STANDARD

MANGANESE SULFATE

CARUS WATER

Municipal Drinking Water Treatment for Radium Removal

CAIROX® POTASSIUM PERMANGANATE
CARUSOL® LIQUID PERMANGANATE

TECHNICAL BRIEF

TECHNICAL SUMMARY

The National Primary Drinking Water Regulations for Radium 226 and Radium 228 have a Maximum Contaminate Level (MCL) of 5 pCi/L. The MCL for gross alpha emitters is 15 pCi/L. Potassium permanganate or sodium permanganate is used in combination with manganese sulfate to produce freshly precipitated Hydrous Manganese Oxides (HMO's). These hydrous manganese oxides have high surface area that is negatively charged which gives it the ability to adsorb positively charged ions, such as radium.

Factors that affect radium removal efficiency include water chemistry and pH. Removal efficiencies increase with increasing pH from 5 to 9. Removal efficiencies decrease with increasing levels of hardness (mg/L as calcium carbonate). Removal efficiencies range from 60-80 percent.

APPLICATION

The hydrous manganese oxides are created by reacting manganous sulfate with permanganate.

CHEMISTRY

$$3MnSO_4 + 2MnO_4^- + 2H_2O \longrightarrow 5MnO_2 + 4H^+ + 3SO_4^=$$

It is recommended that the slurry of HMO then be pH adjusted to 8.0 (minimum) using NaOH.

1 mg/L of soluble manganese requires 1.92 mg/L of permanganate.

DOSAGE

Typically dosages of 0.5 - 1.0 mg/L of HMO are effective for radium reduction.

FACILITY REQUIREMENTS

Proper feed equipment specially designed to handle CAIROX® potassium permanganate or CARUSOL® liquid permanganate are recommended and available from Carus Corporation. There are also feed systems for the proper addition of CARUS® MnS or MnP Manganese Sulfates. For proper removal of the hydrous manganese dioxide, the utility must have filtration or coagulation/filtration to remove the Manganese Dioxide (MnO_2.)In many facilities the preformed HMO is aged for 24 hours and then fed via metering pumps.

Permanganate quickly oxidizes Mn^{2+} to form hydrous manganese oxides. The freshly precipitated HMO will adsorb metal ions and organic compounds.

BENEFITS

Permanganate also:

Improves tastes and odors,
Controls iron and manganese,
Acts as an alternative pre-oxidant to chlorine in a trihalomethane control program, and
Oxidizes and adsorbs arsenic.

REFERENCES

Richard L. Valentine, Alan Kurt, John Meyer, Dave Walsh, and William Mielke. (1992) "Radium Removal Using Preformed Hydrous Manganese Oxides," American Water Works Association Research Foundation, 666 W. Quincy Avenue, Denver, CO 52242.

Ficek, K.J., "Potassium Permanganate/Manganese Greensand for Removal of Metals," Water Quality Association, Convention Paper, March 1994.

Tom Dumbaugh (2004) "Hydrous Manganous Oxide (HMO) Process for Radium Reduction Design and Practical Operating Experience." Water Quality Technology Conference.

CARUS CORPORATION — ONE COMPANY. ENDLESS SOLUTIONS

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rev. 5/15
Form # 3709

CARUS WATER

Municipal Drinking Water Treatment for Radium Removal

CAIROX® POTASSIUM PERMANGANATE
CARUSOL® LIQUID PERMANGANATE

TECHNICAL BRIEF

OTHER APPLICATIONS

- Taste & Odor Control
- Disinfection By-Product Control
- Iron & Manganese Removal
- Arsenic & Radium Reduction/Removal

For further information on CAIROX® potassium permanganate, CARUSOL® liquid permanganate or CARUS® MnS Manganese Sulfate product characteristics and availability, contact Carus Corporation at 1-800-435-6856.

CARUS VALUE ADDED

LABORATORY SUPPORT

Carus Corporation has technical assistance available to answer questions, evaluate treatment alternatives, and perform laboratory testing. Our laboratory capabilities include; treatability studies, feasibility studies, and analytical services.

