

FERRIC SULPHATE

This dossier on ferric sulphate presents the most critical studies pertinent to the risk assessment of ferric sulphate in its use in coal seam gas extraction activities. This dossier does not represent an exhaustive or critical review of all available data. The majority of information presented in this dossier was obtained from the ECHA database that provides information on chemicals that have been registered under the EU REACH (ECHA). Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch et al., 1997).

Screening Assessment Conclusion – Ferric sulphate is classified as a **tier 1** chemical and requires a hazard assessment only.

1 BACKGROUND

Ferric sulphate is an iron salt. Iron salts are non-volatile solid substances which are very soluble in water [Fe(III) species being moderately strong acids]. Ferric sulphate dissociates in aqueous media to iron and sulphate ions, both are ubiquitous in the environment. Iron cations will undergo transformation/speciation processes which limit bioavailability and will not accumulate in living tissues. The sulphate anions can be considered non-toxic.

Iron plays an important role in biological processes, and iron homeostasis is under strict control. Due to the natural occurrence in considerable amounts biota have mechanisms to cope with concentrations of the iron species in equilibrium with the iron cations. Ferric sulphate is of low toxicity concern to aquatic and terrestrial organisms.

2 CHEMICAL NAME AND IDENTIFICATION

Chemical Name (IUPAC): diiron(3+) trisulfate

CAS RN: 10028-22-5

Molecular formula: $\text{Fe}_2\text{O}_{12}\text{S}_3$

Molecular weight: 399.86 g/mol

Synonyms: Ferric sulphate; ferric sulfate; sulfuric acid, iron (3+) salt (3:2); iron (III) sulfate; iron persulfate; diiron tris(sulphate)

3 PHYSICO-CHEMICAL PROPERTIES

Key physical and chemical properties for the substance are shown in Table 1.

Table 1 Overview of the Physico-chemical Properties of Ferric Sulphate

Property	Value	Klimisch score	Reference
Physical state at 20°C and 101.3 kPa	yellow crystalline solid or a grayish-white powder	-	PubChem
Melting Point	Decomposes at 480 °C; the pressure was not indicated	2	ECHA
Boiling Point	Assumed to decompose completely without boiling	-	ECHA
Density	3097 kg/m ³ @ 18 °C	2	ECHA
Vapor Pressure	0 Pa @20 °C	1	ECHA
Partition Coefficient (log K _{ow})	Not applicable this substance is an inorganic	-	-
Water Solubility	4400 g/L@20 °C	2	ECHA
Dissociation Constant (pKa)	Not relevant	-	ECHA
Viscosity	Not relevant	-	ECHA

Ferric sulphate dissociates in aqueous media to the ferric iron cation [Fe³⁺ or Fe (III)] and sulphate anion (SO₄²⁻) (ECHA). The Fe (III) cation rapidly converts to ferric hydroxide [Fe(OH)₃]. The rate at which ferric hydroxides are formed is highly dependent on pH (OECD, 2007). Although certain bacteria can reduce ferric iron [Fe (III)] to the more mobile ferrous iron [Fe²⁺ or Fe(II)], this is rapidly immobilized (USEPA, 1993). The sulphate anions can be considered non-toxic and naturally ubiquitously present in the environment (ECHA).

4 DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken (Table 2). This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. No specific environmental regulatory controls or concerns were identified within Australia and internationally for ferric sulphate.

NICNAS has assessed ferric sulphate in an IMAP Tier 1 assessment and concluded that it poses no unreasonable risk to human health or the environment¹. Ferric sulphate is an inorganic substance comprising ions of low ecotoxicological concern. This chemical is not expected to pose an unreasonable risk to the environment provided that ANZECC water quality guidelines for physical and chemical stressors are not exceeded.

¹ <https://www.industrialchemicals.gov.au/chemical-information/search-assessments?assessmentcasnumber=10028-22-5>

Table 2 Existing International Controls

Convention, Protocol or other international control	Listed Yes or No?
Montreal Protocol	No
Synthetic Greenhouse Gases (SGG)	No
Rotterdam Convention	No
Stockholm Convention	No
REACH (Substances of Very High Concern)	No
United States Endocrine Disrupter Screening Program	No
European Commission Endocrine Disruptors Strategy	No

5 ENVIRONMENTAL FATE SUMMARY

Iron is the fourth most abundant element in the Earth's crust accounting for approximately 5 % by weight. As such, iron is present naturally in abundance in all environmental compartments with large reservoirs in soils and sediments (ECHA).

Ferric sulphate is an iron salt. Iron salts are non-volatile solid substances which are very soluble in water and have an acidic reaction with water [Fe(III) species being moderately strong acids]. Under conditions of high light intensity, ferric iron cations can be photoreduced to ferrous iron. Fe (III) species are soluble and stable in aqueous solution only at very low pH conditions. Both ferrous and ferric ions released into (or generated in) water will rapidly precipitate as highly insoluble oxides and oxo-hydroxides. Any precipitate would in turn undergo further oxidation to form the highly insoluble ferric hydroxide [Fe(OH)₃] as this species autocatalyses the oxidation of Fe(II). As a result, the formation of ferric hydroxide at pH levels above 5.0 limits the presence of iron in aqueous systems (ECHA).

The resulting ferric hydroxide is very insoluble and largely confined to particulate phases. These stable compounds are exactly the forms in which iron is found naturally in the earth's crust. Above pH 2, colloidal gels are formed, giving a precipitate of the red-brown gelatinous hydrous iron oxide. These insoluble species are thus predominant at environmentally relevant pH. With time, these hydroxides either polymerise to form larger insoluble stable complexes or they are trapped and buried in sediments. In addition, in anoxic sediments, sulphide produced by sulphate reduction reacts with Fe (II) ions to form insoluble iron sulphides. Other metals and organic matter may be strongly adsorbed to iron precipitates. Iron precipitates as sulphides and hydroxides contributes to the detoxification of other metals (ECHA).

