Human and Environmental Risk Assessment on ingredients of Household Cleaning Products

Substance: Citric Acid and Salts

(CAS# 77-92-9; 5949-29-1; 6132-04-3)

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1. Substance information

CAS Numbers
This summary covers Citric Acid anhydrous CAS 77-92-9, Citric acid monohydrate CAS 5949-29-1 and Trisodium citrate dihydrate CAS 6132-04-3.

Physical Properties
Citric Acid is a water soluble organic solid with a melting point of approximately 153°C. The acidity of citric acid results from the three carboxylic groups. Having a pKa_1 of 3.13 it is considered as a weak acid.
Citric Acid and its salts undergo dissociation in aqueous media into the citrate anion ($H7C6O7^-$) and the representative cations (H^+, Na^+ and K^+). The chemical structures and available data indicate that the physical-chemical properties, environmental fate behavior, and aquatic and mammalian toxicity of these four compounds mentioned above are similar.

Occurrence
Citric Acid is one of the most widely distributed plant acids and occurs in high concentration in lemon juice (5-7%). It is found in a variety of plants and fruits (especially citrus fruits and berries), leaves, roots etc. Citric acid has a vital function in human and animal metabolism. It appears as an intermediate in the basic physiological citric acid cycle in every eukaryote cell, one of the most important metabolic pathways.

Production and Use
Citric acid has been produced for many years in high volumes and added to processed food and beverages as flavour or stabilizer. It has been used in pharmaceutical preparations, in household cleaners as well as in many special technical applications.

Between 100,000 and 500,0000 tons/annum of citric acid is estimated to have been produced in Europe, including Eastern Europe and Israel, in 1999. Global production is estimated by industry to be approaching 1,000,000 t/a. Worldwide, citric acid production is mainly through microbiological fermentation of molasses and sugar solutions, while extraction from lemon juice or chemical synthesis is negligible. Diluted citric acid from filtered fermentation broths is precipitated with milk of lime (calcium hydroxide) as

practically insoluble calcium citrate, which is then reacted with sulfuric acid to form citric acid and calcium sulfate (gypsum) as a recoverable by-product.
Approximately 50% of the production is estimated to be used by the beverage and soft drinks industry, another 20% in food processing industry and around 10% in pharmaceutical industry, where citric acid is used as an acidulant, buffering agent, taste enhancer and synergist in antioxidant mixtures. Thus, approximately four fifths are destined for human consumption and have a very wide dispersive use. The remainder is split between technical applications in various industries as a complex-forming agent, cleaning agent, softening agent, decalcifying agent, derusting agent, corrosive agent and synergist in antioxidant mixtures; many of those applications also have wide dispersive use, eg, washing powders and detergents. Last, small fractions are used in special applications such as citrate buffering of whole blood samples for transfusion.

Table 1 lists household cleaning applications and typical finished product concentration ranges of Citric Acid (anhydrous and mono-hydrate) and its tri-sodium salt. These figures are based on a survey among 8 detergent manufacturers for the European Union 15+3 (+3 being Iceland, Switzerland and Norway) in 2002. The total consumption in HERA applications is estimated to be at 103,000 tons in 2002 (as Citric Acid).

Table 1:

Product Application	*Range of Citric Acid (anhydrous, monohydrate) and/or its Trisodium Salt in various products.*
Laundry detergents	0-10%
Laundry additives	0-55%
Fabric conditioners	<1%
Machine- / Hand dishwashing detergents	0-45%
Surface Cleaners	0-30%
Toilet Cleaners	0-7%

2. The OECD/ICCA work on Citric Acid / HERA´s conclusion

The member countries of the Organisation for Economic Co-operation and Development (OECD) systematically investigate High Production Volume (HPV) chemicals in order to determine the need for further work on these chemicals. The set of minimum data elements that must be available to draw recommendations is known as the 'Screening Information Data Set' or SIDS. A SIDS Initial Assessment Report (SIAR) for citric acid was presented at SIDS Initial Assessment Meeting (SIAM) 11 in January 2001, and its status was determined to be "currently of low priority for further work"
This Initial Assessment Report (SIAR) is available and accessible at the following address: http://www.chem.unep.ch/irptc/sids/oecdsids/indexcasnumb.htm.

HERA is determined to avoid any duplication of effort and to discourage effort for the sake of only marginal improvements. However, HERA believes that HERA Risk Assessments should be carried out where significant additional risk information can be obtained, and where a refinement of the existing assessments would yield new or significantly different conclusions in particular for the detergent use scenario. A decision which option should be selected has to be taken on a case by case basis.

Human health:
The available data confirm the low acute and (sub)chronic toxicity profile of Citric Acid. The NOAEL for repeated dose toxicity (for rats) is 1200mg/kg/d. It is not suspected of being a carcinogen nor a reprotoxic or teratogenic agent. Citric Acid is not mutagenic *in vitro* and *in vivo*, and its sensitising potential is seen as low.
Citric Acid has wide dispersive use, it is naturally present in common fruit and vegetables and is added to processed food and beverages. Potential consumer exposure to citric acid as a consequence of its presence in household laundry & cleaning products is expected to be several orders of magnitude below the rats` NOAEL and of little significance when compared with the normal dietary intake. The available information is judged to be adequate for concluding that the use of citric acid in household laundry and cleaning products raises no safety concerns for consumers.

