SODIUM BICARBONATE

This dossier on sodium bicarbonate presents the most critical studies pertinent to the risk assessment of sodium bicarbonate in its use in drilling muds. 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 – Sodium bicarbonate is classified as a **tier 1** chemical and requires a hazard assessment only.

1 BACKGROUND

Due to its high water solubility and low vapour pressure, sodium bicarbonate will be found predominantly in the aquatic environment where it dissociates completely to sodium (Na+) and bicarbonate (HCO_3^-) ions. Both ions are ubiquitous in the environment. Sodium bicarbonate is of low toxicity concern to aquatic organisms.

2 CHEMICAL NAME AND IDENTIFICATION

Chemical Name (IUPAC): Sodium; hydrogen carbonate

CAS RN: 144-55-8

Molecular formula: $CH_2O_3.Na$

Molecular weight: 84.01 g/mol

Synonyms: Sodium bicarbonate; sodium hydrogen carbonate; baking soda; carbonic acid monosodium salt

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 Sodium Bicarbonate

Property	Value	Klimisch score	Reference
Physical state at 20°C and 101.3 kPa	White, crystalline solid	-	PubChem
Melting Point	Decomposes @ 50°C (pressure not provided)	-	PubChem
Boiling Point	-	-	-
Density	2,100 kg/m^3 (temperature not indicated)	-	PubChem

Property	Value	Klimisch score	Reference
Vapour Pressure	Negligible, ionizable inorganic compound	-	OECD, 2002
Partition Coefficient (log K_{ow})	Not relevant, ionizable inorganic compound	-	OECD, 2002
Water Solubility	100 g/L @ 25°C	-	PubChem
Dissociation Constant (pKa)	6.3 (temperature not indicated)	-	PubChem

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 sodium bicarbonate.

NICNAS has assessed Portland cement in an IMAP Tier 1 assessment and concluded that it poses no unreasonable risk to human health or the environment[1] . In addition, based on an assessment of environmental hazards, NICNAS also identified sodium bicarbonate as a chemical of low concern to the environment (NICNAS, 2017). Chemicals of low concern are unlikely to have adverse environmental effects if they are released to the environment from coal seam gas operations.

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

Due to its high water solubility and negligible vapour pressure, sodium bicarbonate will be found predominantly in the aquatic environment where it dissociates completely to sodium (Na^+) and bicarbonate (HCO_3^-) ions. Both ions are ubiquitous in the environment (UNEP, 1995).

[1] https://www.industrialchemicals.gov.au/chemical-information/search-assessments?assessmentcasnumber=144-55-8

When bicarbonate is dissolved in water, a re-equilibration takes place according to the following equations:

$HCO_3^- \leftrightarrow CO_3^{2-} + H^+$ pKa=10.33

$CO_2 + H_2O \leftrightarrow HCO_3^- + H^+$ pKa = 6.35

Only a small fraction of the dissolved CO_2 is present as H_2CO_3 (carbonic acid), the major part is present as CO_2. The amount of CO_2 in water is in equilibrium with the partial pressure of CO_2 in the atmosphere. The CO_2/ HCO_3^-/ CO_3^{2-} equilibria are the major buffer of the pH of freshwater.

Based on the above equations, CO_2 is the predominant species at a pH smaller than 6.35, while HCO_3^- is the predominant species at a pH in the range of 6.35-10.33 and CO_3^{2-} is the predominant species at a pH higher than 10.33.

Geochemical and biological processes dictate the natural concentration of CO_2/ HCO_3^-/ CO_3^2 in freshwater. For instance, a continuous source of carbonate in freshwater is from the deposition of carbonate ions from the dissolution of minerals. Carbon dioxide comes from the decay of organic matter in aquatic ecosystems. On the other hand, carbon dioxide dissolved in freshwater is utilised by plants in photosynthesis.

