

Borax

Borax, also known as **sodium borate**, **sodium tetraborate**, or **disodium tetraborate**, is an important boron compound, a mineral, and a salt of boric acid. Powdered borax is white, consisting of soft colorless crystals that dissolve in water. A number of closely related minerals or chemical compounds that differ in their crystal water content are referred to as *borax*, but the word is usually used to refer to the decahydrate.^[1] Commercially sold borax is partially dehydrated.

Borax is a component of many detergents, cosmetics, and enamel glazes. It is used to make buffer solutions in biochemistry, as a fire retardant, as an anti-fungal compound, in the manufacture of fiberglass, as a flux in metallurgy, neutron-capture shields for radioactive sources, a texturing agent in cooking, as a precursor for other boron compounds, and along with its inverse, boric acid, is useful as an insecticide.

In artisanal gold mining, borax is sometimes used as part of a process (as a flux) meant to eliminate the need for toxic mercury in the gold extraction process, although it cannot directly replace mercury. Borax was reportedly used by gold miners in parts of the Philippines in the 1900s.^[6]

Borax was first discovered in dry lake beds in Tibet and was imported via the Silk Road to the Arabian Peninsula in the 8th century AD.^[7] Borax first came into common use in the late 19th century when Francis Marion Smith's Pacific Coast Borax Company began to market and popularize a large variety of applications under the 20 Mule Team Borax trademark, named for the method by which borax was originally hauled out of the California and Nevada deserts in large enough quantities to make it cheap and commonly available.^{[8][9]}

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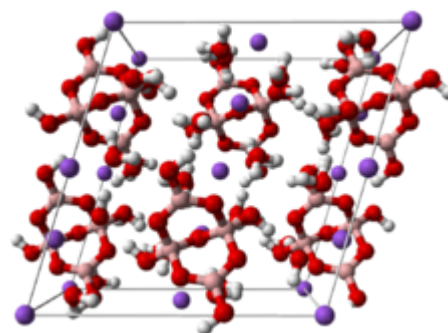
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Borax



Names

IUPAC name

Sodium tetraborate decahydrate

Other names

Borax decahydrate

Identifiers

CAS Number

1303-96-4 (<http://www.commonchemistry.org/ChemicalDetail.aspx?ref=1303-96-4>)
(decahydrate) ✓

3D model (JSmol)

Interactive image (<https://chemapps.stolaf.edu/jmol/jmol.php?model=%5BNa%2B%5D.%5BNa%2B%5D.%5BO-%5DB1OB2OB%28%5BO-%5D%29OB%28>)

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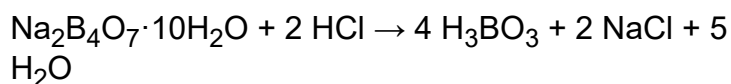
Chemistry

The term *borax* is often used for a number of closely related minerals or chemical compounds that differ in their crystal water content:

- anhydrous sodium tetraborate, Na₂B₄O₇
- sodium tetraborate pentahydrate, Na₂B₄O₇·5H₂O
- sodium tetraborate decahydrate, Na₂B₄O₇·10H₂O

Borax is generally described as Na₂B₄O₇·10H₂O. However, it is better formulated as Na₂[B₄O₅(OH)₄]·8H₂O, since borax contains the [B₄O₅(OH)₄]²⁻ ion. In this structure, there are two four-coordinate boron atoms (two BO₄ tetrahedra) and two three-coordinate boron atoms (two BO₃ triangles).

Borax is also easily converted to boric acid and other borates, which have many applications. Its reaction with hydrochloric acid to form boric acid is:



The "decahydrate" is sufficiently stable to find use as a primary standard for acid base titrimetry.^[10]

When borax is added to a flame, it produces a yellow green color.^[11] Borax is not used for this purpose in fireworks due to the overwhelming yellow color of sodium. Boric acid is used to color methanol flames a transparent green.

