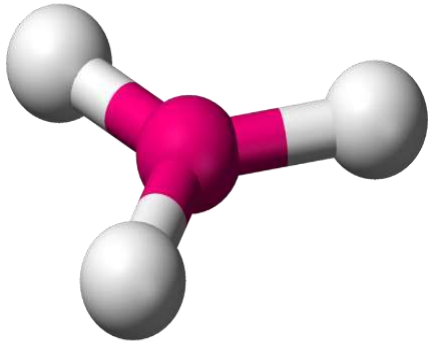
Borates



BY:- Dr. Priyanka

Introduction

- *Borates are the name for a large number of boron- containing oxyanions. The term "borates" may also refer to tetrahedral boron anions, or more loosely to chemical compounds which contain borate anions.*

- joined together via shared oxygen atoms and may be cyclic or linear in structure.

Importance:

- stimulate plant growth
- inhibit bacteria and fungi
- increase crop yields
- to remove stains
- increase its resistance to heat and chemicals
- to personal care products to prevent bacterial growth
- as flame retardants

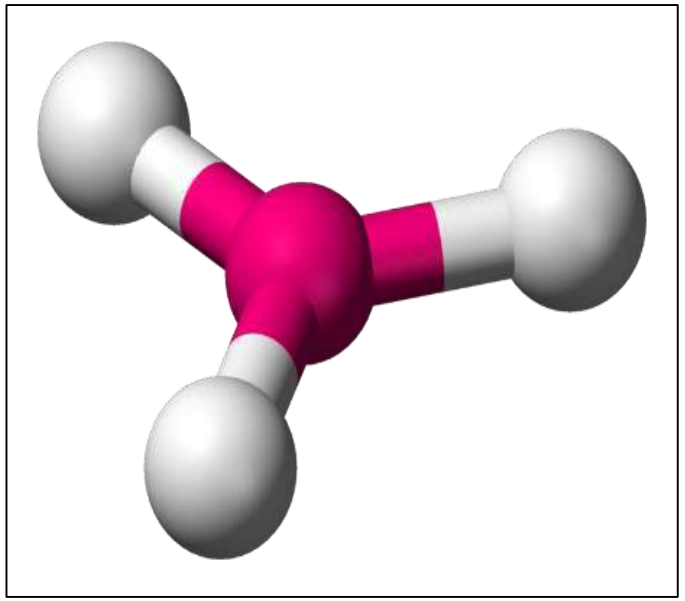
Classification

- **Orthroborates**
- **Metaborates**
- **Triborates**
- **Tertraborates**
- **Pentaborates**
- **Hexaborates**

Orthoborate

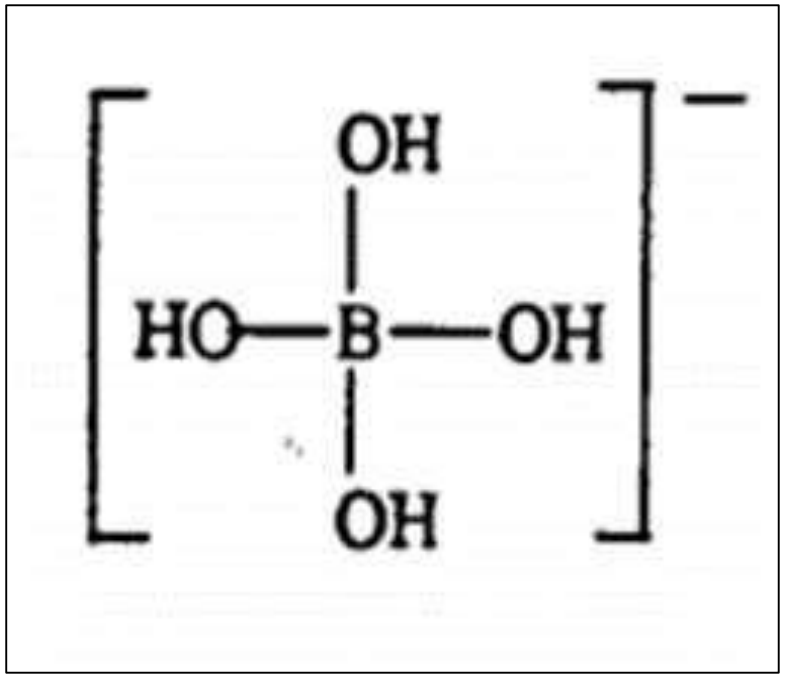
- The simplest borate anion
- BO_3^{-3} is known in the solid state, example in $Ca_3(BO_3)_3$
- trigonal planar structure
- Isoelectonic to CO_3^{-2}