FIELD SERVICES

As an integral part of our technical support, Carus provides extensive on-site treatment assistance. We offer full application services, including technical expertise, supervision, testing, and feed equipment design and installation in order to accomplish a successful evaluation and/or application.

EQUIPMENT SERVICES

Standard feeders are designed specifically for CAIROX® potassium permanganate. Various options and accessories are available to meet a wide range of applications. Carus offers custom-engineered feed systems , pre-engineered and prepackaged systems through an equipment partner. They provide efficient, dust-free methods of storing, mixing, and feeding CAIROX potassium permanganate. System designs are customized to meet specific applications and customer needs.

CARUS CORPORATION

During its more than 100+ year history, Carus' ongoing reliance on research and development, as well as its emphasis on technical support and customer service, have enabled the company to become the world leader in permanganate, manganese, oxidation, and base-metal catalyst technologies.

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CARUS WATER



CARUS® Mn S Manganese Sulfate CAS Registry No. 10034-96-5

CARUS® Mn S MANGANESE SULFATE DATA SHEET

CARUS® Mn S manganese sulfate is an important component in radium removal systems utilizing Hydrous Manganese Oxide (HMO). This NSF certified manganese sulfate provides one of the components necessary for the production of HMO. CARUSOL® liquid permanganate completes the system, allowing for the formation of highly adsorbent hydrous manganese oxide.

PRODUCT SPECIFICATIONS

Assay	**≥ 29.4% as $MnSO_4 \cdot H_2O$**
pH, 5% solution	**5.0 - 8.0**
Insolubles, %	**≤ 0.2%**

Standards and Specifications

CARUS Mn S manganese sulfate is certified by the National Sanitation Foundation (NSF) to ANSI/NSF Standard 60: Drinking Water Treatment Chemicals - Health Effects.

CHEMICAL/PHYSICAL DATA

Formula	$MnSO_4 \cdot H_2O$
Formula Weight	169.0 g/mol
Form	Clear solution
Density	Approximately 10.88 lbs/gal

APPLICATIONS

CARUS Mn S manganese sulfate is utilized as a major component in the creation of Hydrous Manganese Oxide (HMO) for the removal of radium.

SHIPPING CONTAINERS

55-gallon (208.2 L) Closed head HDPE Drum

(Un specifications: 3H1) Made of high density polyethylene (HDPE.) Weighs 20.5 lbs (9.3 kg). The net weight is 598 lbs. The drum stands approximately 35.1 in. tall, has an outside diameter of 23.4 in. (89.1 cm tall, OD 59.4 cm).

275-gallon (1041 L) IBC (Intermediate Bulk Container)

Weighs 139 lbs (65 kg). The net weight is 3000s (1106.8 kg). The IBC dimensions are 45.4 in. high, 48 in. long, and 40 in. wide. The IBC has a 2" butterfly valve with NPT threads in bottom sump.

Bulk Shipping

Quantities from 3000-4200 gallons are available.

HANDLING, STORAGE, AND INCOMPATIBILITY

CARUS Mn S manganese sulfate should be stored in a cool, dry area in a closed container. Segregated from permanganates, other oxidizing agents, peroxides, and chlorates. Protect containers against physical damage.

SHIPPING

CARUS Mn S manganese sulfate is not regulated by the Department of Transportation (DOT). The proper shipping name is Manganese Compound.

CARUS CORPORATION

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RESPONSIBLE CARE®

CARUS®

SAFETY DATA SHEET

1. Identification

Product identifier **C A R U S® Mn S Manganese sulfate**

Other means of identification

SDS number -

Recommended use CARUS® Mn S manganese sulfate is an important component in radium removal systems utilizing Hydrous Manganese Oxide (HMO) and also used as a laboratory chemical and in the manufacture of substances.

Recommended restrictions None known.