Borax is very soluble in ethylene glycol, moderately soluble in diethylene glycol and methanol, slightly soluble in acetone.^[12] It is poorly soluble in cold water, but its solubility increases significantly with temperature.^{[12][13]}

Etymology

	O1%29O2.O.O.O.O.O. O.O.O.O.O.O)
ChEBI	CHEBI:86222 (https://www.ebi.ac.uk/chebi/searchId.do?chebiId=86222) ✖
ChEMBL	ChEMBL1076681 (https://www.ebi.ac.uk/chembl/index.php/compound/inspect/ChEMBL1076681) ✖
ChemSpider	17339255 (http://www.chemspider.com/Chemical-Structure.17339255.html) ✔
ECHA InfoCard	100.014.129 (https://echa.europa.eu/substance-information/-/substanceinfo/100.014.129)
EC Number	215-540-4
E number	E285 (preservatives)
KEGG	D03243 (http://www.kegg.jp/entry/D03243) ✖
PubChem CID	11954323 (https://pubchem.ncbi.nlm.nih.gov/compound/11954323)
UNII	91MBZ8H3QO (https://fdasis.nlm.nih.gov/srs/srsdirect.jsp?regno=91MBZ8H3QO) ✔
InChI	
SMILES	
Properties	
Chemical formula	Na ₂ B ₄ O ₇ ·10H ₂ O or Na ₂ [B ₄ O ₅ (OH) ₄]·8H ₂ O
Molar mass	381.38 (decahydrate) 201.22 (anhydrate)
Appearance	white solid
Density	1.73 g/cm ³

The English word *borax* is Latinized: the Middle English form was *boras*, from Old French *boras*, *bourras*. That may have been from medieval Latin *baurach* (another English spelling), *borac(-/um/em)*, *borax*, along with Spanish *borrax* (> *borraj*) and Italian *borrace*, in the 9th century. Another name for borax is **tincal**, from Sanskrit.^[7]

The word *tincal* /ˈtɪŋkəl/ "tinkle", or *tincar* /ˈtɪŋkər/ "tinker", refers to crude borax, before it is purified, as mined from lake deposits in Tibet, Persia, and other parts of Asia. The word was adopted in the 17th century from Malay *tingkal* and from Urdu/Persian/Arabic تنکار *tinkār/tankār*; thus the two forms in English. These all appear to be related to the Sanskrit टंकण *tāṅkaṇa*.^[14]

Natural sources

Borax occurs naturally in evaporite deposits produced by the repeated evaporation of seasonal lakes. The most commercially important deposits are found in: Turkey; Boron, California; and Searles Lake, California. Also, borax has been found at many other locations in the Southwestern United States, the Atacama desert in Chile, newly discovered deposits in Bolivia, and in Tibet and Romania. Borax can also be produced synthetically from other boron compounds.

Naturally occurring borax (known by the trade name Rasorite-46 in the United States and many other countries) is refined by a process of recrystallization.^[15]

Uses

Household products

Borax is used in various household laundry and cleaning products,^[16] including the "20 Mule Team Borax" laundry booster, "Boraxo" powdered hand soap, and some tooth bleaching formulas.^[17]

pH buffer

Borate ions (commonly supplied as boric acid) are used in biochemical and chemical laboratories to make buffers, e.g. for polyacrylamide gel electrophoresis of DNA and RNA, such as TBE buffer (borate buffered tris-hydroxymethylaminomethonium)^{[18][19][20]} or the newer SB buffer or BBS buffer (borate buffered saline) in coating procedures. Borate buffers (usually at pH 8) are also used as preferential equilibration solution in dimethyl pimelimidate (DMP) based crosslinking reactions.