Biologically, iron is an essential trace element for organisms including micro-organisms, plants and animals. Iron plays an important role in biological processes, and iron homeostasis is under strict control. Due the natural occurrence in considerable amounts biota have mechanisms to cope with concentrations of the iron species in equilibrium with the iron cations. In addition, the aquatic bioavailability is limited, being influenced by transformation/speciation processes. As a result, there is low potential for ferric sulphate to bioaccumulate (ECHA).

6 ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

Ferric sulphate is of low toxicity concern to aquatic and terrestrial organisms.

B. Aquatic Toxicity

Soluble iron salts are considered not toxic to the aquatic life. Results of standard acute toxicity tests on fish and aquatic invertebrates indicate that E(L)C₅₀ values for iron salts would fall in the 1 to >100 mg/L range, with the majority suggesting results in the 10 – 100 mg/L range (see reviews by Vangheluwe & Versonnen 2004, Johnson et al. 2007 and OECD 2007 as summarized in ECHA). However, none of the toxicity tests reported to date have been able to avoid the expected precipitation of ferric hydroxide in the test vessels and the subsequent mortality to test organisms due to smothering or clogging of the gills or respiratory membranes. Thus, these test results are not reliable. Furthermore, little or no systemic effects of iron (e.g. on growth or reproduction) have been reported in long-term tests at nominal concentrations >1 mg/L (see reviews by Vangheluwe & Versonnen 2004, Johnson et al. 2007 and OECD 2007 as summarized in ECHA). In addition, iron is an essential trace element for plant development. The presence of higher concentrations of iron in aquatic environments can however lead to growth impairment due to an indirect effect of nutrient (phosphate) removal. Standard algal toxicity test data cannot therefore be relied upon to give a true indication iron toxicity unless steps have been taken to compensate for nutrient removal (OECD, 2007).

C. Terrestrial Toxicity

The USEPA (2003) Eco-SSL for Iron summarizes as follows: *“Iron is essential for plant growth, and is generally considered to be a micronutrient. Iron is considered the key metal in energy transformations needed for syntheses and other life processes of the cells (Thompson & Troeh 1973). Consequently, plants regulate its uptake. In well aerated soils between pH 5 and 8, the iron demand of plants is higher than the amount available (Römheld & Marschner 1986). Because of this limitation, plants have evolved various mechanisms to enhance iron uptake (Marschner 1986). Under these soil conditions, iron is not expected to be toxic to plants.”* (ECHA).

Iron species do not exhibit relevant acute avian toxicity. Chronic toxic effects to birds under environmental conditions seem unlikely (ECHA).

7 CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU REACH Criteria methodology (DEWHA, 2009; ECHA, 2008).

Ferric sulphate is an inorganic substance. Biodegradation is not applicable. For the purposes of this PBT assessment, the persistent criteria are not considered applicable.

Biologically, iron is an essential trace element for organisms including micro-organisms, plants and animals. Iron plays an important role in biological processes, and iron homeostasis is under strict

control. Bioaccumulation is not relevant. Further, the aquatic bioavailability of iron is limited, being influenced by transformation/speciation processes. As a result, bioaccumulation criteria are not considered applicable.

Soluble iron salts are considered not toxic to the aquatic life. Little or no systemic effects of iron (e.g. on growth or reproduction) have been reported in long-term tests at nominal concentrations >0.1 mg/L. Results of acute toxicity tests are >1 mg/L. Thus, ferric sulphate does not meet the screening criteria for toxicity.

The overall conclusion is that ferric sulphate is not a PBT substance.

B. Other Characteristics of Concern

No other characteristics of concern were identified for ferric sulphate.

8 SCREENING ASSESSMENT

Chemical Name	CAS No.	Overall PBT Assessment ¹	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Risk Assessment Actions Required ³
			Listed as a COC on relevant databases?	Identified as Polymer of Low Concern	P criteria fulfilled?	Other P Concerns	B criteria fulfilled?	T criteria fulfilled?	Acute Toxicity ²	Chronic Toxicity ²	
Ferric sulphate	10028-22-5	Not a PBT	No	No	NA	No	NA	No	1	1	1

Footnotes:

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 - Tier 1 – Hazard Assessment only.

Notes:

NA = not applicable

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

9 REFERENCES, ABBREVIATIONS AND ACRONYMS

A. References

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B. Abbreviations and Acronyms

°C	degrees Celsius
AICS	Australian Inventory of Chemical Substances
BCF	bioconcentration factor
COC	constituent of concern
DEWHA	Department of the Environment, Water, Heritage and the Arts
EC	effective concentration
ECHA	European Chemicals Agency
EU	European Union
g/L	grams per litre
hPa	hectopascal
IUPAC	International Union of Pure and Applied Chemistry
kg	kilograms
kg/m ³	kilograms per cubic metre
KI	Klimisch scoring system
kPa	kilopascal
L	litre
L/kg	litres per kilogram
LC	lethal concentration
m ³	cubic metre
mg/kg	milligrams per kilogram
mg/L	milligrammes per litre
mg/m ³	milligrams per cubic metre
mL	millilitre
mPa s	millipascal second
NICNAS	The National Industrial Chemicals Notification and Assessment Scheme
OECD	Organisation for Economic Co-operation and Development
Pa	pascal
PBT	Persistent, Bioaccumulative and Toxic
ppm	parts per million
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SGG	Synthetic Greenhouse Gases
USEPA	United States Environmental Protection Agency