

**Committee for Risk Assessment**

**RAC**

**Opinion**

proposing harmonised classification and labelling  
at EU level of

**Tetracopper hexahydroxide sulphate [1]**  
**Tetracopper hexahydroxide sulphate hydrate [2]**

**EC number: 215-582-3**

**CAS number: 1333-22-8 [1]**

**12527-76-3 [2]**

CLH-O-0000001412-86-42/F

**Adopted**

**04 December 2014**



4 December 2014

CLH-O-0000001412-86-42/F

## **OPINION OF THE COMMITTEE FOR RISK ASSESSMENT ON A DOSSIER PROPOSING HARMONISED CLASSIFICATION AND LABELLING AT EU LEVEL**

In accordance with Article 37 (4) of Regulation (EC) No 1272/2008, the Classification, Labelling and Packaging (CLP) Regulation, the Committee for Risk Assessment (RAC) has adopted an opinion on the proposal for harmonised classification and labelling (CLH) of:

**Chemicals name: Tetracopper hexahydroxide sulphate and Tetracopper hexahydroxide sulphate hydrate**

**EC number: 215-582-3**

**CAS number: 1333-22-8 [1] 12527-76-3 [2]**

The proposal was submitted by **France** and received by the RAC on **13 December 2013**.

In this opinion, all classifications are given in the form of CLP hazard classes and/or categories.

### **PROCESS FOR ADOPTION OF THE OPINION**

**France** has submitted a CLH dossier containing a proposal together with the justification and background information documented in a CLH report. The CLH report was made publicly available in accordance with the requirements of the CLP Regulation at **<http://echa.europa.eu/harmonised-classification-and-labelling-consultation>** on **18 December 2013**. Concerned parties and Member State Competent Authorities (MSCA) were invited to submit comments and contributions by **3 February 2014**.

### **ADOPTION OF THE OPINION OF THE RAC**

Rapporteur, appointed by RAC: **Stephen Dungey**

Co- rapporteur, appointed by RAC: **Marja Pronk**

The opinion takes into account the comments provided by MSCAs and concerned parties in accordance with Article 37(4) of the CLP Regulation. The comments received are compiled in Annex 2.

The RAC opinion on the proposed harmonised classification and labelling was reached on **4 December 2014**.

The RAC opinion was adopted by **consensus**.

## OPINION OF THE RAC

The RAC adopted the opinion that **Tetracopper hexahydroxide sulphate and Tetracopper hexahydroxide sulphate hydrate** should be classified and labelled as follows:

### Classification and labelling in accordance with the CLP Regulation (Regulation (EC) 1272/2008)

	Index No	International Chemical Identification	EC No	CAS No	Classification		Labelling			Specific Conc. Limits, M-factors	Notes	
					Hazard Class and Category Code(s)	Hazard statement Code(s)	Pictogram, Signal Word Code(s)	Hazard statement Code(s)	Suppl. Hazard statement Code(s)			
Current Annex VI entry					n/a							
Dossier submitters proposal	029-RST-00-Y	Tetracopper hexahydroxide sulphate [1] Tetracopper hexahydroxide sulphate hydrate [2]	215-582-3	1333-22-8 [1] 12527-76-3 [2]	Acute Tox. 4 Aquatic Acute 1 Aquatic Chronic 2	H302 H400 H411	GHS07 GHS09 Wng	H302 H410		M=10		
RAC opinion	029-018-00-7	Tetracopper hexahydroxide sulphate [1] Tetracopper hexahydroxide sulphate hydrate [2]	215-582-3	1333-22-8 [1] 12527-76-3 [2]	Acute Tox. 4 Aquatic Acute 1 Aquatic Chronic 1	H302 H400 H410	GHS07 GHS09 Wng	H302 H410		M=10 M=10		
Resulting Annex VI entry if agreed by COM	029-018-00-7	Tetracopper hexahydroxide sulphate [1] Tetracopper hexahydroxide sulphate hydrate [2]	215-582-3	1333-22-8 [1] 12527-76-3 [2]	Acute Tox. 4 Aquatic Acute 1 Aquatic Chronic 1	H302 H400 H410	GHS07 GHS09 Wng	H302 H410		M=10 M=10		



## **SCIENTIFIC GROUNDS FOR THE OPINION**

### **RAC general comment**

In addition to tetracopper hexahydroxide sulphate ECHA received CLH proposals for nine other copper compounds or forms of copper from the same dossier submitter (France). The dossier submitter stated that where systemic toxicity is concerned, the toxicologically relevant moiety is the  $\text{Cu}^{2+}$  ion, which is released to a different degree from all the copper compounds. A comparison of the bioavailability (and hence toxicity) of various copper compounds showed that bioavailability is highest for the most soluble compound copper sulphate. Consequently, the use of copper sulphate data would represent a worst-case scenario for the determination of the systemic toxicity of relatively insoluble copper compounds. For the systemic endpoints the dossier submitter therefore proposed to read-across between the different copper compounds, and introduced identical sections on specific target organ toxicity, mutagenicity, carcinogenicity and reproductive toxicity in the CLH reports for all compounds. The studies reported in these common sections mostly concern copper sulphate pentahydrate, sometimes also other copper compounds. The sections on acute toxicity, skin irritation/corrosion, eye damage/irritation and sensitisation in the CLH reports are specific for each substance/form.

RAC considered the dossier submitter's proposal to group the substances together for consideration of STOT RE and the CMR endpoints. RAC noted that differences in solubility and other physico-chemical properties may potentially impact the toxicity of the various copper compounds, in particular locally after inhalation exposure. RAC noted further that the anions, in particular thiocyanate, might also be a contributing factor to the toxicity. However, these aspects were not addressed in the CLH reports, whereas RAC concluded that these would need a more detailed analysis. As none of the studies with tribasic copper sulphate or the other tested copper substances yielded positive evidence for the classification for these endpoints, RAC did not pursue the aspect of grouping the nine substances any further.

Tetracopper hexahydroxide sulphate can exist in several hydrated forms. The EC number in the proposed Annex VI entry covers all hydrated forms of tetracopper hexahydroxide sulphate and all hydrated forms are to be covered by the entry. For clarity, the name and CAS number for a common hydrated form, tetracopper hexahydroxide sulphate hydrate, is also specified in the proposed entry. Tetracopper hexahydroxide sulphate is referred to as tribasic copper sulphate throughout the CLH report.