Environment:
Citric acid is a chemical substance with a very favourable ecological profile. Due to the very low aquatic toxicity and the ready biodegradability, wide dispersive use of citric acid does not present a hazard to the environment.

Several laboratory biodegradation tests (both ready and inherent) show that citric acid and citrate, respectively, is rapidly degraded in both sewage works and surface waters (OECD, 2001; Hoyt and Gewanter, 1992). Available environmental monitoring data show that while raw sewage contains up to 10 mg citrate/l, background concentrations in river water range between <0.04 and maximally 0.2 mg/l (OECD, 2001). It should be kept in mind that these citrate concentrations do not only derive from manmade citric acid, of which the HERA usage accounts for less than 20%, but that citric acid is extremely widespread in nature.

A worst case estimate of the environmental concentrations can be deduced from the available information (see 2.) about the total production figure of citric acid of max.500 000 tons/a in Europe, including Eastern Europe and Israel and a 20% share of wide dispersive use in technical applications. Based on a population figure of ca. 470 million of people (EU-25) and a per capita water consumption of 200 l/day, a raw waste water concentration of 2.9 mg/l can be calculated which shows a good agreement with the mentioned monitoring data.
Conservatively assuming a degree of elimination in WWTP of 87% (based on the figure for readily biodegradable substances provided in Appendix 1 of Part II of the TGD), a WWTP effluent concentration of 0.38 mg/l can be calculated leading to a river concentration of approximately 0.04 mg/l. This figure corresponds again very well to the mentioned few river monitoring data.

In freshwater, citric acid appears to be of low acute toxicity to fish, daphnia and algae, with consistent LC_{50}/EC_{50} values of several hundred milligrams per litre (OECD, 2001). Based on an overview of concrete acute toxicity data of sodium citrate on fish, daphnia and algae (Hoyt and Gewanter, 1992) with an EC50 range of 825 – 1750 mg/l, a PNEC of 0.8 mg/l can be derived (applying an assessment factor of 1000 acc. to TGD). Available (sub)chronic data with a "long-term" daphnia test giving a geometric mean EC_{50} of 98 mg/l and lowest reported EC_0 in cyanobacteria of 80 mg/l (OECD, 2001) support the assumption that the derived PNEC is very conservative.

In spite of the conservativism of this rough exposure and effects assessment, the preliminary risk characterisation shows that the estimated river concentration of citrate is far below the PNEC. Therefore the available information is judged to be adequate for concluding that the use of citric acid in household laundry and cleaning products raises no safety concerns for the environment.

3. THE SIDS INITIAL ASSESSMENT PROFILE

CAS No. 77-92-9

Chemical Name Citric acid

RECOMMENDATIONS
The chemical is currently of low priority for further work.

SUMMARY CONCLUSIONS OF THE SIAR

Human Health
Based on many experimental data in animals and on human experience, citric acid is of low acute toxicity. The NOAEL for repeated dose toxicity for rats is 1200 mg/kg/d. The major, reversible (sub)chronic toxic effects seem to be limited to changes in blood chemistry and metal absorption/excretion kinetics. Citric acid is not suspected of being a carcinogen nor a reprotoxic or teratogenic agent. The NOAEL for reproductive toxicity for rats is 2500 mg/kg/d. Further, it is not mutagenic *in vitro* and *in vivo*. Also, the sensitising potential is seen as low. In contrast, irritation, in particular of the eyes but also of the respiratory pathways and the skin, is the major toxicological hazard presented by citric acid; this conclusion is confirmed by a series of reports relating to eye and skin irritation.

Environment
Due to its physico -chemical characteristics citric acid is highly mobile in the environment and will partition to the aquatic compartment. Citric acid is rapidly degraded in both sewage works and surface waters and in soil. Citric acid is of low acute toxicity to freshwater fish, daphnia and algae and also to the few marine species tested; longer -term tests show comparable effect values. Similarly, citric acid has no obvious toxic potential against protozoans and many species or strains of bacteria including activated sludge micro-organisms. Based on the available data, citric acid is not judged to be a substance that presents a hazard to the environment.

Exposure
Citric acid is a water soluble organic solid. It is a natural substance that appears as an intermediate in the basic physiological citric acid or Krebs cycle in every eukaryote cell. Citric acid has been produced for many years in high volumes, current global production is estimated to approach 1,000,000 t/a. It has wide dispersive use, being added to processed food and beverages, used in pharmaceutical preparations and in household cleaners as well as in special technical applications.

A large body of physico-chemical, toxicological and environmentally relevant data exists for citric acid, many of which are relatively old and some located only in standard reference works and reviews. While the quality of a single result often may be hard or even impossible to assess, the sheer volume and high congruence of the data result in a uniform picture all the same.

NATURE OF FURTHER WORK RECOMMENDED
No further work recommended.

4. References

ECAMA / The European Citric Acid Manufacturers Association http://www.ecama.org

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5. Contributors

This dossier has been prepared by the HERA Secretariat on behalf of the ECAMA, the European Citric Acid Manufacturer Association and its member companies.
Additional input was provided by the experts of the HERA (Environment and Human Health) Task Forces. Volume and exposure information for the use of household detergents and cleaners was gathered among the HERA Formulator Companies and has been aggregated by the Cefic Statistical Service department.