Manufacturer/Importer/Supplier/Distributor information

Company name CARUS CORPORATION

Address 315 Fifth Street,
Peru, IL 61354, USA

Telephone +1 815 223-1500 - All other non-emergency inquiries about the product should be directed to the company

E-mail salesmkt@caruscorporation.com

Website www.caruscorporation.com

Contact person Dr. Chithambarathanu Pillai

Emergency Telephone For Hazardous Materials [or Dangerous Goods] Incidents ONLY
(spill, leak, fire, exposure or accident), call CHEMTREC at
CHEMTREC®, USA: 001 (800) 424-9300
CHEMTREC®, Mexico (Toll-Free - must be dialed from within country):
01-800-681-9531
CHEMTREC®, Other countries: 001 (703) 527-3887

2. Hazard(s) identification

Physical hazards Not classified.

Health hazards	Specific target organ toxicity, repeated exposure	Category 2 (Central Nervous System)
Environmental hazards	Hazardous to the aquatic environment, acute hazard	Category 2
	Hazardous to the aquatic environment, long-term hazard	Category 2

OSHA defined hazards Not classified.

Label elements

Signal word Warning

Hazard statement May cause damage to organs (Central Nervous System) through prolonged or repeated exposure by inhalation and ingestion. Toxic to aquatic life with long lasting effects.

Precautionary statement

Prevention Do not breathe mist or vapor. Avoid release to the environment.

Response Get medical advice/attention if you feel unwell. Collect spillage.

Storage Store away from incompatible materials.

Disposal Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazard(s) not otherwise classified (HNOC) None known.

3. Composition/information on ingredients

Mixtures

Chemical name	CAS number	%
Manganese Sulfate Monohydrate	10034-96-5	29.4 - 33

Composition comments All concentrations are in percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.

4. First-aid measures

Inhalation Move to fresh air. If breathing is difficult, give oxygen. If not breathing, give artificial respiration. Call a physician if symptoms develop or persist.

Skin contact Wash off immediately with soap and plenty of water while removing all contaminated clothes and shoes. Get medical attention if irritation develops and persists.

Eye contact Hold eyelids apart and flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation develops and persists.

Ingestion Rinse mouth. Immediately give a couple of glasses of water or milk, provided the victim is fully conscious. Never give anything by mouth to an unconscious person. Get medical attention if symptoms occur.

Most important symptoms/effects, acute and delayed Decrease in motor functions. Behavioral changes. Narcosis. Nausea, vomiting. Coughing. Prolonged exposure may cause chronic effects.

Indication of immediate medical attention and special treatment needed Provide general supportive measures and treat symptomatically. Keep victim under observation. Symptoms may be delayed.

General information If you feel unwell, seek medical advice (show the label where possible). Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media Water fog. Foam. Dry chemical powder. Carbon dioxide (CO2).

Unsuitable extinguishing media Do not use water jet as an extinguisher, as this will spread the fire.

Specific hazards arising from the chemical During fire, gases hazardous to health may be formed.

Special protective equipment and precautions for firefighters Self-contained breathing apparatus and full protective clothing must be worn in case of fire.

Fire fighting equipment/instructions Move containers from fire area if you can do so without risk. Use water spray to cool unopened containers.

Specific methods Use standard firefighting procedures and consider the hazards of other involved materials.

General fire hazards No unusual fire or explosion hazards noted.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Wear appropriate protective equipment and clothing during clean-up. Avoid ingestion. Avoid contact with skin and eyes. Do not breathe mist or vapor. Ensure adequate ventilation. Local authorities should be advised if significant spillages cannot be contained. For personal protection, see section 8 of the SDS.

Methods and materials for containment and cleaning up Large Spills: Stop the flow of material, if this is without risk. Use water spray to reduce vapors or divert vapor cloud drift. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Absorb in vermiculite, dry sand or earth and place into containers. Prevent entry into waterways, sewer, basements or confined areas. Following product recovery, flush area with water.

Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination.

Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.

Environmental precautions Avoid release to the environment. Prevent further leakage or spillage if safe to do so. Avoid discharge into drains, water courses or onto the ground. Inform appropriate managerial or supervisory personnel of all environmental releases.

7. Handling and storage

Precautions for safe handling
Do not breathe mist or vapor. Avoid ingestion. Avoid contact with skin and eyes. Avoid prolonged exposure. Provide adequate ventilation. Wear appropriate personal protective equipment. Avoid release to the environment. Observe good industrial hygiene practices.

