ELEMENT OF THE FUTURE – BOR

Bor (Borum) - a chemical element, denoted by the letter B with atomic number 5, 3rd group of the second period of the periodic system of chemical elements, atomic mass 10.81. Bor is a semi-metal, by the type of conductivity it belongs to semiconductors. In nature, boron is in the form of two stable isotopes 10B (19.1 - 20.3%) and 11B (79 - 80.9%).

Bor is never found in free form in nature, forming connections, possessing various properties, with various metals or non-metals.

Due to their properties, boron compounds are widely used in industrial production. Bor compounds are essentially non-metals, but in its pure form, bor, like carbon, conducts electricity. Thanks to its crystalline appearance, optical characteristics and hardness, boron resembles diamond.

Bor element in pure form was first obtained in 1808 by the French chemists J.L. Gay Lussac and L.J. Thénard, and the English chemist H. Devi.

ATOMIC STRUCTURE

+ Atomic diameter: 1.17Å;

+ Atomic volume: 4.6 cm3 / mol;

+ Crystal structure: Rhombohedral;

+ Electronic configuration: $1s^2 2s^2 p^1$;

+ Ionic radius: 0.23Å;

+ Number of electrons: 5;

+ Number of neutrons: 6;

+ Number of protons: 5;

+ Valence electrons: $2s^2 p^1$;

CHEMICAL PROPERTIES

+ Electrochemical equivalent: 0.1344 g / amp-hour;

+ Relative electronegativity (Pauling): 2.04;

+ Heat of decomposition: 50.2 kJ / mol;

+ Ionization potential:

- First: 8.298 eV

- Second: 25.154 eV

- Third: 37.93 eV

+ Potential of valence electrons: 190 eV;

PHYSICAL PROPERTIES

+ Atomic mass: 10.811;

+ Boiling point: 4275K, 4002 ° C, 7236 ° F;

+ Coefficient of thermal expansion: 0.0000083 ° C-1 * (cm / cm), (0 ° C);

+ Conductivity:

- Electrical conductivity: 1.0E -12 106 cm;

- Thermal conductivity: 0.274 W / cm * K;

+ Density: 2.34 g / cm3 @ 300K;

+ Appearance: Yellow-brown non-metallic crystal.

- modulus of elasticity: 320 Gpa;

- Atomization energy: 573.2 kJ / mol @ 25 ° C.

+ Specific heat of fusion: 22.18 kJ / mol;

+ Heat of vaporization: 480 kJ / mol;

+ Specific Heat of Vaporization: 489.7 kJ / mol;

+ Melting point: 2573K 2300 ° C 4172 ° F;

+ Molar volume: 4.68 cm3 / mol;

+ Physical state: (20 ° C & 1atm): solid;

+ Specific heat: 1.02 J / g * K;

+ Saturated steam pressure: 0.348Pa @ 2300 ° C.

RESOURCES OF BOR IN THE WORLD

Due to the rapid depletion of raw materials in the world and their use in many industries, the importance of boron is growing every day. Turkey, which has the largest bor reserves in the world, is followed by Russia, South America and the United States.

Country	Total reserves (thousand tons B203)	Percent (%)
Turkey	948,712	73,4
USA	80,000	6.2
Russia	100,000	7.7
China	36,000	2.8
Peru	22,000	1.7
Argentina	9,000	0.7
Bolivia	19,000	1.5
Chile	41,000	3.2
Kazakhstan	15,000	1.2
Serbia	21,000	1.6
Total	**1,291.712**	**100**

BOR AS A GROWING VALUE OF TURKEY

Famous bor deposits in Turkey, which has 73% of the world's reserves, are: Eskisehir-Kyrka, Kutahya-Emet, Balikesir-Bigadich, Bursa-Kestelek.

The most common bor minerals in Turkey in terms of reserves are Tinkal and Colemanite. In Turkey, tinkal reserves are located in Eskisehir - Kyrka, colemanite reserves - in Kutahya - Emet, Balikesir - Bigadich and Bursa - Kestelek. In addition, ulexite is also present in Balikesir-Bigadic, and from time to time ulexite is mined as a by-product in Bursa-Kestelek.