Although the CLH report makes references to copper sulphate and the dossier submitter considered tetracopper hexahydroxide sulphate to be a form of copper sulphate (and thus currently covered by the Annex VI entry for copper sulphate, Index No. 029-004-00-0), RAC considers this not to be the case and therefore viewed the CLH report as a proposal for a new Annex VI entry.

### **RAC evaluation of physical hazards**

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

Tetracopper hexahydroxide sulphate is a stable inorganic salt with copper in a high oxidation state. Its physicochemical properties indicate that it is neither explosive, flammable nor oxidising. The dossier submitter proposed no classification for physical hazards.

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

No comments were received during the public consultation.

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

Since tetracopper hexahydroxide sulphate does not have explosive or oxidising properties and is not (auto-)flammable, RAC supports the non-classification for physical hazards, as proposed by the dossier submitter.

## HUMAN HEALTH HAZARD ASSESMENT

### RAC evaluation of acute toxicity

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

Two acute toxicity studies (one via the oral route, one via the dermal route) are included in the CLH report, both conducted with tetracopper hexahydroxide sulphate in rats. The oral study (Sanders, 2002a), conducted according to OECD TG 423, determined the LD<sub>50</sub> to be between 300 and 500 mg/kg bw. In this study two doses were tested, with no animals (3/sex) dying at 200 mg/kg bw while all animals (3 females) died at 2000 mg/kg bw. In the dermal study (Sanders, 2002b), conducted according to OECD TG 402, no animals (5/sex) died at the dose level of 2000 mg/kg bw tested. The LD<sub>50</sub> was therefore determined to be above 2000 mg/kg bw. The dossier submitter concluded that as the oral LD<sub>50</sub> value was between 300 and 2000 mg/kg bw, classification as Acute Tox. 4 – H302 is warranted. No classification was proposed for the dermal route, nor for the inhalation route for which no study was available.

The CLH report also contains a review of seven studies reporting on a possible association between copper exposure and Metal Fume Fever (MFF) in humans (Borak *et al.*, 2000). MFF presents as an influenza-like illness with cough and dyspnoea followed by fever, sweating and shivering, accompanied by nausea, headache, weakness, a sweet metallic taste and muscle and joint pain. The dossier submitter concluded (in agreement with the authors of the review) that none of the reports contain enough conclusive evidence to associate copper fumes or particles with MFF. Another review (Chuttani *et al.*, 1965) reports on several cases of self-poisoning by oral ingestion of copper sulphate. Intoxication is associated with nausea, epigastric burning, vomiting, diarrhoea, ulcerations of the gastric and intestinal mucosa, and liver and kidney histopathology. Rapid chelation therapy increases survival.

#### Comments received during public consultation

One MSCA expressed a general support for the classification proposal, but also commented that a conclusion regarding inhalation toxicity could not be reached due to lack of data and that an acute inhalation study should be requested for tetracopper hexahydroxide sulphate as an active substance under Directive 91/414/EEC. The dossier submitter considered such a request not necessary, because it is very difficult to generate a proper inhalable atmosphere from the dense aqueous paste of tetracopper hexahydroxide sulphate, the vapour pressure of tetracopper hexahydroxide sulphate is low and, moreover, the authorised plant protection products containing tetracopper hexahydroxide sulphate are not classified for acute inhalation toxicity based on experimental data.

#### Assessment and comparison with the classification criteria

Following a comparison of the LD<sub>50</sub> values in the key studies with the criteria, RAC agrees with the conclusion of the dossier submitter that for the oral route tetracopper hexahydroxide sulphate should be classified as **Acute Tox. 4 – H302** and that for the dermal route classification is not warranted.

For the inhalation route, no animal data are available and the available human data are insufficient for classification. No conclusion can be drawn for classification for acute inhalation toxicity.

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

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

No clear evidence of specific toxic effects on organs was reported in the acute toxicity studies. Clinical signs of toxicity were transient in nature and considered to be unspecific signs of general acute toxicity. Liver and kidney damage in human case studies with copper sulphate were seen as secondary to massive or poorly reported doses. The dossier submitter concluded that no classification is warranted for STOT SE.

#### Comments received during public consultation

No comments were received during the public consultation.

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

In the available acute toxicity studies, no clinical signs of toxicity or signs of skin irritation were observed following dermal exposure. Following oral exposure, no clinical signs were observed in male rats whereas in female rats piloerection, hunched posture and diarrhoea (at 200 and 2000 mg/kg bw) and lethargy, decreased respiration rate, laboured respiration and ataxia (at 2000 mg/kg bw) were observed. Symptoms occurred at day 1 for both dose levels, and at 200 mg/kg bw all animals had recovered by day 2. The transient signs at the non-lethal dose level are indicative of non-specific, general acute toxicity, just like the most frequently observed symptoms in human self-poisoning cases (nausea, epigastric burning, vomiting, diarrhoea). RAC agrees with the conclusion of the dossier submitter that tetracopper hexahydroxide sulphate should not be classified for specific target organ toxicity – single exposure (STOT SE).

### **RAC evaluation of skin corrosion/irritation**

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

One skin irritation study with rabbits, conducted with tetracopper hexahydroxide sulphate according to OECD TG 404, is reported in the CLH report (Sanders, 2002c). As no erythema or oedema was observed in any animal at any time point, the dossier submitter concluded that tetracopper hexahydroxide sulphate should not be classified for skin irritation.

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

One MSCA supported the proposal for non-classification for skin irritation. One other MSCA expressed general support for the classification proposal.

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

Given that all three test-animals scored zero for both erythema and oedema over 24/48/72 h in the available skin irritation study, RAC agrees with the conclusion of the dossier submitter that tetracopper hexahydroxide sulphate should not be classified for skin irritation.

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

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

One eye irritation study with rabbits, conducted with tetracopper hexahydroxide sulphate according to OECD TG 405, is reported in the CLH report (Sanders, 2002d). Slight conjunctival redness was seen in one animal at 24 h (Draize score of 1). All other scores were 0 at 24, 48 and 72 h. The dossier submitter concluded that tetracopper hexahydroxide sulphate is not an eye irritant according to the criteria and that therefore no classification for eye irritation is warranted.

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

One MSCA supported the proposal for non-classification for eye irritation. One other MSCA expressed a general support for the classification proposal.

