Determination of the<br>Biodegradability or the Elimination<br>of Protectol GDA in the DOC Die<br>Away (ISO 7827)-Test. BASF AG,<br>Department of Ecology,<br>Ludwigshafen/Rhein, Germany,<br>Report No: 93/0406/21/1<br><br>Unpublished                                      | Yes                                       | BASF   | A7.1.1.2.1_01                          |
| Tallant,<br>M.J.,<br>Beskitt, J.L.,<br>and Frantz,<br>S.W.   | 1991 | Glutaraldehyde: Species<br>Comparisons of <i>In Vitro</i> Skin<br>Penetration Following a Single<br>Application to the Excised Skin of<br>Humans, Fischer 344 Rats, CD-1<br>Mice, Hartley Guinea pigs, and<br>New Zealand white rabbits<br>Union Carbide Corporation<br>53-15 | Yes                                       | Dow    | A6_2/04                                |
| Teta J.M.,<br>Avashia B.<br>H., Cawley<br>T.J. and<br>Yamin A.T.                                   | 1995 | Absences of sensitizations and<br>cancer increases<br>among glutaraldehyde workers<br><br>Toxic Substance Mechanisms 14,<br>293-305   | No  | Public |  |

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| Vyas, A.,<br>Pickering,<br>C.A.C,<br>Oldham, L.,<br>Francis,<br>H.C.,<br>Fletcher,<br>A.M.,<br>Merret, T.<br>and Niven,<br>R. McL | 2000  | Survey of symptoms, respiratory<br>function, and immunology and their<br>relation to glutaraldehyde and other<br>occupational exposures among<br>endoscopy nursing staff<br><br>Occupational and Environmental<br>Medicine,<br>57: 752-759   | No  | Public |  |
| Water A.,<br>Beach J. and<br>Abramson<br>M.   | 2003  | Symptoms and lung function in<br>health care personnel exposed to<br>glutaraldehyde<br><br>American Journal of Industrial<br>Medicine 43, 196-203  | No  | Public |  |
| Wells, D.F  | 1994a | Ucarcide 250 Antimicrobial-<br>Determination of the Solubility in<br>Water and Selected Solvents<br>Springborn Laboratories, Inc.<br>DR-0222-1070-001  | Yes                                       | Dow    | A3_5/01                                |
| Werley,<br>M.S.,<br>Burleigh-<br>Flayer, H.D.<br>and<br>Ballantyne,<br>B.   | 1995  | Respiratory peripheral sensory<br>irritation and hypersensitivity<br>studies with glutaraldehyde vapour<br><br>Toxicology and Industrial Health,<br>11: 489-501  | No  | Public | A6.01.4_04;<br>BASF                    |
| Wetton,<br>P.M. and<br>Bartlett, A.J.   | 1997  | Ucarcide Antimicrobial 250: Acute<br>Toxicity to <i>Acartia Tonsa</i><br>Safepharm Laboratories Limited<br>DR-0222-1070-033  | Yes                                       | Dow    | A7_4_1_2/04                            |
| Wittmer, E.   | 2012  | Summary Report; Protectol GA 50<br>- Technical trail<br>12I0674/05I015   | Yes                                       | BASF   | A6.01.3_01a                            |
| Zeller H  | 1975  | Bericht ueber die Pruefung von<br>Methoxidihydropyran im Vergleich<br>zu Methoxidihydropyran, roh und<br>Relugan GT auf etwaige<br>hautsensibilisierende Wirkung.<br><br>BASF AG, Department of<br>Toxicology, Ludwigshafen/Rhein,<br>Germany, Report No: XXIII/115,<br>(German report),<br><br>Non GLP, Unpublished | Yes                                       | BASF   | A6.01.5_01                             |

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| Zhang, F., Hansen, S.C. and Clark, A.J.  | 2007 | Glutaraldehyde: Identification of metabolites in the Wistar-rat. The Dow Chemical Company, Toxicology and Environmental Research and Consulting (TERC), Midland, Michigan 48674, USA, Report No: 041032<br><br>Unpublished                 | Yes                              | BASF  | A6.02_05                         |
| Zok, S.                                  | 2000 | Protectol GDA (50% Glutaraldehyde) - Early Life-Stage toxicity test on the Rainbow trout ( <i>Oncorhynchus mykiss</i> ). BASF AG, Department of Product Safety, Ludwigshafen/Rhein, Germany, Report No: 52F0447/975114,<br><br>Unpublished | Yes                              | BASF  | A7.4.3.2_01                      |

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