Distribution of consumption of boron compounds in Turkey: 40% - in glass, 34% - in ceramics, 7% - in agriculture, 5% - in cleaning and detergents, 3% - in chemistry and 11% - in other industries.

Field name	Tons
Emet (colemanite-ulexite)	1,811,072,52
Kyrka (tinkal)	824,720,95
Bigadich (colemanite-ulexite)	628,350,48
Kestelek (colemanite)	5,254,92
Total	**3,269,398,87**

BOR MINERALS

Bor minerals are natural compounds containing boron oxide in varying proportions. There are 230 different bor minerals in nature. The most commercially important bor minerals are: Tinkal, Colemanite, Kernite, Ulexite, Pandermit, Boracite, Sheibelite and Hydroboracite.

THE MAIN BOR MINERALS BY THEIR COMMERCIAL SIGNIFICANCE:

Mineral	Formula
Kernite	$Na_2B_40_7.4H_2O$
Tinkalconite	$Na_2B_40_7.5H_2O$
Tinkal	$Na_2B_40_7.10H_2O$
Probert	$NaCaB_50_9.5H_2O$
Ulexite	$NaCaB_50_9.8H_2O$
Colemanite	$Ca_2B_6O_{11}.5H_2O$
Meyerhofferite	$Ca_2B_6O_{11}.7H_2O$
Inionite	$Ca_2B_6O_{11}.13H_2O$
Pandermit	$Ca_4B_{10}O_{19}.7H_2O$
Inderite	$Mg_2B_6O_{11}.15H_2O$
Hydroborasite	$CaMgB_6O_{11}.6H_2O$
Borasite	$Mg_3B_7O_{13}Cl$
Asharit	$Mg_2B_2O_5.H_2O$
Datolite	$Ca_2B_2Si_2O_9.H_2O$
Sassolite (natural boric acid)	$B(OH)_3$

BOR İN THE OİL AND GAS İNDUSTRY

One of the dynamically developing areas of application of bor compounds is the oil and gas industry. They are used in a number of reagents, in particular, in the composition of borate crosslinkers for hydraulic fracturing, in the composition of drilling fluids.

Application in borate crosslinkers.

Hydraulic fracturing is one of the methods for intensifying the operation of oil and gas wells and increasing the infectivity of injection wells. The method consists in creating a highly conductivity fracture in the target formation to ensure the inflow of the produced fluid (gas, water, condensate, oil or their mixture) to the bottom of the well. After hydraulic fracturing, the flow rate of the well, as a rule, increases by 5-10 times. The method makes it possible to “revive” idle wells, where oil or gas production by traditional methods is no longer possible or unprofitable. In addition, the method is currently used to develop new oil reservoirs, the extraction of oil from which by traditional methods is unprofitable due to the low production rates. As well applicable for the extraction of shale gas and compacted sandstone gas. The essence of the method is as follows: the fracturing fluid is pumped into the well under such pressure and at such a rate that is sufficient to break the rock and create fractures of a given size in it. To keep the fracture open when the injection is stopped and the pressure is reduced, a special agent, sand or a ceramic material - proppant, is added to the working fluid. When performing hydraulic fracturing, in most cases, an aqueous solution of high molecular weight polymers such as guar gum and its derivatives is used as a working fluid. To give them the necessary technological properties and, in particular, the viscosity required to obtain the required cracks and retain the proppant, special reagents are used, the so-called crosslinkers. Since the mid-90s of the last century, compositions based on bor compounds have been mainly used as crosslinkers. The crosslinking effect of the working fluid is provided by the introduction of bor oxide B_2O_3. Increasing the viscosity of the working fluid using a borate crosslinker is more cost effective than increasing the viscosity due to the greater amount of guar gum. Currently, the main bor compounds for the production of crosslinkers are:

- ulexite ($Na_2O * 2CaO * 5B_2O_3 * 16H_2O$) fraction -45 or -75 microns,
- borax pentahydrate ($Na_2B_4O_7 * 5 H_2O$),
- borax decahydrate ($Na_2B_4O_7 * 10 H_2O$).