for



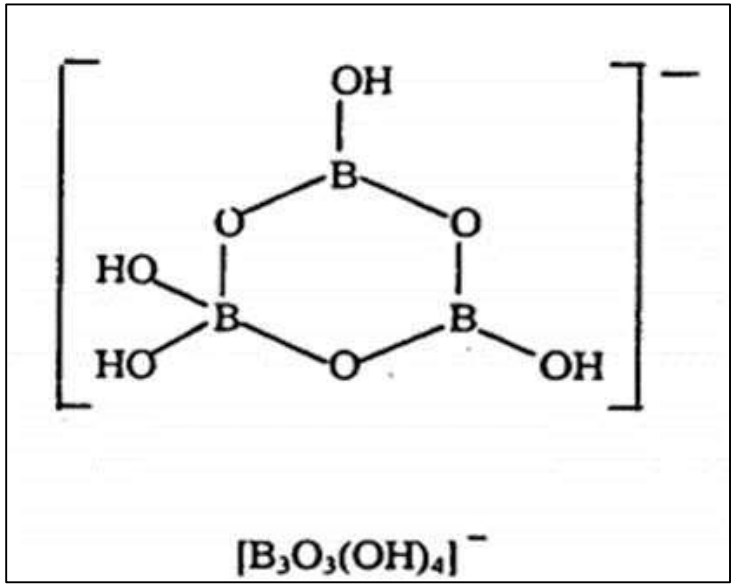
Metaborate anion

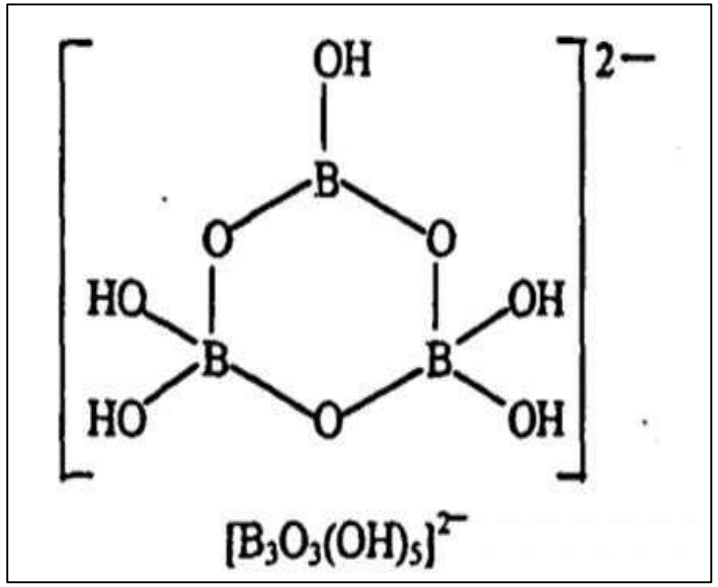
- Tetrahedral form
- When it is heated, boric acid loses water to form various condensed boric acids, such as cyclic metaboric acid



Triborate anion

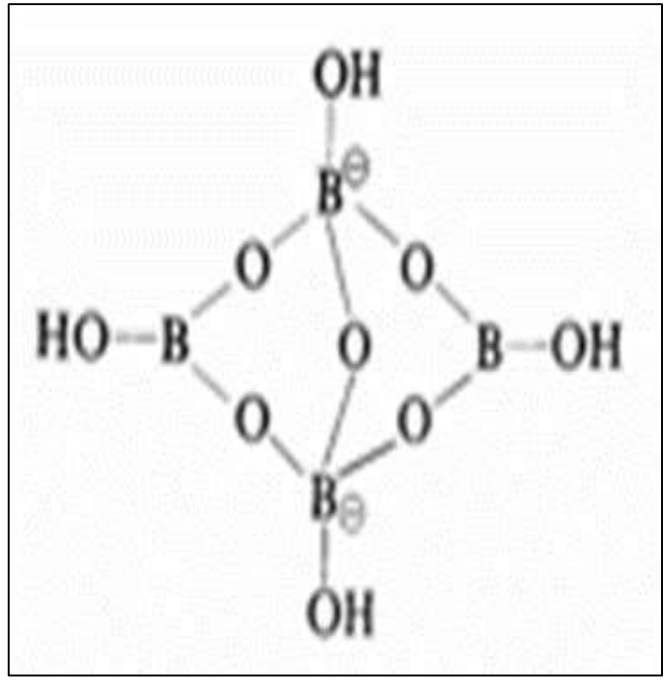
- the triborate anion is a six-member BO ring (referred to as a boroxyl ring)
- triborate B3O5−7, found in CaAlB3O7 (johachidolite)