Conditions for safe storage, including any incompatibilities
Store in original tightly closed container. Store in a well-ventilated place. Store away from incompatible materials (see Section 10 of the SDS).

8. Exposure controls/personal protection

Occupational exposure limits

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Components	Type	Value
Manganese Sulfate Monohydrate (CAS 10034-96-5)	Ceiling	5 mg/m3

US. ACGIH Threshold Limit Values

Components	Type	Value	Form
Manganese Sulfate Monohydrate (CAS 10034-96-5)	TWA	0.1 mg/m3	Inhalable fraction.
		0.02 mg/m3	Respirable fraction.

US. NIOSH: Pocket Guide to Chemical Hazards

Components	Type	Value	Form
Manganese Sulfate Monohydrate (CAS 10034-96-5)	STEL	3 mg/m3	Fume.
	TWA	1 mg/m3	Fume.

Biological limit values
No biological exposure limits noted for the ingredient(s).

Appropriate engineering controls
Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level.

Individual protection measures, such as personal protective equipment

Eye/face protection
Chemical respirator with organic vapor cartridge and full facepiece.

Skin protection

Hand protection
Wear appropriate chemical resistant gloves.

Other
Use of an impervious apron is recommended.

Respiratory protection
Chemical respirator with organic vapor cartridge and full facepiece.

Thermal hazards
Wear appropriate thermal protective clothing, when necessary.

General hygiene considerations
Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance
Clear solution.

Physical state
Liquid.

Form
Clear solution.

Color
Clear.

Odor
Odorless.

Odor threshold
Not available.

pH
5 - 8 (pH of 5% solution)

Melting point/freezing point
Not available.

Initial boiling point and boiling range
> 212 °F (> 100 °C)

Flash point
Not available.

Evaporation rate	Not available.
Flammability (solid, gas)	Not available.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Relative density	1.30±0.03 (77 °F (25 °C))
Solubility(ies)	
Solubility (water)	20 % (72 °F (22.22 °C))
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not available.

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Material is stable under normal conditions.
Possibility of hazardous reactions	No dangerous reaction known under conditions of normal use.
Conditions to avoid	Contact with incompatible materials.
Incompatible materials	Strong acids. Strong oxidizing agents. Powdered metals. Hydrogen peroxide (H2O2).
Hazardous decomposition products	Carbon dioxide. Sulfur oxides. Manganese oxides.

11. Toxicological information

Information on likely routes of exposure

Inhalation	May cause damage to organs through prolonged or repeated exposure by inhalation.
Skin contact	Prolonged skin contact may cause temporary irritation.
Eye contact	Direct contact with eyes may cause temporary irritation.
Ingestion	May cause malaise, nausea, gastrointenstinal damage, or even death unless treated promptly.
Symptoms related to the physical, chemical and toxicological characteristics	Behavioral changes. Decrease in motor functions. Narcosis. Nausea, vomiting. Coughing.

Information on toxicological effects

Acute toxicity	May cause skin irritation. May cause eye irritation.
Skin corrosion/irritation	Prolonged skin contact may cause temporary irritation.
Serious eye damage/eye irritation	Direct contact with eyes may cause temporary irritation.
Respiratory or skin sensitization	
Respiratory sensitization	Not a respiratory sensitizer.
Skin sensitization	This product is not expected to cause skin sensitization.
Germ cell mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.
Carcinogenicity	This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

Reproductive toxicity	Based on available data, the classification criteria are not met.

Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	May cause damage to organs (Central Nervous System) through prolonged or repeated exposure by inhalation and ingestion.
Aspiration hazard	Not an aspiration hazard.
Chronic effects	Men exposed to manganese dusts showed a decrease in fertility. Chronic manganese poisoning primarily involves the central nervous system. Early symptoms include languor, sleepiness and weakness in the legs. A stolid mask-like appearance of the face, emotional disturbances such as uncontrollable laughter and a spastic gait with tendency to fall in walking are findings in more advanced cases. High incidence of pneumonia has been found in workers exposed to the dust or fume of some manganese compounds., Prolonged or repeated inhalation may cause:, Pneumonia .