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

Tetracopper hexahydroxide sulphate caused slight eye irritation in the available eye irritation study, consisting of conjunctival redness (in 3 animals, two with score 1, one with score 2) and chemosis (in 2 animals, both score 1) at the 1 h time point, and conjunctival redness (in 1 animal, score 1) at the 24 h timepoint. No effects on the conjunctivae were seen at 48 and 72 h. Corneal opacity and iris lesions were not observed in any animal at any time point. The mean scores over 24-72 h for corneal opacity (0), iris lesions (0), conjunctival redness (0.33) and chemosis (0) are all below the threshold values for classification ( $\geq 1$ ,  $\geq 1$ ,  $\geq 2$  and  $\geq 2$ , respectively, in at least 2 of 3 tested animals). Hence, RAC agrees with the conclusion of the dossier submitter that tetracopper hexahydroxide sulphate should not be classified for eye irritation.

## **RAC evaluation of skin sensitisation**

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

One guinea pig maximisation test (GPMT), conducted with tetracopper hexahydroxide sulphate according to OECD TG 406, is included in the CLH report (Sanders, 2002e). Intradermal and topical induction doses were 0.1% (w/w) and 75% (w/w) at days 1 and 7, respectively. Animals were challenged with 25% (w/w) and 10% (w/w) at day 21 after initiation. No reactions were seen in any of the tested (n=20) or control (n=10) animals.

A few clinical cases of allergic dermatitis upon copper exposure and skin reactions following use of copper-based intrauterine contraceptive devices have been reported, but overall the findings indicate that in comparison with other metals, copper was relatively rarely a cause of allergic contact dermatitis. The dossier submitter concluded, based on the negative GPMT and the rare cases of allergic reactions to copper compounds in humans, that no classification for skin sensitisation for tetracopper hexahydroxide sulphate is warranted.

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

No comments were received during the public consultation.

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

Given the absence of skin reactions in the available skin sensitisation study, and the few individual cases of allergic reactions in humans, RAC agrees with the conclusion of the dossier submitter that tetracopper hexahydroxide sulphate should not be classified for skin sensitisation.

## **RAC evaluation of specific target organ toxicity – repeated exposure (STOT RE)**

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

No data on tetracopper hexahydroxide sulphate are available in the CLH report. However, in light of the proposal to read-across between the different copper compounds for systemic endpoints (see section "RAC general comment" above), the dossier submitter included in the CLH report several animal studies with repeated exposure to other copper compounds (predominantly copper sulphate pentahydrate) for various durations and routes, as well as some human data.

Hébert *et al.* (1993) reported on oral 15-day drinking water and feeding studies and 90-day feeding studies in both rats and mice, all conducted with copper sulphate pentahydrate but none guideline compliant. In addition, three studies where copper sulphate was administered in the diet at one or several doses for up to 15 weeks and animals sacrificed at several intervals, were also reported (Haywood, 1980, 1985; Haywood & Comerford, 1980). One OECD TG 412 compliant 28-day rat inhalation study conducted with dicopper oxide (Kirkpatrick, 2010) is included as well as an older non-guideline compliant study where guinea pigs were exposed via inhalation to Bordeaux mixture for about 6 months (Pimentel & Marques, 1969). Finally, an OECD TG 410 compliant dermal rabbit study is included (Paynter, 1965), with exposure to copper dihydroxide for 3 weeks (5 days per week). A human case study of chronic oral self-administration of copper causing liver failure (O'Donohue *et al.*, 1993) and human volunteer studies demonstrating nausea associated with copper sulphate in drinking water (Araya *et al.*, 2001, 2003) are also reported, as are human case studies of chronic inhalation exposure to Bordeaux Mixture causing pulmonary lesions (e.g. Pimentel & Marques, 1969; Pimentel & Menezes, 1975, 1977).

Inhalation exposure to dicopper oxide resulted in no irreversible adverse effects up to the highest dose tested in rats (2 mg/m<sup>3</sup>). Following dermal exposure to rabbits, degenerative skin abnormalities were only observed at 1000 but not at 500 mg copper/kg bw/day. Human data is poorly reported and doses are difficult to estimate. Following oral exposure in rats, target organs of copper were the liver (inflammation), kidneys (histopathological changes) and forestomach (hyperplasia and hyperkeratosis), with some evidence of haematological changes. Mice were less sensitive, with adverse effects limited to the forestomach. According to the dossier submitter, no serious adverse effects were observed in the available oral studies below the cut-off value for classification (100 mg/kg bw/day for a 90-day study). After considering all available human and

animal data, the dossier submitter concluded that they do not support classification for specific target organ toxicity following repeated exposure.

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

No comments were received during the public consultation.

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

RAC notes that no data are available on tetracopper hexahydroxide sulphate. The CLH report contains data on other copper compounds (predominantly copper sulphate pentahydrate), from which the dossier submitter proposed to read-across to tetracopper hexahydroxide sulphate. In view of the considerations presented in the section "RAC general comment", RAC has not pursued the aspect of grouping any further. RAC concludes that in the absence of relevant data no proposal for classification for specific target organ toxicity following repeated exposure can be made for tetracopper hexahydroxide sulphate.

## **RAC evaluation of germ cell mutagenicity**

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

No data on tetracopper hexahydroxide sulphate are available in the CLH report. However, in light of the proposal to read-across between the different copper compounds for systemic endpoints (see section "RAC general comment" above), the dossier submitter included in the CLH report mutagenicity studies with other copper compounds (predominantly copper sulphate pentahydrate).

Ten *in vitro* studies were very briefly summarised in tabular form. Three Ames tests conducted with copper sulphate (pentahydrate) and another four conducted with Bordeaux Mixture, dicopper chloride trihydroxide, copper Nordox Technical and copper chloride were all reported as negative as well as a rec-assay with copper chloride. An unscheduled DNA synthesis (UDS) test conducted with copper sulphate in primary hepatocytes and an UDS and sister chromatid exchange (SCE) assay with copper nitrate in Chinese hamster V79 cells showed positive results in the absence of metabolic activation. The dossier submitter did not discuss these studies further in the report, as *in vitro* data are not considered appropriate to assess the genotoxic potential of copper. This is because absorbed copper is normally always bound to proteins in the body, where the *in vitro* tests present the cells with free copper, which is highly reactive.