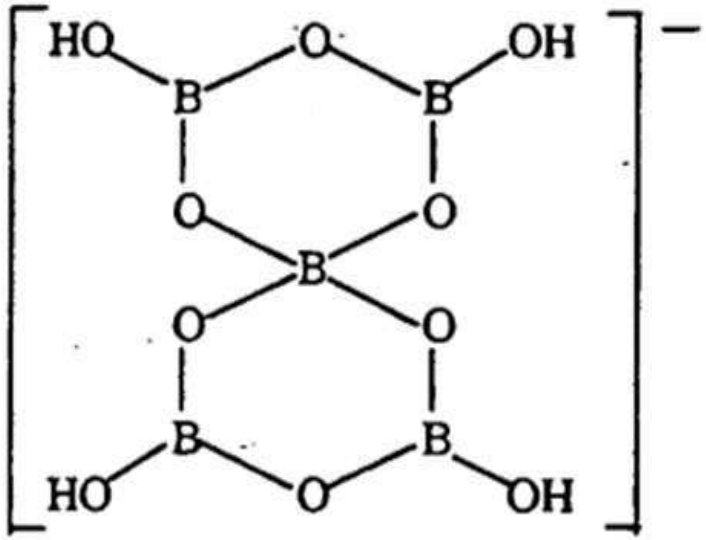
Tetraborate anion

- the tetraborate anion is a bridged eight-member B-O ring
- The tetraborate anion (tetramer) includes two tetrahedral and two trigonal boron atoms symmetrically assembled in cyclic structure
- sodium tetraborate, $Na_2[B_4O_5(OH)_4]\cdot 8H_2O$, which is commonly called borax , formula is often written as $Na_2B_4O_7\cdot 10H_2O$



Pentaborate anion

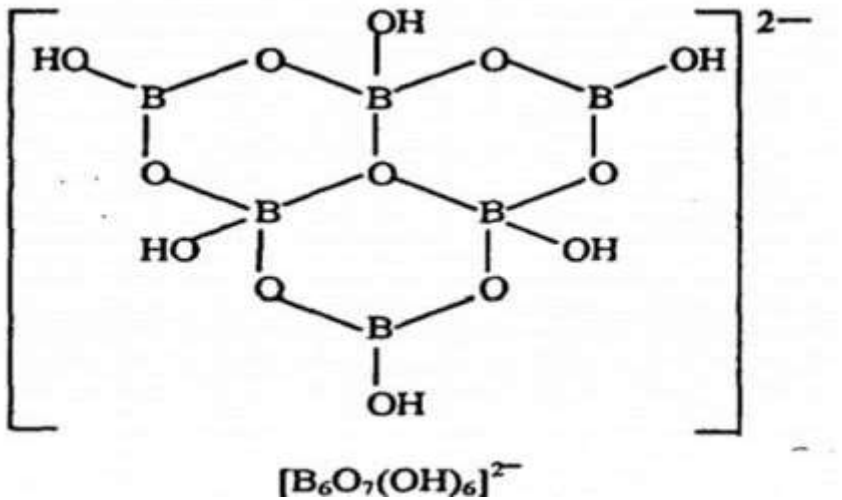
- consists of two six-member B-O rings sharing a common boron atom.



$[B_5O_6(OH)_4]^-$

Hexaborate anion

- consists of three B-O rings that share three boron atoms and one oxygen atom.