Recently, in connection with the increased requirements for the quality characteristics of crosslinkers and the creation of new brands of crosslinkers for a specific type of wells, more and more interest of manufacturers is shown in the following compounds:

- colemanite ($2CaO.3B_2O_3.5H_2O$) fraction -45 or -75 microns,
- boric acid (H_3BO_3),
- Etidot-67 ($Na_2B_8O_{13}.4H_2O$).

The most preferred component of the borate crosslinker used in guar-based fluids is ulexite due to its delayed solubility in the guar fluid.

Application in drilling fluids.

When developing an oil or gas well, a special drilling fluid is used while drilling. Its use allows cleaning the bottom of the well and the wellbore space from cuttings, cooling the surface of the bit and lubricating it, increasing the resistance of pipes and equipment to corrosion, preventing debris and collapses, forming a filtration layer in the rock, maintaining pressure that prevents the penetration of formation fluid into the wellbore.

Various reagents are used to control the properties of drilling fluids. For example, a clay swelling inhibitor. Bor products are found in clay swelling inhibitors such as borosilicate inhibitors. This reagent is used to reduce the rate of hydration of clays, exhibiting inhibitory properties. Effective in water-based drilling fluids. Boric acid (H_3BO_3) is used for clay swelling inhibitors.

BOR, STORAGE OF RENEWABLE ENERGY SOURCES.

Reduction of reserves of primary energy resources, such as coal and oil, and an increase in demand for them leads to the search for alternative energy sources. Continuous technological development and the ever-growing population of the earth require more and more energy. Therefore, the development of new energy sources and their production are very important now. The energy needs of the future can be met through the efficient contribution of boron products and the creation of environmentally friendly alternative energy sources. Boron products will play an important role in the energy sector.

Strength and value of energy with boron.

Fuel cells, in which hydrogen can be converted to electricity, will play a leading role in energy resources in the future. The sodium borohydride fuel cell is one of the promising developments that allow the use of hydrogen energy with high efficiency. In addition, sodium borohydride is widely used in cleaning chemicals, pulp bleaching, metal surface cleaning, precious metal recovery in metal surface treatment, and heavy metal removal from wastewater.

Boron's touch to the energy of the future.

Bor as sodium bor-hydride with its renewable structure contributes to sustainable and highly efficient energy sources of the future, adding value to the energy sector. Sodium bor-hydride is a widespread product used in portable electronic devices, vehicles and electrical / thermal power plants, fuel cells used for military and civil purposes. Sodium bor-hydride can store up to 10.8% hydrogen, is not flammable or explosive, and its hydrogen evolution reaction is controlled. Development of a technology for the production of sodium bor-hydride, which is one of the important raw materials used in hydrogen storage technology, is very important in terms of efficient use of boron.

"GLITTER OF GLASS" FROM BOR.

Bor products produced in Turkey, which has 73% of the world's reserves, are widely used in the glass industry both by the Turkish industry and in the international market. Bor, which is used in many industries due to its unique properties, is one of the important raw materials of the glass industry. Glass products, which contain boron, have high heat resistance and chemical resistance. A large number of research works are being carried out to expand the use of bor in the compositions of various types of glasses.

Borosilicate glass made using boric products is used in various fields such as kitchenware, glass trays, storage containers, teapots and coffee pots, which must be more resistant to heat and chemicals, protective glasses for electronic devices, lamps, solar energy systems, lenses for cameras, binoculars, products used in the aviation and automotive industries, in medicine, products that are used as containers for syrup, antibiotics, vitamin tablets, etc., as container glass and glass for laboratory glassware.

Eco-friendly glass wool.

Glass wool made from fiberglass, which is exposed to heat and converted into an ergonomic structure, provides a strong and durable structure due to the introduction of boron oxide during the manufacturing phase. Glass wool, which is effectively used for heat and sound insulation, is produced in various forms, such as mats, panels, pipes. They are used on interior surfaces of walls, staircase and elevator spaces, in wood and metal structures, in air conditioners and as roofing, in external insulation of industrial pipes, in heating systems, in individual and central heating systems. Glass wool that does not mold, crumble, rot, corrode or rust, is resistant to temperature and moisture, and, moreover, is not susceptible to pests and microorganisms.

Reinforcing fiberglass, another glass product made from boron, is an industrial product with low cost, high tensile strength, resistance to chemical reactions and other influences.