Five *in vivo* studies are included in the CLH report, all conducted with copper sulphate pentahydrate. A negative mouse bone marrow micronucleus assay (Riley, 1994) and a negative rat liver USD assay (Ward, 1994) administering copper sulphate pentahydrate by gavage are presented. In addition, three studies administering copper sulphate pentahydrate by intra-peritoneal (IP) injection to mice are included. Two bone marrow chromosome aberration assays were concluded as positive as well as a sperm abnormality assay and one out of two micronucleus assays (Bhunya & Pati, 1987; Agarwal et al., 1990; Tinwell & Ashby, 1990). Mice also scored positive for bone marrow chromosome aberrations following oral and subcutaneous administration of copper sulphate pentahydrate (Bhunya & Pati, 1987). Considering that the IP route bypasses the normal processing of copper in the body, that there were conflicting results for two IP micronucleus assays, and that two reliable studies via the oral route (where uptake is controlled by homeostatic mechanisms) were negative, the dossier submitter concluded that the available data do not support classification for germ cell mutagenicity for copper compounds, including tetracopper hexahydroxide sulphate.

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

For five of the ten copper compounds under consideration, one MSCA commented that the available genotoxicity data are insufficient to evaluate, and thus to conclude on, the genotoxic potential of copper compounds. The dossier submitter responded that in their opinion the data do not meet the criteria for classification, but acknowledged that insufficient evidence exists to exclude a genotoxic potential via the IP route, referring also to the EFSA peer review of copper substances (EFSA, 2008) where it was concluded that genotoxicity is not of concern upon oral

administration, but that there is insufficient evidence to exclude a (local) genotoxic potential upon non-oral administration.

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

RAC notes that no data on tetracopper hexahydroxide sulphate are available. The CLH report contains data on other copper compounds (predominantly copper sulphate pentahydrate), from which the dossier submitter proposed to read-across to tetracopper hexahydroxide sulphate. In view of the considerations presented in the section "RAC general comment", RAC has not pursued the aspect of grouping any further. RAC concludes that in the absence of relevant data no proposal for classification for germ cell mutagenicity exposure can be made for tetracopper hexahydroxide sulphate.

## **RAC evaluation of carcinogenicity**

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

No data on tetracopper hexahydroxide sulphate are available in the CLH report. However, in light of the proposal to read-across between the different copper compounds for systemic endpoints (see section "RAC general comment" above), the dossier submitter referred in the CLH report to several long-term animal studies with other copper compounds and to human data on copper exposure.

Several animal studies administering copper compounds in either drinking water or diet of rats and mice for various periods of time (up to two years) are presented. However, none meet the guidelines for carcinogenicity testing and several have shortcomings when it comes to evaluating carcinogenicity, such as short duration. None of the studies showed an indication of carcinogenic potential of copper administered systemically. Co-administration of copper with known carcinogens appeared to lower the risk of tumour formation in some cases.

Several cohort or epidemiological studies in humans exposed to copper through copper mining, smelting and refining are briefly summarised in the CLH report. The dossier submitter concluded that they provide little evidence for increased risk of cancer with exposure to copper compounds. Reference is also made to reports of the occupational disease Vineyard Sprayer's Lungs (VSL) associated with exposure to home-made Bordeaux Mixture. Due to poor reporting and possible confounders such as smoking, the dossier submitter concluded that a link between lung cancer and VSL cannot be established. There are two rare genetic diseases of copper in humans (Wilson's disease and Menkes' disease), but there is no evidence of increased incidences of cancer in patients with either disease, despite the chronic high tissue copper levels.

The dossier submitter concluded that the weight of evidence in humans and animals is that copper is not carcinogenic and that therefore no classification for carcinogenicity is warranted for copper compounds, including tetracopper hexahydroxide sulphate.

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

No comments were received during the public consultation.

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

RAC notes that no data are available on tetracopper hexahydroxide sulphate. The CLH report contains some data on other copper compounds (among which copper sulphate pentahydrate), from which the dossier submitter proposed to read-across to tetracopper hexahydroxide sulphate. In view of the considerations presented in the section "RAC general comment", RAC has not pursued the aspect of grouping any further. RAC concludes that in the absence of relevant data no proposal for classification for carcinogenicity can be made for tetracopper hexahydroxide sulphate.

## **RAC evaluation of reproductive toxicity**

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

No data on tetracopper hexahydroxide sulphate are available in the CLH report. However, in light of the proposal to read-across between the different copper compounds for systemic endpoints (see section "RAC general comment" above), the dossier submitter included in the CLH report several animal studies investigating the reproductive toxicity of other copper compounds, as well as some human data.

*Fertility* – Effects of copper sulphate pentahydrate on fertility were examined in a 2-generation study conducted according to OECD TG 416 (Mylchreest, 2005). No treatment-related effects were seen on any of the fertility and litter parameters investigated. Two other non GLP studies conducted with copper gluconate (De la Iglesia *et al.*, 1973) and copper sulphate (Lecyk, 1980), included as supporting evidence, also showed no effects on fertility.

*Development* – An OECD TG 414 compliant rabbit developmental toxicity study conducted with copper dihydroxide (Munley, 2003d) showed some slightly increased incidences in common skeletal variants that were considered secondary non-specific consequences of maternal toxicity. Two other non-guideline studies exposing rats and mice to copper gluconate via gavage (De la Iglesia *et al.*, 1972) did not reveal treatment-related effects on developmental parameters. Another non-guideline compliant study with copper acetate administered to rats via drinking water (Haddad *et al.*, 1991) showed some delayed ossification in foetuses but not in new-borns. In addition, two studies exposing pregnant rats, rabbits and hamsters to intra-uterine copper wire (to mimic exposure to intra-uterine contraceptive device (IUD)) showed no teratogenic or growth-retarding effects in the offspring (Barlow *et al.*, 1981; Chang & Tatum, 1973).

*Human exposure* – Copper in the uterus (as IUD) is known to prevent implantation of the blastocyst, but once implantation takes place the foetus develops normally. The CLH report mentions that although two cases of anencephaly after use of IUD have been reported (Graham *et al.*, 1980), more recent reports indicated that IUD did not increase the risk of congenital abnormalities (Pasquale, 1996; Weissmann-Brenner *et al.*, 2007). No further details on any of these publications were however presented. Dietary exposure to copper does not appear to result in adverse effects on pregnancy, birth or growth and development (Ralph & McArdle, 2001).