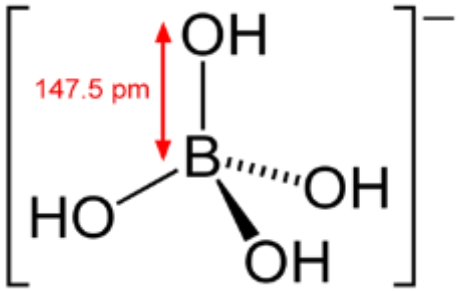


$[B_6O_7(OH)_6]^{2-}$

Boric acid:

- Boric acid is a weak proton donor (pKa ~ 9) in the sense of Brønsted acid, but is a Lewis acid, i.e., it can accept an electron pair
- Boric acid does not dissociate in aqueous solution, but is acidic due to its interaction with water molecules, forming tetrahydroxyborate
- Acidic, its reaction with OH– from water, forming the tetrahydroxyborate complex ($B(OH)^{-4}$), proton left by the water autoprotolysis

$$B(OH)_3 + 2H_2O \rightleftharpoons B(OH)^{-4} + H_3O^+ \qquad (pKa = 8.98)$$



Polymeric ions:

- Under acid conditions boric acid undergoes condensation reactions to form polymeric oxyanions:

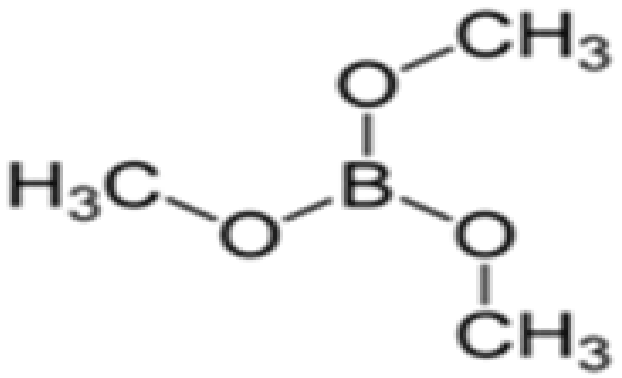
$$4B(OH)_4^- + 2H^+ \rightleftharpoons B_4O_5(OH)_4^{2-} + 7H_2O$$

Borate esters:

- organic compounds of the type B(OR)3 where R is alkyl or aryl
- prepared by condensation reaction of boric acid and the alcohol:

$$B(OH)_3 + 3\ ROH \rightarrow B(OR)_3 + 3\ H_2O$$

- Borate esters are volatile and can be purified by distillation
- alkyl borates burn with a characteristic green flame



- Trimethyl borate B(OCH3)3 is a popular borate ester used in organic synthesis
- borate esters are prepared from alkylation of trimethyl borate:

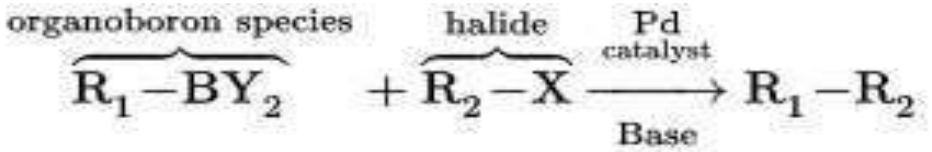
$$ArMgBr + B(OCH_3)_3 \rightarrow MgBrOCH_3 + ArB(OCH_3)_2$$

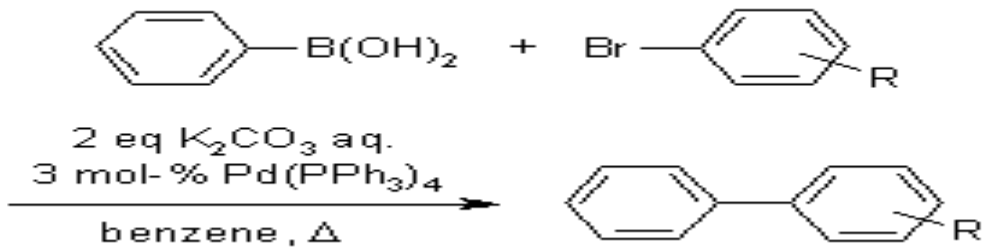
$$ArB(OCH_3)_2 + 2\ H_2O \rightarrow ArB(OH)_2 + 2\ HOCH_3$$

