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Magnesium sulfate

Magnesium sulfate is an inorganic salt with the formula $MgSO_4(H_2O)_x$ where $0 \le x \le 7$. It is often encountered as the heptahydrate sulfate mineral epsomite ($MgSO_4 \cdot 7H_2O$), commonly called **Epsom salt**. The overall global annual usage in the mid-1970s of the monohydrate was 2.3 million tons, of which the majority was used in agriculture.[1]

Epsom salt has been traditionally used as a component of bath salts. Epsom salt can also be used as a beauty product. Athletes use it to soothe sore muscles, while gardeners use it to improve crops. It has a variety of other uses: for example, Epsom salt is also effective in the removal of splinters.[2]

Contents

Hydrates and anhydrous material, production

A variety of hydrates are known.[3]

The heptahydrate (epsomite) readily loses one equivalent of water to form the hexahydrate. Epsom salt takes its name from a bitter saline spring in Epsom in Surrey, England, where the salt was produced from the springs that arise where the porous chalk of the North Downs meets non-porous London clay.

The monohydrate, $MgSO_4 \cdot H_2O$ is found as the mineral kieserite. It can be prepared by heating the hexahydrate to approximately 150 °C. Further heating to approximately 200 °C gives anhydrous magnesium sulfate. Upon further heating, the anhydrous salt decomposes into magnesium oxide (MgO) and sulfur trioxide (SO_3).

The heptahydrate can be prepared by neutralizing sulfuric acid with magnesium carbonate or oxide, but it is usually obtained directly from natural sources.

Uses

Medical

It is on the WHO Model List of Essential Medicines, the most important medications needed in a basic health system.[4]

Magnesium sulfate is a common mineral pharmaceutical preparation of magnesium, commonly known as Epsom salt, used both externally and internally. Magnesium sulfate is highly water-soluble and solubility is inhibited with lipids typically used in lotions. Lotions often employ the use of emulsions or suspensions to include both oil and water-soluble ingredients. Hence, magnesium sulfate in a lotion may not be as freely available to migrate to the skin nor to be absorbed through the skin, hence both studies may properly suggest absorption or lack thereof as a function of the carrier (in a water solution vs. in an oil emulsion/suspension). Temperature and concentration gradients may also be contributing factors to absorption.[5]

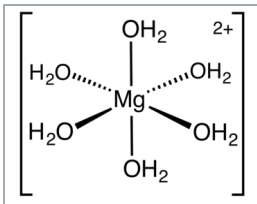
Externally, magnesium sulfate paste is used to treat skin inflammations such as small boils or localised infections. Known in the UK as "drawing paste", it is also used to remove splinters.[6] The standard British Pharmacopoeia composition is dried Magnesium Sulfate 47.76 % w/w, Phenol 0.49 % w/w. and glycerol (E422).[7]

Epsom salt is used as bath salts and for isolation tanks. Magnesium sulfate is the main preparation of intravenous magnesium.

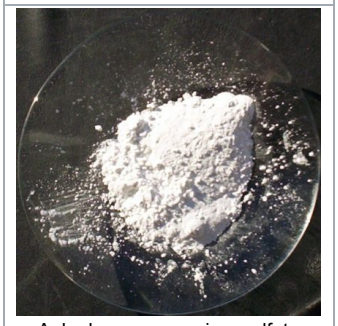
Internal uses include:

- Oral magnesium sulfate is commonly used as a saline laxative or osmotic purgative.
- Replacement therapy for hypomagnesemia[8]
- Magnesium sulfate is a antiarrhythmic agent for torsades de pointes in cardiac arrest under the ECC guidelines and for managing quinidine-induced arrhythmias.[9]

Magnesium sulfate



hexahydrate



Anhydrous magnesium sulfate

Epsomite (heptahydrate)

