

## PHYSICO-CHEMICAL CHARACTERISTICS AND METHODS OF PURIFICATION OF SODIUM CHLORIDE

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### ABSTRACT

Sodium chloride, called table salt, plays a huge role in maintaining life. The human body contains about 0.25% sodium chloride (in the form of ions). A person needs 5-10 g of table salt daily, since the salt balance is related to the body's water balance. Sodium chloride retains water in tissues, the necessary amount of it in the body creates a favorable environment for the action of protolytic enzymes of gastric juice, affect the electrical conductivity of cell membranes, etc. In addition, especially pure sodium chloride is used to prepare 0.9% isotonic solution for intravenous infusion, 20% solution to stop bleeding, as well as to obtain drugs "Hemodesis", "Rehydron" and for other purposes in medicine. Therefore, obtaining especially pure sodium chloride for the needs of the pharmacopoeia is an important task.

This article provides information about the physico-chemical characteristics and various methods of purification of sodium chloride for its further use in medicine.

**Keywords:** sodium chloride, table salt, purification, pharmacopoeia, medicine.

### INTRODUCTION

Sodium chloride (Table salt) NaCl — colorless crystals with a cubic face-centered lattice,  $a = 5,63874 \text{ \AA}$ ; density 2,161; melting point 801°C, Boiling point 1413°C; permittivity 6,12; specific heat 0.20 cal/g·grad, Mohs hardness 2. Heat of formation  $dH_{298}^0 = -98,232 \text{ kcal / mol}$ . Solubility in water (in %): 26.28 (0°C); 26.43 (25°C); 28.12 (100°C) (little depends on temperature). In the presence of NaOH, HCl, MgCl<sub>2</sub>, CaCl<sub>2</sub> and other salts, the solubility of sodium chloride in water is greatly reduced. The cryohydrate point is -21.1°C (23.0% NaCl). The saturated aqueous solution boils at 108.8°C and contains 40.7 g of NaCl per 100 g of H<sub>2</sub>O. The density of aqueous solutions is shown in Table 1.

Table 1. The density of aqueous solution of sodium chloride

%, NaCl	5	10	15	20	25
$d^{20}$	1.03460	1.07142	1.10939	1.14876	1.18975

Pure sodium chloride is slightly hygroscopic, but in the presence of impurities (magnesium salts), its hygroscopicity increases greatly. NaCl·2H<sub>2</sub>O dihydrate crystallizes from aqueous solutions at temperatures from -21.1°C to +0.1°C - thin needles or well-faceted monoclinic prismatic crystals; density 1.6 soluble in liquid ammonia; insoluble in most organic solvents [1-9].

Suffice it to say that the same compound, depending on the thermodynamic conditions in which it is located, can be listed either to the category of simple or to the category of

complex compounds. Sodium chloride in the vapor state consists of individual NaCl molecules; in this case, it is a simple binary compound. If we take the same salt in the crystalline state, then, as X-ray analysis shows, a high-molecular complex compound  $(\text{NaCl})_n$  was found, in which each sodium ion is symmetrically surrounded by chlorine ions, and each chlorine ion is surrounded by sodium ions (Fig.1) [10-11]. In nature, sodium chloride is well distributed in the form of the mineral halite (rock salt). It forms powerful deposits, the thickness of which reaches hundreds and thousands of meters. Often sodium chloride lies together with salts K, Mg, etc.