- These esters hydrolyze to boronic acids, which are used in Suzuki couplings

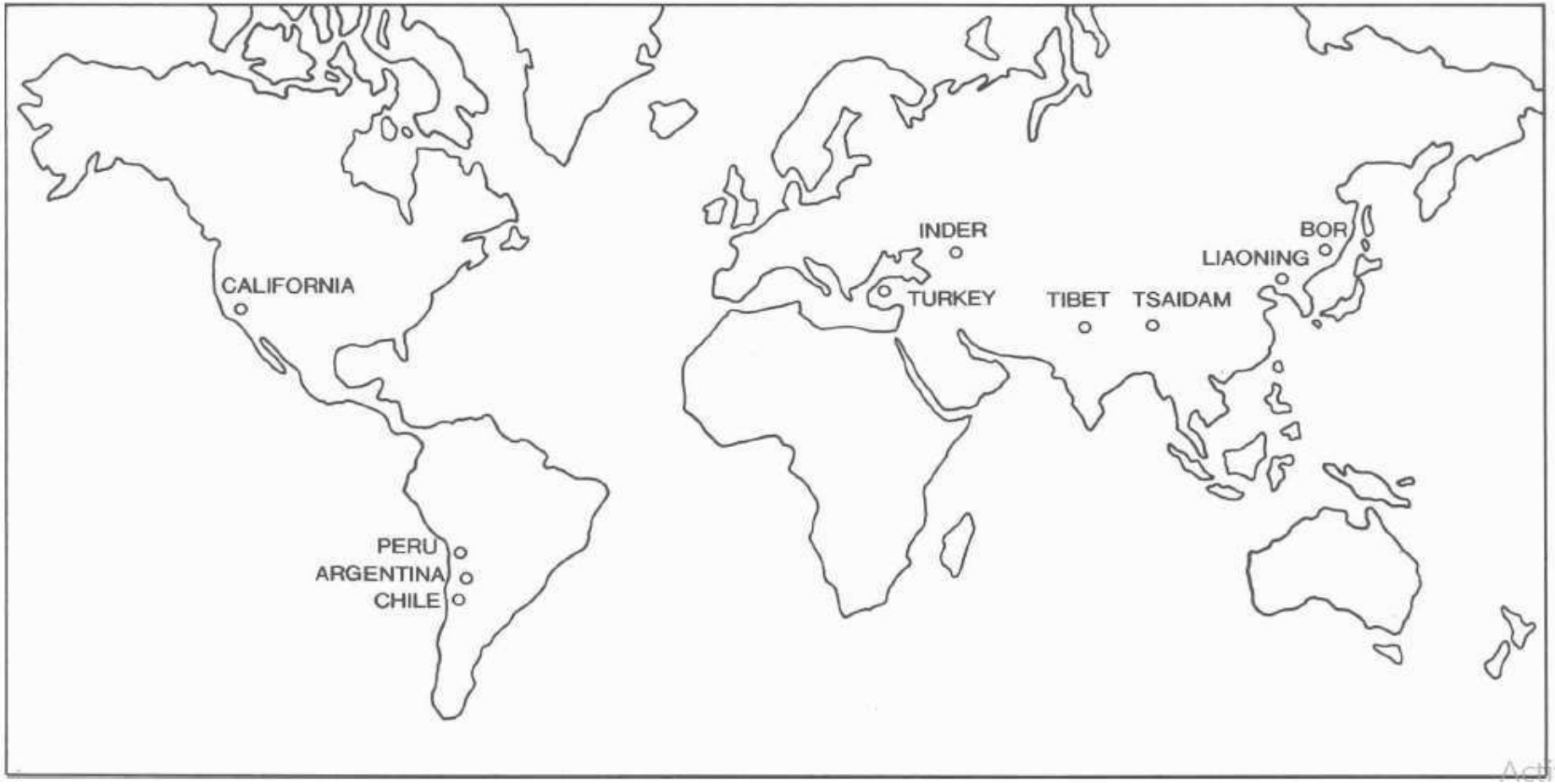
Suzuki couplings

- The Suzuki reaction is an organic reaction, classified as a coupling reaction, where the coupling partners are a **boronic acid** and an **organohalide** catalyzed by a **palladium** complex.





Natural Occurance:



Ulexite:

- $(NaCaB_5O_6(OH)_{4.}8H_2O)$ (hydrated sodium calcium borate hydroxide)
- sometimes known as **TV rock**
- is usually found as evaporite deposits along with borax
- occurs in the form of white, rounded crystalline masses or as closely packed fibrous crystals
- The isolated borate poly anion $[B_5O_9]^{-3}$ has five boron atoms, therefore placing ulexite in the **pentaborate** group.
- Widely used on basis of optical properties.

Colemanite

- ($CaB_3O_4(OH)_3.H_2O$) secondary mineral that forms by alteration of borax and ulexite
- It has many industrial uses, like the manufacturing of heat resistant glass.
- deposits in parts of Turkey, the United States (particularly Death Valley, Argentina, and Kazakhastan, as well as other parts of the globe