Based on the available data and the weight of evidence, the dossier submitter concluded that no classification for reproductive and developmental effects is warranted for copper compounds, including tetracopper hexahydroxide sulphate.

## **Comments received during public consultation**

No comments were received during the public consultation.

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

RAC notes that no data on tetracopper hexahydroxide sulphate are available. The CLH report contains data on other copper compounds (among which copper sulphate pentahydrate), from which the dossier submitter proposed to read-across to tetracopper hexahydroxide sulphate. In view of the considerations presented in the section "RAC general comment", RAC has not pursued the aspect of grouping any further. RAC concludes that in the absence of relevant data no proposal for classification for reproductive toxicity can be made for tetracopper hexahydroxide sulphate.

## **ENVIRONMENTAL HAZARD ASSESMENT**

### **RAC evaluation of environmental hazards**

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

The dossier submitter (DS) considered tetracopper hexahydroxide sulphate to be a form of copper sulphate and thus currently covered by the Annex VI entry for copper sulphate (Index No. 029-004-00-0). The DS's proposal specified an acute M-factor to be assigned to the existing harmonised classification as Aquatic Acute 1 and proposed to change the harmonised chronic classification from Aquatic Chronic 1 to Aquatic Chronic 2, based on the following arguments:

The water solubility of tetracopper hexahydroxide sulphate (3.42 mg/L and 0.255 mg/L at pH 6.2 at pH 9.8, respectively) exceeds the acute ERV of the dissolved metal ion. Taking into account the recommendations of the CLP guidance<sup>1</sup>, this compound is considered to be a readily soluble metal compound for classification purposes.

For aquatic acute classification, the lowest acute Ecotoxicity Reference Value (acute ERV<sub>Cu<sub>4</sub>(OH)<sub>6</sub>SO<sub>4</sub>·½H<sub>2</sub>O</sub> 0.05 mg/L) was considered to be below the trigger value of 1 mg/L, the DS concluded the classification as Aquatic Acute 1 (H400) is appropriate.

As the lowest acute ERV<sub>Cu<sub>4</sub>(OH)<sub>6</sub>SO<sub>4</sub>·½H<sub>2</sub>O</sub> (0.05 mg/L) is above 0.01 mg/L but ≤0.1 mg/L, the DS proposed an acute M-factor of 10.

In order to demonstrate removal from the water column (> 70% removal within 28 days) to assess the “persistence” or lack of degradation of metal ions the DS considered information provided by the copper task force (Rader, 2013). Evidence of rapid removal from the water column was based on the TICKET-Unit World Model (UWM), which describes partitioning to dissolved organic carbon, particulates, etc., deposition and transformation to sulfides in sediment. Together with evidence from field studies, the dossier submitter considered that this provides a satisfactory description of copper ion dynamics, and was therefore of the opinion that more than 70% of dissolved copper (II) ions are removed from the water column within 28 days, i.e. that dissolved copper compounds are rapidly removed. The potential for copper remobilisation from sediment was expected to be limited in oxic and anoxic conditions.

For aquatic chronic classification, the DS proposed that rapid removal of tetracopper hexahydroxide sulphate from the water column can be demonstrated. The lowest chronic ERV<sub>Cu<sub>4</sub>(OH)<sub>6</sub>SO<sub>4</sub>·½H<sub>2</sub>O</sub> (0.013 mg/L) is above 0.01 mg/L but ≤0.1 mg/L, hence the DS concluded that classification as Aquatic Chronic 2 (H411) is appropriate for a substance subject to rapid removal. A chronic M-factor is not applicable.

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

Five comments were submitted on the environmental part of the DS’s proposal of which one commenter agreed with the proposal without further comment, one agreed but with some observations, one agreed but suggested an acute M-factor of 100, and four commenters provided extensive comments challenging the DS’s proposal.

An industry association pointed to disagreements in the selection and interpretation of ecotoxicity data between the CLH report and the REACH dossier, but agreed with the proposal. Four MSCAs objected to the use of the TICKET-UWM, for several reasons. Among them the fact that the model is designed for shallow lakes (so is not representative of turbulent or flowing systems or circumstances where sediment is not present), it includes significant assumptions about transformation to sulfides, and uses default assumptions for factors (like concentration of the particulate matter) that may vary spatially and temporally. One MSCA pointed out that dissolution data for copper (II) oxide (CuO) show an increase in dissolved copper ion concentrations by a factor of four between day 7 and day 28 at a loading rate of 1 mg/L, which does not suggest rapid transformation to less soluble forms. The lack of an existing international agreement about how to apply the rapid removal concept was also highlighted (including by one other CA, although they did not object to the approach taken). These CAs therefore indicated that dissolved copper (II) ions should not be considered to be rapidly removed from the aquatic environment, and that the chronic classification should therefore be Aquatic Chronic 1 (M-factor of 1) rather than Aquatic Chronic 2. In response, the dossier submitter agreed that copper (II) ions cannot currently be considered to be rapidly removed from the water column, and proposed changes to the proposed classification accordingly.

In addition, in several comments, MSs requested changes to, or better justification of, the selection of the lowest ecotoxicity data values, since there appeared to be discrepancies between some of the source documents and the way the information was summarised in the CLH report. Some of the differences were related to the use of geometric means rather than the lowest value

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<sup>1</sup> ECHA Guidance on the Application of the CLP criteria (version 4.0 November 2013)

for a species, and in other cases it was due to uncertainties about whether the cited data referred to the compound itself or to the metal ion. Furthermore one CA pointed out that it may be appropriate to apply the surrogate approach, since there is no chronic test result available for the most sensitive species (*Pimephales promelas*) in the acute tests. In addition, the same CA noted that there are data on other invertebrate species and it was not clear why these were not included in the CLH report. Moreover, considering the amount of ecotoxicological data available for copper, it was proposed to use the species sensitivity distribution (SSD) curve for each trophic level for both short and long-term effects.

Another MSCA suggested that an explicit statement should be included that nano-forms should be considered separately.