12. Ecological information

Ecotoxicity	Toxic to aquatic life with long lasting effects.
Persistence and degradability	No data is available on the degradability of this product.
Bioaccumulative potential	No data available.
Mobility in soil	No data available.
Other adverse effects	No other adverse environmental effects (e.g. ozone depletion, photochemical ozone creation potential, endocrine disruption, global warming potential) are expected from this component.

13. Disposal considerations

Disposal instructions	Collect and reclaim or dispose in sealed containers at licensed waste disposal site. Do not allow this material to drain into sewers/water supplies. Do not contaminate ponds, waterways or ditches with chemical or used container. Dispose of contents/container in accordance with local/regional/national/international regulations.
Local disposal regulations	Dispose in accordance with all applicable regulations.
Hazardous waste code	The waste code should be assigned in discussion between the user, the producer and the waste disposal company.
Waste from residues / unused products	Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).
Contaminated packaging	Empty containers should be taken to an approved waste handling site for recycling or disposal. Since emptied containers may retain product residue, follow label warnings even after container is emptied.

14. Transport information

DOT

UN number	UN3082
UN proper shipping name	Environmentally hazardous substances, liquid, n.o.s. (MANGANESE SULFATE MONOHYDRATE)
Transport hazard class(es)	
Class	9
Subsidiary risk	-
Label(s)	9
Packing group	III
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.
Special provisions	8, 146, 335, IB3, T4, TP1, TP29
Packaging exceptions	155
Packaging non bulk	203
Packaging bulk	241

This material is not regulated under 49 CFR if in a container of 119 gallon capacity or less.

IATA

UN number	UN3082
UN proper shipping name	Environmentally hazardous substances, liquid, n.o.s. (MANGANESE SULFATE MONOHYDRATE)
Transport hazard class(es)	
Class	9
Subsidiary risk	-
Label(s)	9
Packing group	III

Environmental hazards	No.
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.

IMDG

UN number	UN3082
UN proper shipping name	Environmentally hazardous substances, liquid, n.o.s. (MANGANESE SULFATE MONOHYDRATE)
Transport hazard class(es)	
Class	9
Subsidiary risk	-
Label(s)	9
Packing group	III
Environmental hazards	
Marine pollutant	No.
EmS	Not available.
Special precautions for user	Read safety instructions, SDS and emergency procedures before handling.
Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code	Not established.

15. Regulatory information

US federal regulations

This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
All components are on the U.S. EPA TSCA Inventory List.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

CERCLA Hazardous Substance List (40 CFR 302.4)

Manganese Sulfate Monohydrate (CAS 10034-96-5) LISTED

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories

Immediate Hazard - No
Delayed Hazard - Yes
Fire Hazard - No
Pressure Hazard - No
Reactivity Hazard - No

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical Yes

SARA 313 (TRI reporting)

Chemical name	CAS number	% by wt.
Manganese Sulfate Monohydrate	10034-96-5	29.4 - 33

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Manganese Sulfate Monohydrate (CAS 10034-96-5)

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act (SDWA) Not regulated.

US state regulations

US. Massachusetts RTK - Substance List

Not regulated.

US. New Jersey Worker and Community Right-to-Know Act

Manganese Sulfate Monohydrate (CAS 10034-96-5)

US. Pennsylvania Worker and Community Right-to-Know Law

Not listed.

US. Rhode Island RTK

Manganese Sulfate Monohydrate (CAS 10034-96-5)

US. California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins.

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates this product complies with the inventory requirements administered by the governing country(s).
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date 26-February-2015

Revision date -

Version # 01

NFPA ratings

Disclaimer cannot anticipate all conditions under which this information and its product, or the products of other manufacturers in combination with its product, may be used. It is the user's responsibility to ensure safe conditions for handling, storage and disposal of the product, and to assume liability for loss, injury, damage or expense due to improper use. The information in the sheet was written based on the best knowledge and experience currently available.