Names	
IUPAC name	Magnesium sulfate
Other names	Epsom salt (heptahydrate) English salt Bitter salts Bath salts
Identifiers	
CAS Number	7487-88-9 (http://www.commonchemistry.org/ChemicalDetail.aspx?ref=7487-88-9) (anhydrous) ✓ 14168-73-1 (http://www.commonchemistry.org/ChemicalDetail.aspx?ref=14168-73-1) (monohydrate) ✓ 24378-31-2 (http://www.commonchemistry.org/ChemicalDetail.aspx?ref=24378-31-2) (tetrahydrate) ✓ 15553-21-6 (http://www.commonchemistry.org/ChemicalDetail.aspx?ref=15553-21-6) (pentahydrate) ✓

- As a bronchodilator after beta-agonist and anticholinergic agents have been tried, e.g. in severe exacerbations of asthma,[10] magnesium sulfate can be nebulized to reduce the symptoms of acute asthma.[10] It is commonly administered via the intravenous route for the management of severe asthma attacks.
- Magnesium sulfate is effective in decreasing the risk that pre-eclampsia progresses to eclampsia.[11] IV magnesium sulfate is used to prevent and treat seizures of eclampsia. It reduces the systolic blood pressure but doesn't alter the diastolic blood pressure, so the blood perfusion to the fetus isn't compromised. It is also commonly used for eclampsia where compared to diazepam or phenytoin it results in better outcomes.[12][13]

Agriculture

In agriculture, magnesium sulfate is used to increase magnesium or sulfur content in soil. It is most commonly applied to potted plants, or to magnesium-hungry crops, such as potatoes, roses, tomatoes, lemon trees, carrots, and peppers. The advantage of magnesium sulfate over other magnesium soil amendments (such as dolomitic lime) is its high solubility, which also allows the option of foliar feeding. Solutions of magnesium sulfate are also nearly neutral, compared with alkaline salts of magnesium as found in limestone; therefore, the use of magnesium sulfate as a magnesium source for soil does not significantly change the soil pH.[14]

Food preparation

Magnesium sulfate is used as a brewing salt in making beer.[15]

It may also be used as a coagulant for making tofu.[16]

Chemistry

Anhydrous magnesium sulfate is commonly used as a desiccant in organic synthesis due to its affinity for water. During work-up, an organic phase is treated with anhydrous magnesium sulfate. The hydrated solid is then removed with filtration or decantation. Other inorganic sulfate salts such as sodium sulfate and calcium sulfate may be used in the same way.

Niche uses

Magnesium sulfate heptahydrate is also used to maintain the magnesium concentration in marine aquaria which contain large amounts of stony corals, as it is slowly depleted in their calcification process. In a magnesium-deficient marine aquarium, calcium and alkalinity concentrations are very difficult to control because not enough magnesium is present to stabilize these ions in the saltwater and prevent their spontaneous precipitation into calcium carbonate.[17]

Minerals

Magnesium sulfates are common minerals in geological environments. Their occurrence is mostly connected with supergene processes. Some of them are also important constituents of evaporitic potassium-magnesium (K-Mg) salts deposits.

Bright spots observed by the Dawn Spacecraft in Occator Crater on the dwarf planet Ceres are most consistent with reflected light from magnesium sulfate hexahydrate.[18]

Almost all known mineralogical forms of $MgSO_4$ are hydrates. Epsomite is the natural analogue of "Epsom salt". Another heptahydrate, the copper-containing mineral alpersite $(Mg,Cu)SO_4 \cdot 7H_2O$,[19] was recently recognized. Both are, however, not the highest known hydrates of $MgSO_4$, due to the recent terrestrial find of meridianiite, $MgSO_4 \cdot 11H_2O$, which is thought to also occur on Mars. Hexahydrite is the next lower (6) hydrate. Three next lower hydrates—pentahydrite, starkeyite, and especially sanderite are rare. Kieserite is a monohydrate and is common among evaporitic deposits. Anhydrous magnesium sulfate was reported from some burning coal dumps.

Double salts

Double salts containing magnesium sulfate exist; for example, there are several known as sodium magnesium sulfates and potassium magnesium sulfates.

Safety

An abnormally elevated plasma concentration of magnesium is called hypermagnesemia.