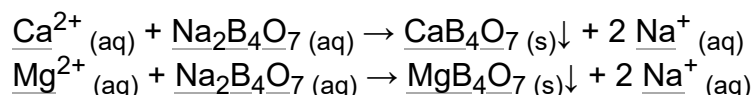
Co-complexing agent

	(decahydrate, solid) ^[1] 2.4 g/cm ³ (anhydrate, solid) ^[1]
Melting point	743 °C (1,369 °F; 1,016 K) (anhydrate) ^[1] 75 °C (decahydrate, decomposes) ^[1]
Boiling point	1,575 °C (2,867 °F; 1,848 K) (anhydrate) ^[1]
Magnetic susceptibility (χ)	$-85.0 \cdot 10^{-6}$ cm ³ /mol
Structure	
Crystal structure	Monoclinic Prismatic
Space group	C2/c
Point group	2/m
Pharmacology	
ATC code	S01AX07 (WHO (http://www.whooc.no/atc_ddd_index/?code=S01AX07))
Hazards	
GHS pictograms	
GHS hazard statements	H360
GHS precautionary statements	P201, P308+313
NFPA 704	^[5]
US health exposure limits (NIOSH):	
PEL (Permissible)	none ^[2]
REL (Recommended)	TWA 1 mg/m ³ (anhydrate and pentahydrate) ^{[2][3]} TWA 5 mg/m ³ (decahydrate) ^[4]
IDLH (Immediate danger)	N.D. ^[2]

Borax as a source of borate has been used to take advantage of the co-complexing ability of borate with other agents in water to form complex ions with various substances. Borate and a suitable polymer bed are used to chromatograph non-glycosylated hemoglobin differentially from glycosylated hemoglobin (chiefly HbA1c), which is an indicator of long term hyperglycemia in diabetes mellitus.

Water-softening agent

Borax alone does not have a high affinity for the *hardness cations*, although it has been used for water-softening. Its chemical equation for water-softening is given below:



The sodium ions introduced do not make water 'hard'. This method is suitable for removing both temporary and permanent types of hardness.

Flux

A mixture of borax and ammonium chloride is used as a flux when welding iron and steel. It lowers the melting point of the unwanted iron oxide (scale), allowing it to run off. Borax is also used mixed with water as a flux when soldering jewelry metals such as gold or silver, where it allows the molten solder to wet the metal and flow evenly into the joint. Borax is also a good flux for "pre-tinning" tungsten with zinc — making the tungsten soft-solderable.^[21] Borax is often used as a flux for forge welding.

Small-scale gold mining

Borax is replacing mercury as the preferred method for extracting gold in small-scale mining facilities. The method is called the borax method and is used in the Philippines.^[22]



Borax-based laundry detergent

Flubber

A rubbery polymer sometimes called Slime, Flubber, 'gluep' or 'glurch' (or erroneously called Silly Putty, which is based on silicone polymers), can be made by cross-linking polyvinyl alcohol with borax. Making flubber from polyvinyl acetate-based glues, such as Elmer's Glue, and borax is a common elementary-science demonstration.^{[23][24]}

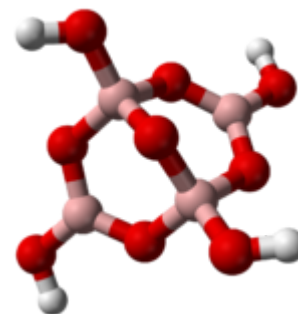
Related compounds

Other anions	Sodium aluminate; sodium gallate
Other cations	Potassium tetraborate
Related compounds	Boric acid, sodium perborate

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



The structure of the anion $[\text{B}_4\text{O}_5(\text{OH})_4]^{2-}$ in borax



Borax "cottonball"



Traction steam engine hauling borax, Death Valley National Park, California, 1904

Food additive

Borax, given the E number *E285*, is used as a food additive in some countries, but is banned in some countries, like the U.S., and Thailand. As a consequence, certain foods, such as caviar, produced for sale in the US contain higher levels of salt to assist preservation.^[25] Its use as a cooking ingredient is to add a firm rubbery texture to the food, or as a preservative. In Asian cooking it is mostly used for its texturing properties. In China, borax (Chinese: 硼砂; pinyin: *péng shā* or Chinese: 月石; pinyin: *yuè shí*) was found to have been added to some Chinese foods like hand-pulled noodles lamian and some rice noodles like shahe fen, kway teow, and chee cheong fun recipes.^[26] In Indonesia it is a common, but forbidden, additive to such foods as noodles, bakso (meatballs), and steamed rice. The country's Directorate of Consumer Protection warns of the risk of liver cancer with high consumption over a period of 5–10 years.^[27]