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

### **Water solubility:**

The CLH report does not present transformation/dissolution data for  $\text{Cu}_4(\text{OH})_6\text{SO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$  over different timescales, pH values or loading rates. RAC notes that such data do not exist according to the industry comments submitted during public consultation, so in its absence the available water solubility data have been used. Section 1 of the CLH report indicates that the water solubility value is 500 mg/L (280 mg/L as dissolved copper) at pH 5.6, < 3.42 mg/L (1.88 mg/L as dissolved copper) at pH 6.2 and  $\leq 0.255$  mg/L ( $\leq 0.141$  mg/L as dissolved copper) at pH 9.8 (at 20 °C).

### **Degradability**

**Rapid removal:** RAC considers that the TICKET-UWM provides a useful insight into key fate pathways for metal ions including copper in a model shallow lake system. This generic approach allows systematic comparisons to be made between metals. However, the choice of model default parameters has not (yet) been resolved, especially as some properties are likely to vary spatially and temporally. For example, comparison with monitoring data in the CLH report suggested that the model may overestimate the extent to which copper binds to particles, and may use a settling velocity that is higher than observed in reality. In addition, post-loading simulations for one field study that was claimed to be "more representative of a worst case scenario" (on the basis of settling velocity, distribution coefficient and a relatively low suspended solids concentration compared to model defaults) did not predict 70% removal from the water column after 28 days. As this was a natural lake, RAC does not agree that it should be dismissed as a "worst case". Since the concept of rapid degradation for organic substances is conservative and does not include sequestration by particulate matter (or other fate pathways such as volatility), it seems inconsistent to apply such approaches to metals.

The DS's proposal also relied heavily on the premise that copper (II) ions will partition rapidly to sediment, where they will be transformed at the surface to insoluble minerals (especially copper (II) sulfide) over a relatively short timescale so that binding to sediment is effectively irreversible. RAC notes that the DS's proposal did not describe the behaviour of copper (II) ions in aquatic systems with little or no sediment (e.g. rivers or lakes with sand or gravel substrates), high turbulence or sediment at depths substantially in excess of 3 metres. Even where sediment is present, the oxidation state of surface layers may not always favour sulfide formation, and the situation may also be complicated if there is a high level of existing metal contamination. RAC therefore does not consider that a convincing case has been made that copper (II) ions will always rapidly speciate to non-available forms, or that this process was demonstrated to be irreversible under all relevant circumstances. At a general level, RAC considers that decisions about rapid removal could be based on observations from a standardised OECD Transformation/Dissolution test. In this case, T/D studies showed increasing concentrations of copper ions over 28 days (not a decline), indicating that copper (II) ions remained in solution under these test conditions.

In conclusion, RAC considers that copper (II) ions are not subject to rapid environmental transformation for the purposes of classification and labelling.

### **Bioaccumulation**

The bioaccumulation behaviour of copper (II) ions in organisms should consider both essentiality and homeostatic mechanisms. The DS's proposal did not present a clear description of the

available data for comparison with the CLP criteria. However, in view of the degradability conclusion, this end-point does not influence the determination of the chronic M-factor and so was not considered further.

### **Ecotoxicity**

Choice of ecotoxicity data: The ecotoxicity database for copper (II) ions is extensive, with many studies of acute and chronic toxicity in fish, invertebrates and algae/higher plants using a variety of copper compounds at different pH values as well as hardness and dissolved organic carbon (DOC) levels. The two principal sources of information cited in the DS's proposal are the pesticide DAR and the vRAR (2008). RAC considers that the chronic ecotoxicity information in the vRAR is generally reliable for hazard assessment as it was evaluated in depth by the relevant industry experts and reviewed by the pre-REACH CAs<sup>1</sup>. However, Tables 1-3 in the section "Additional key elements" show that the presentation of ecotoxicity information in these sources is inconsistent (presumably due to differences in data aggregation as pointed out in the public comments). This is considered further below:

- a) Given the large number of studies for individual species, the data in the CLH report were aggregated to present single values for each species in three different pH bands. The CLP Guidance for metals recommends transformation/dissolution testing at different pHs, so RAC agrees that grouping into pH bands is appropriate as there is a clear trend in toxicity that would be overlooked if all the data for a species were combined. However, the reasons for the choice of the actual pH bands were not explained, and the effects of hardness and DOC were not discussed.
- b) The dossier submitter's proposal used geometric means even if there are only two data points for a species in a particular pH band. This is not consistent with the CLP Guidance (which indicates that at least four data points are preferred) or the REACH CSRs, and led to discrepancies between the data sets, which were noted during public consultation.
- c) For invertebrates, data were presented for only two species of crustacean (*Daphnia magna* and *Ceriodaphnia dubia*). RAC notes that it is standard practice to consider all relevant data from reliable standard test guideline studies, and so the dossier submitter's proposal was not necessarily based on a comprehensive data set. The dossier submitter did not provide any additional information in response to the public consultation comments on this issue. However, RAC notes that the vRAR (2008) contains long-term toxicity data for several other invertebrate taxonomic groups (including molluscs and insects) as well as higher plants (*Lemna minor*). Further details are provided in the section "Additional key elements".
  - i) In the vRAR (2008), all the reliable chronic NOEC data were compiled in a species sensitivity distribution, deriving a hazardous concentration for 5% of the species (HC<sub>5</sub>) (with the 50<sup>th</sup> percentile confidence interval) of 7.3 µg/L (6.1-7.9 µg/L) based on the best fitting approach, or 6.1 µg/L (3.7-8.6 µg/L) using the log normal curve fitting. These values are very similar to the lowest NOEC in the dataset (6.0 µg/L for the mollusc *Juga plicifera*).
  - ii) Due to the variation in physico-chemical conditions used in the tests, in the vRAR (2008) the data were also 'normalised' using a biotic ligand model. The lowest normalised NOEC is 5.3 µg/L for the rotifer *Brachionus calyciflorus* (at pH 8.1, hardness of 165 mg/L CaCO<sub>3</sub> and DOC of 3.2 mg/L). The lowest HC<sub>5</sub>-50 derived for an ecoregion is 7.8 µg/L (4.4-11.7 µg/L).

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<sup>1</sup> Italy has been acting as a reviewing Member State for the substance and the risk assessment report has been reviewed by the Technical Committee on New and Existing Substances (TC NES) according to standard operational procedures of the Committee.