References

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	13778-97-7 (http://www.commonchemistry.org/ChemicalDetail.aspx?ref=13778-97-7) (hexahydrate) ✓ 10034-99-8 (http://www.commonchemistry.org/ChemicalDetail.aspx?ref=10034-99-8) (heptahydrate) ✓
3D model (JSmol)	Interactive image (https://chemapps.stolaf.edu/jmol/jmol.php?model=%5BMg%2B2%5D.%5BO-%5DS%28%5BO-%5D%29%28%3DO%29%3DO)
ChEBI	CHEBI:32599 (https://www.ebi.ac.uk/chebi/searchId.do?chebiId=32599) ✓
ChEMBL	ChEMBL1200456 (https://www.ebi.ac.uk/chembldb/index.php/compound/inspect/ChEMBL1200456) ✗
ChemSpider	22515 (http://www.chemspider.com/Chemical-Structure.22515.html) ✓
DrugBank	DB00653 (https://www.drugbank.ca/drugs/DB00653) ✓
ECHA InfoCard	100.028.453 (https://echa.europa.eu/substance-information/-/substanceinfo/100.028.453)
E number	E518 (acidity regulators, ...)
PubChem CID	24083 (https://pubchem.ncbi.nlm.nih.gov/compound/24083)
RTECS number	OM4500000
UNII	ML30MJ2U7I (https://fdasis.nlm.nih.gov/srs/srsdirect.jsp?regno=ML30MJ2U7I) ✓
InChI	
SMILES	
Properties	
Chemical formula	$MgSO_4$
Molar mass	120.366 g/mol (anhydrous) 138.38 g/mol (monohydrate) 174.41 g/mol (trihydrate) 210.44 g/mol

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External links

- International Chemical Safety Cards – Magnesium Sulfate (https://www.cdc.gov/niosh/ipcsneng/neng1197.html)

	(pentahydrate) 228.46 g/mol (hexahydrate) 246.47 g/mol (heptahydrate)
Appearance	white crystalline solid
Odor	odorless
Density	2.66 g/cm^3 (anhydrous) 2.445 g/cm^3 (monohydrate) 1.68 g/cm^3 (heptahydrate) 1.512 g/cm^3 (11-hydrate)
Melting point	anhydrous decomposes at 1,124°C monohydrate decomposes at 200°C heptahydrate decomposes at 150°C undecahydrate decomposes at 2°C
Solubility in water	*anhydrous* 26.9 g/100 mL (0 °C) 35.1 g/100 mL (20 °C) 50.2 g/100 mL (100 °C) *heptahydrate* 113 g/100 mL (20 °C)
Solubility	1.16 g/100 mL (18°C, ether) slightly soluble in alcohol, glycerol insoluble in acetone
Magnetic susceptibility (χ)	$-50 \cdot 10^{-6}$ cm^3/mol
Refractive index (n_D)	1.523 (monohydrate) 1.433 (heptahydrate)
Structure	
Crystal structure	monoclinic (hydrate)
Pharmacology	
ATC code	A06AD04 (WHO (https://www.whocc.no/atc_ddd_index/?code=A06AD04)) A12CC02 (WHO (https://www.whocc.no/atc_ddd_index/?code=A12CC02)) B05XA05 (WHO (https://www.whocc.no/atc_ddd_index/?code=B05XA05)) D11AX05 (WHO (https://www.whocc.no/a

	tc_ddd_index/?code=D11AX05)) V04CC02 (WHO (https://www.whocc.no/atc_ddd_index/?code=V04CC02))
Hazards	
Safety data sheet	External MSDS (http://hazard.com/msds/mf/baker/baker/files/m0234.htm)
NFPA 704	
Related compounds	
Other cations	Beryllium sulfate Calcium sulfate Strontium sulfate Barium sulfate
Except where otherwise noted, data are given for materials in their standard state (at 25 °C [77 °F], 100 kPa). ✗ verify (what is ✓✗ ?) Infobox references	

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