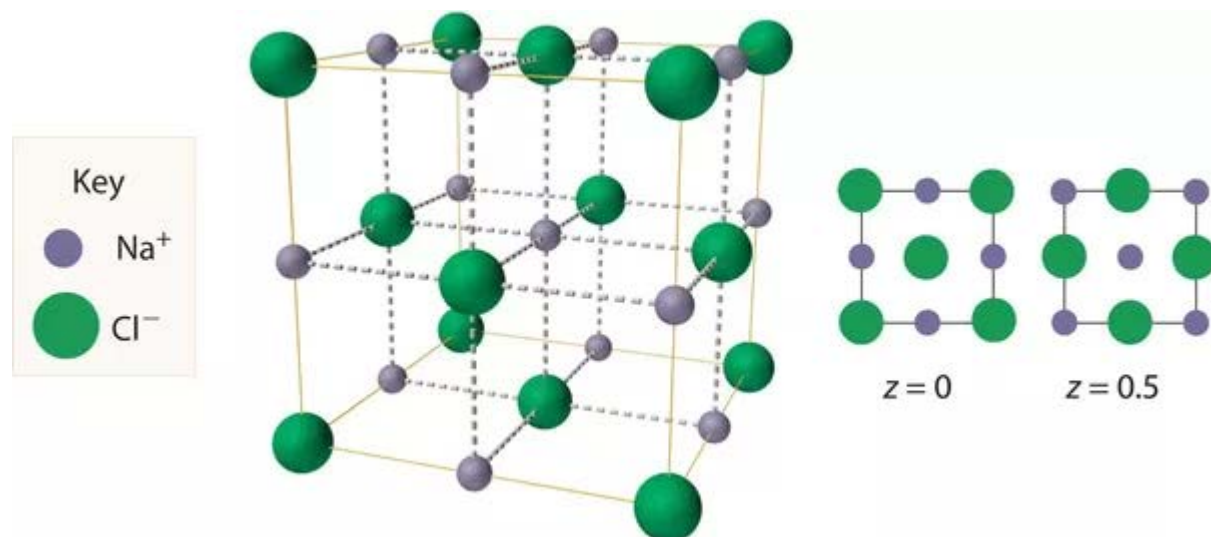


Fig. 1. Crystal lattice structure of NaCl [11]

Natural halite is sometimes colored blue, blue or purple due to the presence of traces of metallic sodium. Huge amounts of sodium chloride are found in seawater, brine of salt lakes and underground brines. In summer, during the evaporation of brine in many lakes, sodium chloride crystallization occurs (self-settling salt, *novosadka*). Sometimes in salt lakes under a layer of brine lies a layer of salt precipitation of previous years, which does not dissolve in the autumn-winter period (*starosadka*). In winter,  $\text{NaCl} \cdot 2\text{H}_2\text{O}$  (hydrogalite) dihydrate sometimes crystallizes from the brine of salt lakes [1-2].

## **RESULTS AND DISCUSSION**

The development of rock salt deposits is usually carried out by a closed (mine) method and less often by an open method. To extract salt, the method of underground leaching is widely used with the help of wells into which water is injected. Lake salt is extracted mechanically using scrapers, bulldozers, excavators and salt pumps. Usually lake salt is contaminated with silt, for the removal of which it is washed with rapeseed. The washed salt is centrifuged and dried. To obtain pool salt, regulated solar evaporation of sea or lake brines is used in a system of specially arranged pools. In areas with a cold climate, table salt is obtained from brines by freezing. Rock and self-settling salt usually contains a certain amount of impurities ( $\text{CaSO}_4$ ,  $\text{MgSO}_4$ ,  $\text{MgCl}_2$ ,  $\text{CaCl}_2$ , substances insoluble in water, etc.). The purest salt is obtained by evaporation of natural or artificially obtained and purified brines in vacuum

evaporators (boiling or vacuum salt). Sodium chloride -  $\tau$  is an important food product, used to produce caustic soda, chlorine, soda, sodium sulfate [2,3,5].

Depending on the deposits, sodium chloride may contain sand, calcium and sodium sulfate, salt carbonates as impurities.

Data on deposits of the Republic of Kazakhstan and some methods of purification of these salts are given [12]. The works [13,14] present ways to reduce the content of impurities by grinding and fractionation. For example, it has been found that when natural table salt containing up to 7% sodium sulfate is crushed, the latter passes into small fractions, with which up to 90% of the total amount of  $\text{Na}_2\text{SO}_4$  can be removed.

The solubility diagrams of  $\text{NaCl} - \text{MgSO}_4 - \text{H}_2\text{O}$  systems at various temperatures have been studied in the works of a number of institutes [15-18], and salt crystallization schemes have been created based on these data. It has been found that up to 96% of table salt can be crystallized by evaporation of the desulfurized sea salt concentrate.

In the works of American scientists [19, 20], a purification method is described - the rapid boiling of salt. According to this technology, the brine heated from 10-15°C to 60-70°C enters an open rectangular tank in which the constant brine level is 18-20 cm. Then, the brine is heated to 108°C, while accompanying salts ( $\text{CaSO}_4$ ,  $\text{CaCO}_3$ ) fall out, hydrogen sulfide and other dissolved gases are released. Upon reaching saturation (6-8 hours),  $\text{NaCl}$  begins to crystallize. According to this method, 98% purity sodium chloride is obtained. To clean the salt, surfactants are sometimes added to the brine - soaps, fats, alcohols - 0.0002 g of the weight of the salt obtained [21, 22].