- iii) RAC notes that the CLH report also mentioned a NOEC of 3.12 µg/L (as copper) from an indoor microcosm study using copper hydroxide, without specifying the measured end-point or study duration; it was also pointed out, in comments during the public consultation, that in the final EFSA conclusion a NOEC of 4.8 µg/L is cited which was used for the overall risk assessment for aquatic organisms. As it was not clear how this information would be used in hazard classification, it was not considered further.

In summary, the lowest long-term NOEC reported in the CLH report is 7.4 µg/L for *Ceriodaphnia dubia* at pH 6.5-7.5. The omission of data for other invertebrate groups from the DS's proposal does not appear to make a significant difference as the most sensitive data all lie in the range 1-10 µg/L.

Discrepancies in the ecotoxicity data as presented: The lowest acute toxicity value selected in the CLH report is 0.029 mg/L (29 µg/L) at pH 5.5-6.5, giving the source as the vRAR. The origin of this data point is unclear, but RAC assumes that it relates to data for *O. mykiss* (a similar value was obtained with *Ceriodaphnia dubia* at pH >7.5-8.5). However, the lowest geometric mean LC<sub>50</sub> reported in the CLH report is 8.1 µg/L (as copper) for fathead minnow *P. promelas* at pH 5.5-6.5 (cited as coming from the vRAR – an actual study reference was not provided). This is based on two values, both for larval fish, 15.0 µg/L and 4.4 µg/L. One comment received during public consultation suggested that this latter value should be used for the acute ERV, which would in turn lead to an acute M-factor of 100. Further comments from industry during PC indicated that the test medium in the study which resulted in the lowest EC<sub>50</sub> (cited as Erickson *et al.*, 1996) used a high flow-through rate, had low hardness (22 mg CaCO<sub>3</sub>/L) and low DOC concentration (not stated), and used larvae that were less than 24 hours' old. Although not mentioned in the CLH report, in the original paper the lowest LC<sub>50</sub> was determined at the minimum pH, i.e. 6.0. Industry therefore considered this test to represent a worst case, and suggested that the sensitivity of this species at pH 6 versus pH 7 was unexpected and may be related to insufficient adaptation to low pH conditions. The data were therefore not considered reliable and not used for classification in the REACH registrations as well as the vRAR. Nevertheless, RAC notes that other minimum acute fish LC<sub>50</sub>s are of the same order of magnitude (e.g. *O. mykiss* at all pHs, and *P. promelas* at pH 6.5-7.5). The OECD TG 203 permits testing in waters with total hardness as low as 10 mg CaCO<sub>3</sub>/L, and a preferred minimum pH of 6.0, so the conditions used in the Erickson (1996) study were within the validity criteria of the guidelines and cannot be considered a worst case. In addition, this species can tolerate poor conditions such as turbid, hot, poorly oxygenated, intermittent streams, which are unsuitable for most fishes

(<http://www.fishbase.org/Summary/speciesSummary.php?ID=4785&AT=fathead+minnow>)

Further papers provided by industry stakeholders following public consultation (Mount, 1973 and Zischke *et al.*, 1983) indicate that *P. promelas* can survive at pHs as low as 4.5, so that a pH of 6.0 does not appear to be intolerable over short exposures. RAC also notes that the replacement test for acute fish toxicity (OECD TG 236) involves embryos, so the life stage argument was not considered relevant either. It is also unclear why the dossier submitter decided to include them in the CLH report if they had been previously rejected. RAC accepts that an acute toxicity test with fish larvae may be more sensitive than one with older fish if they were not properly acclimated, but does not find the other reasons for rejection convincing.

Data for other species show a trend of increasing acute fish toxicity with declining pH, presumably due to increasing bioavailability. The acute LC<sub>50</sub> for *Danio rerio* at pH 6.5-7.5 (35 µg/L, n=3 so a geometric mean is not appropriate) is similar to that of *O. mykiss* at pH 5.5-6.5 (geometric mean 29 µg/L), implying that the sensitivity of *D. rerio* at the lower pH could be higher. Rather than ignoring the *P. promelas* data completely, the geometric mean LC<sub>50</sub> of 8.1 µg/L is therefore considered to be relevant for hazard classification as it takes account of uncertainties about the sensitivity of fish at acidic pH, although this is a conservative approach given the life stages that were tested (N.B. if the most sensitive value of 4.4 µg/L were used the classification and acute M-factor would be 100 for tetracopper hexahydroxide sulphate). RAC has not considered how DOC or hardness affect the observed pattern in ecotoxicity data, as such an analysis was not presented in the CLH report.

As noted above, the lowest reported long-term NOEC in the CLH report is 7.4 µg/L for *Ceriodaphnia dubia* at pH 6.5-7.5, and this value is consistent with the large amount of chronic data presented in the vRAR (2008), including the HC<sub>5</sub>. However, this is almost identical to the acute LC<sub>50</sub> for *P. promelas* at pH 5.5-6.5, and there are no measured chronic toxicity data for any fish species in the pH range of 5.5-6.5. Consequently, the adequacy of the long-term study results was questioned. At first sight it might seem disproportionate to consider the whole long-term fish toxicity data set (n=29) as 'non-adequate'. However, the acute fish test data clearly show that for the three species for which data across the total pH range of 5.5-8.5 are available, the toxicity is the highest in the lowest pH range, i.e., 5.5-6.5. Therefore, despite the large number of fish studies used in the dossier submitter's proposal, RAC believes that it is appropriate to consider the surrogate method for the fish trophic group (as was suggested in one of the public consultation comments). [N.B. The CLP criteria and guidance do not address this specific issue, but Example D in Section 4.1.3.4.4 of the CLP guidance is comparable to some extent. It describes a substance with a large data set, for which acute as well as chronic toxicity data are available for all three trophic levels. For crustacea, chronic data are available for *Daphnia magna*, which is clearly the least sensitive of the invertebrate species for which acute data are available. Hence, according to the guidance, the chronic aquatic toxicity data for *D. magna* in this case should be considered not in conformity with the definition of 'adequate chronic data'.]