Old steam tractor and borax wagons, Death Valley National Park

Other uses

- Ingredient in enamel glazes
- Component of glass, pottery, and ceramics
- Used as an additive in ceramic slips and glazes to improve fit on wet, greenware, and bisque
- Fire retardant
- Anti-fungal compound for cellulose insulation
- Moth proofing 10% solution for wool^[28]
- Pulverized for the prevention of stubborn pests (e.g. German cockroaches) in closets, pipe and cable inlets, wall panelling gaps, and inaccessible locations where ordinary pesticides are undesirable
- Anti-fungal foot soak
- Precursor for sodium perborate monohydrate that is used in detergents, as well as for boric acid and other borates
- Tackifier ingredient in casein, starch and dextrin based adhesives
- Precursor for boric acid, a tackifier ingredient in polyvinyl acetate, polyvinyl alcohol based adhesives
- Fluoride detoxification
- Treatment for thrush in horses' hooves
- To make indelible ink for dip pens by dissolving shellac into heated borax
- Curing agent for snake skins
- Curing agent for salmon eggs, for use in sport fishing for salmon
- Swimming pool buffering agent to control pH
- Neutron absorber, used in nuclear reactors and spent fuel pools to control reactivity and to shut down a nuclear chain reaction
- As a micronutrient fertilizer to correct boron-deficient soils.^{[29][30]}
- Preservative in taxidermy
- To color fires with a green tint^[31]
- Was traditionally used to coat dry-cured meats such as hams to protect them from becoming fly-blown during further storage
- Is found in some commercial vitamin supplements
- For stopping car radiator and engine block leaks^[32]
- Used by blacksmiths in forge welding
- Used as a woodworm treatment (diluted in water)
- Used in the treatment or prevention of wood rot in classic wood boats
- Used to enrich beets with Boron when leaves are wilting



Rio Tinto Borax Mine Pit, Boron, California

Toxicity

Borax, sodium tetraborate decahydrate, according to one study, is not acutely toxic.^[33] Its LD_{50} (median lethal dose) score is tested at 2.66 g/kg in rats,^[34] meaning that a significant dose of the chemical is needed to cause severe symptoms or death. The lethal dose is not necessarily the same for humans. On pesticide information websites it is listed as a non-lethal compound and of no hazardous concerns.^[35]

Borax has been in use as an insecticide in the United States with various restrictions since 1946. All restrictions were removed in February 1986 due to the low toxicity of borax, as reported in two EPA documents relating to boric acid and borax.^{[36][37]}

EPA has determined that, because they are of low toxicity and occur naturally, boric acid and its sodium salts should be exempted from the requirement of a tolerance (maximum residue limit) for all raw agricultural commodities.^[36]

Although it cited inconclusive data, a re-evaluation in 2006 by the EPA still found that "There were no signs of toxicity observed during the study and no evidence of cytotoxicity to the target organ."^[38] In the reevaluation, a study of toxicity due to overexposure was checked and the findings were that "The residential handler inhalation risks due to boric acid and its sodium salts as active ingredients are not a risk concern and do not exceed the level of concern..." but that there could be some risk of irritation to children inhaling it if used as a powder for cleaning rugs.