Organic manganese compounds have been proposed as additives by authors from Canada and Japan [23, 24].

Cleaning methods sodium chloride from calcium sulfate and the effect of their amount on the formation of scale on evaporators are given in [24]. It was found that the addition of sulfitecellulose liquor to  $\text{NaCl}$  brine slows down the transition of calcium sulfate crystalhydrate to  $\text{CaSO}_4$ , which, according to the researchers, should help reduce scale deposition.

In the works [25-27], soda, lime-sulfate-soda method of purification of sodium chloride brines from calcium and magnesium salts are given. With these methods, a significant part of the calcium and magnesium salts precipitate, and the  $\text{NaCl}$  brine is subjected to evaporation.

In the Japanese patent [28, 29], it is recommended to introduce surfactants for the purification of  $\text{NaCl}$  brines together with settling reagents (0.5-2)% of their weight, in particular, alkylamine salts with 10-18 carbon atoms.

Many options have been proposed in soda and lime-soda brine purification [30], as well as other methods to prevent the deposition of  $\text{CaSO}_4$  during evaporation, for example, the addition of calcium chloride to the brine in an amount corresponding to the molar ratio of  $\text{CaSO}_4$  2.4:1 [30].

A method of purification of  $\text{NaCl}$  solution from  $\text{CaSO}_4$  by holding the solution over a layer of solid table salt at a temperature above the transition point of gypsum to anhydrite, 95-100°C [31] is also proposed.

The authors [31, 32] proposed to introduce 2-6 g/l of  $\text{Na}_2\text{SO}_4$  or  $\text{MgSO}_4$  into the solution to reduce the solubility of  $\text{CaSO}_4$  in  $\text{NaCl}$  brine. At the same time, in the latter case,  $\text{Mg}^{2+}$  is released from the brine in one of the evaporation stages in the form of  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ , which is returned to the process.

In the method [33], which provides good cleaning with minimal soda consumption, the longest sedimentation is recommended. To accelerate the settling, coagulants are sometimes administered.

The thermal method of brine purification from  $\text{CaSO}_4$  is given in the works [34, 35]. In this method, the evaporation temperature is increased to  $200^\circ\text{C}$  at 15 atm. In this method, salt is obtained, with a basic substance content of 99.8%.

In patents [36, 37], it is proposed to add carboxymethyl cellulose and some other high-molecular compounds to salt solutions, which serve to enlarge salt crystals,  $\text{NaSO}_4$  is removed almost completely, and calcium is (60-70)% and dried with hot air or flue gases [35, 38-41].

A promising method that reduces the moisture content of salt to 0.03% is described in the article [42]. It is proposed to use hot air heated to  $200^\circ\text{C}$  under a pressure of 575 mm of water for drying.

Many works are devoted to the methods of obtaining sodium chloride from brines when salting it with magnesium chloride or calcium chloride. Usually, sodium chloride heated to  $110^\circ\text{C}$  is mixed for a certain time with a 25% solution of calcium chloride. The mixture is then cooled to room temperature. The precipitated and filtered sodium chloride crystals contain 99.2% of the basic substance [43-44].

To obtain sodium chloride with a NaCl content of 99.7%, a flotation method is proposed [45]. Lead or bismuth salts are used as flotation agents, which float impurities from brines, but the salts contaminate sodium chloride.

Data on the production of high purity sodium chloride with a NaCl content of 99.9% are given in [46]. To purify from impurities and accompanying salts, salts are washed with hydrochloric acid or an unsaturated solution of pure salt under pressure, followed by crystallization or melting to purify from organic impurities.

## CONCLUSION

Table salt (sodium chloride) plays an important role in the history of human development. Sodium chloride has also been used for a long time as a preservative that protects against rotting - for salting fish, meat, vegetables, skins, etc. With the development of industry, table salt is widely used in various industries as the main raw material. Currently, less than half of the world's salt production is consumed for food purposes. But sodium chloride plays a huge role in human life. As mentioned earlier, a large amount of sodium chloride goes to the needs of medicine. Therefore, pharmacopoeial sodium chloride has special requirements for its purity.

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