The addition of sodium bicarbonate to the aquatic environment could potentially increase the sodium and bicarbonate concentration. However, unlike sodium carbonate, sodium bicarbonate does not increase the pH of the water to high and/or lethal levels. Addition of bicarbonate to water will move the pH towards 8.34 (the mean of the two pKa values from the two above equations) (OECD, 2002).

Na^+ and HCO_3^- ions will not adsorb on particulate matter or surfaces and will not accumulate in living tissues.

6 ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

Sodium bicarbonate is of low toxicity concern to aquatic organisms.

B. Aquatic Toxicity

Acute Studies

Table 3 lists the results of acute aquatic toxicity studies on sodium bicarbonate.

Table 3 Acute Aquatic Toxicity Studies on Sodium Bicarbonate

Test Species	Endpoint	Results (g/L)	Klimisch score	Reference
Oncorhynchus mykiss	96-hour LC_{50}	7,700	2	OECD, 2002

Test Species	Endpoint	Results (g/L)	Klimisch score	Reference
Lepomis macrochirus	96-hour LC_{50}	7,100	2	OECD, 2002
Daphnia magna	48-hour EC_{50}	4,100	2	OECD, 2002
Daphnia magna	48-hour EC_{50}	>1,000	2	OECD, 2002
Ceriodaphnia dubia	48-hour EC_{50}	1,020	2	OECD, 2002

Chronic Studies

The NOEC from a 21-day *Daphnia* reproduction study is >576 mg/L (OECD, 2002) [Kl. score = 2].

C. Terrestrial Toxicity

The 48-hour LC_{50} and NOEC from an acute honeybee test on sodium bicarbonate was >24 and 24 µg/bee, respectively (OECD, 2002).

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).

Sodium bicarbonate is an inorganic salt that dissociates completely to sodium and bicarbonate ions in aqueous solutions. Biodegradation is not applicable to these inorganic ions; both sodium and bicarbonate ions are also ubiquitous and are present in most water, soil and sediment. For the purposes of this PBT assessment, the persistent criteria is not considered applicable to this inorganic salt.

Sodium and bicarbonate ions are essential to all living organisms and their intracellular and extracellular concentrations are actively regulated. Therefore, sodium bicarbonate is not expected to bioaccumulate and does not meet the screening criteria for bioaccumulation.

The NOEC for sodium bicarbonate from a chronic *Daphnia* study is >0.1 mg/L. The acute EC_{50} values for sodium bicarbonate are >1 mg/L in fish and invertebrates. Thus, sodium bicarbonate does not meet the screening criteria for toxicity.

The overall conclusion is that sodium bicarbonate is not a PBT substance.

B. Other Characteristics of Concern

No other characteristics of concern were identified for sodium bicarbonate.

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]	
Sodium Bicarbonate	144-55-8	Not a PBT	No	No	NA	No	No	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

Department of the Environment, Water, Heritage and the Arts [DEWHA]. (2009). Environmental risk assessment guidance manual for industrial chemicals, Department of the Environment, Water, Heritage and the Arts, Commonwealth of Australia.

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Klimisch, H.J., Andreae, M., and Tillmann, U. (1997). A systematic approach for evaluating the quality of experimental and toxicological and ecotoxicological data. Regul. Toxicol. Pharmacol. 25:1-5.

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UNEP. (1995). Water quality of world river basins. UNEP Environment Library No. 14, Nairobi, Kenya; cited in OECD, 2002.

B. Abbreviations and Acronyms

^{o}C	degrees Celsius
AICS	Australian Inventory of Chemical Substances
COC	constituent of concern
DEWHA	Department of the Environment, Water, Heritage and the Arts
EC	effective concentration
ECHA	European Chemicals Agency
EU	European Uniong/L grams per litre
IUPAC	International Union of Pure and Applied Chemistry
Kl	Klimisch scoring system

kg/m^3	kilograms per cubic metre
kPa	kilopascal
LC	lethal concentration
mg/L	milligrams per litre
NOEC	no observed effective concentration
Pa	pascal
PBT	Persistent, Bioaccumulative and Toxic
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SGG	Synthetic Greenhouse Gases
µg	micrograms