Sodium tetraborate decahydrate has no known hazard issues.^[39]

Conditions defined as "over-exposure" to borax dust can cause respiratory irritation, while no skin irritation is known to exist due to borax. Ingestion may cause gastrointestinal distress including nausea, persistent vomiting, abdominal pain, and diarrhea. Effects on the vascular system and human brain include headaches and lethargy, but are less frequent. "In severe poisonings, a beefy red skin rash affecting palms, soles, buttocks and scrotum has been described. With severe poisoning, erythematous and exfoliative rash, unconsciousness, respiratory depression, and renal failure."^[33]

A draft risk assessment released by Health Canada in July 2016 has found that overexposure to boric acid has the potential to cause developmental and reproductive health effects. Since people are already exposed to boric acid naturally through their diets and water, Health Canada advised that exposure from other sources should be reduced as much as possible, especially for children and pregnant women. The concern is not with any one product, but rather multiple exposures from a variety of sources. With this in mind, the department also announced that registrations for certain pesticides that contain boric acid, which are commonly used in homes, will have their registrations cancelled and be phased out of the marketplace. As well, new, more protective label directions are being introduced for other boric acid pesticides that continue to be registered in Canada (for example, enclosed bait stations and spot treatments using gel formulations).^[40]

Possible carcinogen

The Indonesian Directorate of Consumer Protection warns of the risk of liver cancer with high consumption of borax over a period of 5–10 years.^[27]

Risk to fertility and pregnancy

Borax was added to the Substance of Very High Concern (SVHC) candidate list on 16 December 2010. The SVHC candidate list is part of the EU Regulations on the Registration, Evaluation, Authorisation and Restriction of Chemicals 2006 (REACH), and the addition was based on the revised classification of borax as *toxic for reproduction* category 1B under the CLP Regulations. Substances and mixtures imported into the EU which contain borax are now required to be

labelled with the warnings "May damage fertility" and "May damage the unborn child".^[41] It was proposed for addition to REACH Annex XIV by the ECHA on 1 July 2015.^[42] If this recommendation is approved, all imports and uses of borax in the EU will have to be authorized by the ECHA. Review of the boron toxicity (as boric acid and borates) published 2012 in *Journal of Toxicology and Environmental Health* concluded: "It clearly appears that human B [boron] exposures, even in the highest exposed cohorts, are too low to reach the blood (and target tissue) concentrations that would be required to exert adverse effects on reproductive functions."^[43]

See also

- [Borax bead test](#)
- [John Veatch](#)
- [List of cleaning agents](#)
- [Sodium borohydride](#)
- [Ulexite](#)

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43. Bolt, Hermann M.; Başaran, Nurşen; Duydu, Yalçın (2012). "Human Environmental and Occupational Exposures to Boric Acid: Reconciliation with Experimental Reproductive Toxicity Data". *Journal of Toxicology and Environmental Health, Part A*. **75** (8–10): 508–514. doi:10.1080/15287394.2012.675301 (<https://doi.org/10.1080%2F15287394.2012.675301>). PMID 22686310 (<https://www.ncbi.nlm.nih.gov/pubmed/22686310>).

External links

- [International Chemical Safety Card 0567](http://www.inchem.org/documents/icsc/icsc/eics0567.htm) (<http://www.inchem.org/documents/icsc/icsc/eics0567.htm>)
- [International Chemical Safety Card 1229](http://www.inchem.org/documents/icsc/icsc/eics1229.htm) (<http://www.inchem.org/documents/icsc/icsc/eics1229.htm>) (fused borax)
- [National Pollutant Inventory – Boron and compounds](https://web.archive.org/web/20060209040519/http://www.npi.gov.au/database/substance-info/profiles/15.html) (<https://web.archive.org/web/20060209040519/http://www.npi.gov.au/database/substance-info/profiles/15.html>)
- [NIOSH Pocket Guide to Chemical Hazards](https://www.cdc.gov/niosh/npg/npgd0058.html) (<https://www.cdc.gov/niosh/npg/npgd0058.html>)
- [Sodium Borate in sefsc.noaa.gov](https://web.archive.org/web/20020821230321/http://www.sefsc.noaa.gov/HTMLdocs/SodiumBorate.htm) (<https://web.archive.org/web/20020821230321/http://www.sefsc.noaa.gov/HTMLdocs/SodiumBorate.htm>)

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