In addition, it was indicated in comments received during public consultation that in the DAR for copper hydroxide, a 92-d NOEC of 1.7 µg/L was obtained in a fish early life stage test for *O. mykiss* at pH 8.0 (cited as Schäfers, 2000). This result does not appear to have been taken into account in the data aggregation used in the dossier submitter's proposal. Another reliable chronic result for this species in the pH range > 7.5-8.5 was included in the CLH report (NOEC 16 µg Cu/L). Industry in their comments following the public consultation raised some issues about the reliability of the lower value of 1.7 µg/L (e.g. the reported copper concentrations were highly variable in this study and the test substance was a formulation containing 10% w/w dispersant and also an adhesive). Whilst toxicity was still likely to have been driven by copper ions, the composition might have had some influence. It was also sparingly soluble, rather than a soluble salt. This result was therefore not used directly but is considered by RAC as supporting information for chronic classification purposes.

**ERV derivation:** The lowest acute L(E)C<sub>50</sub> (as dissolved copper) presented in the CLH report is 8.1 µg/L for *P. promelas* at pH 5.5-6.5. The acute ERV<sub>Cu<sub>4</sub>(OH)<sub>6</sub>SO<sub>4</sub>½H<sub>2</sub>O</sub> is therefore equal to 0.015 mg/L [ $\{ \text{acute ERV of metal ion} \times \text{molecular weight of the metal compound} / (\text{atomic weight of the metal} \times \text{number of metal ions}) \}$ , so  $0.0081 \times 461.3 / (63.5 \times 4)$ ]. This is lower than the acute ERV proposed in the CLH report (0.05 mg/L), which is based on a different acute toxicity value.

The lowest long-term NOEC (as dissolved copper) presented in the CLH report is 7.4 µg/L for *Ceriodaphnia dubia* at pH 6.5-7.5. The chronic ERV<sub>Cu<sub>4</sub>(OH)<sub>6</sub>SO<sub>4</sub>½H<sub>2</sub>O</sub> is equal to 0.013 mg/L [ $\{ \text{chronic ERV of metal ion} \times \text{molecular weight of the metal compound} / (\text{atomic weight of the metal} \times \text{number of metal ions}) \}$ , so  $0.0074 \times 461.3 / (63.5 \times 4)$ ]. As noted under in Annex 1, other apparently reliable NOEC data exist that are lower than this value, but still in the range 1-10 µg/L (e.g. a normalised NOEC of 5.3 µg/L for the rotifer *Brachionus calyciflorus* at pH 8.1, hardness of 165 mg/L CaCO<sub>3</sub> and DOC of 3.2 mg/L). Similarly, it was suggested in comments received during public consultation to use the lowest chronic NOEC from the DAR derived for *Daphnia magna* of 5.7 µg Cu/L. These data will make only a very small difference to the chronic ERV<sub>Cu<sub>4</sub>(OH)<sub>6</sub>SO<sub>4</sub>½H<sub>2</sub>O</sub>. However, there are no chronic toxicity data for the fish species that is acutely most sensitive at pH 5.5-6.5, so the surrogate method for the fish trophic group is therefore considered.

#### **Acute aquatic hazard:**

The water solubility (280 mg/L at pH 5.6, 1.88 mg/L at pH 6.2 and ≤0.141 mg/L at pH 9.8, all as dissolved copper) exceeds the acute ERV of the dissolved metal ion (0.0081 mg/L based on the *P. promelas* data), so the substance is considered to be a readily soluble metal compound. RAC agrees to classify tetracopper hexahydroxide sulphate **Aquatic Acute 1 (H400)** on the basis of the acute ERV<sub>Cu<sub>4</sub>(OH)<sub>6</sub>SO<sub>4</sub>½H<sub>2</sub>O</sub> (0.015 mg/L). As the lowest acute ERV<sub>Cu<sub>4</sub>(OH)<sub>6</sub>SO<sub>4</sub>½H<sub>2</sub>O</sub> is above 0.01 mg/L but ≤0.1 mg/L, the **acute M-factor is 10**.

#### **Chronic aquatic hazard:**

As the substance is considered to be a readily soluble metal compound, classification may be based on the lowest chronic  $ERV_{Cu_4(OH)_6SO_4 \cdot \frac{1}{2}H_2O}$  (0.013 mg/L based on data for *Ceriodaphnia dubia*). Since this is below 0.1 mg/L, classification as **Aquatic Chronic 1 (H410)** is appropriate for a substance not subject to rapid environmental transformation based on RAC conclusion on rapid removal from the environment. As the lowest chronic  $ERV_{Cu_4(OH)_6SO_4 \cdot \frac{1}{2}H_2O}$  is above 0.01 mg/L but  $\leq$  0.1 mg/L, the chronic M-factor would be 1 for a substance not subject to rapid environmental transformation. However, using the surrogate method for the fish trophic group, the **chronic M-factor** should be consistent with the acute M-factor, i.e. **10**.

In summary, RAC agrees with the DS's proposal to classify tetracopper hexahydroxide sulphate as **Aquatic Acute 1 (H400)** with an **acute M-factor** of **10** but considers that a more stringent chronic classification (**Aquatic Chronic 1 (H410), chronic M-factor 10**) is required than originally proposed (Aquatic Chronic 2 (H411)) because of the conclusion on rapid environmental transformation as well as the most sensitive fish toxicity data. The classification is based on a MW of 461.3 (based on the formula  $Cu_4(OH)_6SO_4 \cdot \frac{1}{2}H_2O$ ) and the presence of 4 copper atoms per molecule.

### **Additional references**

European Copper Institute 2008. Appendix K1 in *Voluntary Risk Assessment of copper, copper II sulphate pentahydrate, copper(I)oxide, copper(II)oxide, dicopper chloride trihydroxide*. European Copper Institute (ECI). Available at (19/09/2014): <http://echa.europa.eu/fi/copper-voluntary-risk-assessment-reports/-/substance/474/search/+/term>

Mount, D. (1973). Chronic Effect of Low pH on Fathead Minnow Survival, Growth and Reproduction. *Water Research*, 7, 987-993.

Zischke, J.A., Arthur J.W., Nordlie K.J., Hermanutz R.O., Standen D.A., and Henry T.P. (1983). Acidification effects on macroinvertebrates and fathead minnows (*Pimephales promelas*) in outdoor experimental channels. *Water Research*, 17, 47- 63.

### **ANNEXES:**

- Annex 1 Background Document (BD) gives the detailed scientific grounds for the opinion. The BD is based on the CLH report prepared by the Dossier Submitter; the evaluation performed by RAC is contained in RAC boxes.
- Annex 2 Comments received on the CLH report, response to comments provided by the Dossier Submitter and by RAC (excl. confidential information).