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Study of the Process of Obtaining Sodium Sesquicarbonate from Na_2CO_3 and $NaHCO_3$ in Liquid-Phase Mode

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Abstract: Sodium sesquicarbonate, $Na_2CO_3 * NaHCO_3 * 2H_2O$, can be made using a technique called polythermal crystallization from a solution that is saturated at 100°C and contains NaCl, Na_2CO_3, and $NaHCO_3$ in a 2:1 molecular ratio. It has been demonstrated that the result of crystallization is a big plate-shaped crystal up to 2 millimeters long. A practical method for producing $Na_2CO_3 * NaHCO_3 * 2H_2O$ is put forth; it calls for the mother liquor to be recycled along with cleaning water, increasing the final output from 54.7 to 74.3%.

Keywords: sodium sesquicarbonate, sodium carbonate, crystallization, system.

Introduction: The formula for sodium sesquicarbonate is $Na_2CO_3*NaHCO_3*2H_2O$. It is a combined solution of carbonic acid. Currently, this substance is utilized in the creation of phosphate-free, ecologically responsible detergents and cosmetics. Synthetic manufacture of sodium sesquicarbonate is interesting due to the energy and laboriousness of the process of extracting $Na_2CO_3*NaHCO_3*2H_2O$ from the trona mineral. There are known manufacturing techniques that combine sodium bicarbonate in liquid solution with sodium carbonate powder [1]. The poor concentration of $Na_2CO_3*NaHCO_3*2H_2O$ in the synthesis products is a drawback of these techniques. Additionally, there are published data on the polythermal crystallization of sodium sesquicarbonate from a concentrated solution, which contains 96.0–98.0% $Na_2CO_3*NaHCO_3*2H_2O$. Also of importance are preparation techniques that depend on the reaction of sodium carbonate with chemicals that contain protons, particularly phosphoric acid. By adding extra compounds with anti-corrosion, surface-active, degreasing, and other characteristics in this situation, products with complicated compositions can be produced. In this respect, the work's goal was to investigate the circumstances surrounding $Na_2CO_3*NaHCO_3*2H_2O$ formation in carbonate, sodium bicarbonate, and phosphoric acid-based systems.

Sodium sesquicarbonate was made by either combining sodium carbonate with an H_3PO_4 solution in a high-speed laboratory blender or by saturating water at 100°C with sodium carbonate and sodium bicarbonate while adding NaCl [2]. The product then crystallized polythermally when the solution was cooled to 35°C. X-ray phase analysis was used to determine the phase composition, and quantitative analysis techniques were used to determine the chemical makeup based on the material balance created by mixing the original reagents.

It is demonstrated that gradual cooling of a saturated solution made in the Na_2CO_3-$NaHCO_3$-$NaCl$-H_2O system allows for tighter control of the sodium sesquicarbonate crystallization process and, as a result, a higher yield of the end product. Calculations show that the sodium sesquicarbonate output in relation to $NaHCO_3$ is 54.7%. Re-crystallizing Na_2CO_3*$NaHCO_3$*$2H_2O$ and bringing the mother liquor back to saturation have both been shown to raise product output to 74.3% while consuming fewer starting reagents. It is demonstrated that sodium sesquicarbonate accounts for 97.0–98.0% of the solid phase formed during both the first and second cycles of crystallization [3]. The sodium sesquicarbonate produced in the Na_2CO_3-$NaHCO_3$-$NaCl$-H_2O system is big lamellar crystals with a length of up to 2 mm, according to electron microscopic examination.

In a system based on Na_2CO_3 and a proton-containing reagent, specifically an H_3PO_4 solution, the circumstances for the precipitation of sodium sesquicarbonate were investigated. It is demonstrated how the proton-containing reagent contributes to the creation of $NaHCO_3$ as the initial reagent for liquid phase saturation and the breakdown of sodium carbonate, which results in the formation of Na_2CO_3*$NaHCO_3$*$2H_2O$ in the H_3PO_4 - Na_2CO_3 - H_2O system. It has been determined that the system under investigation must have at least 25–35 weight percent water in order to obtain the stoichiometric ratio of $NaHCO_3$ to Na_2CO_3 in a saturated liquid phase. Carbonate- and phosphate-containing stages are the end results of the reaction between orthophosphoric acid and sodium carbonate. The phosphate-containing phase can be represented by $Na2HPO_4$*$7H_2O$, Na_2HPO_4*$2H_2O$, Na_3PO_4*$8H_2O$, or Na_3PO_4 $12H_2O$, depending on the manufacturing circumstances. The carbonate-containing phase can be represented by $NaHCO_3$, Na_2CO_3*$2H_2O$, Na_2CO_3*$NaHCO_3$*$2H_2O$. It should be observed that variables like the molar ratios of H_2O/Na_2O and Na_2O/P_2O_5 affect the mass ratio between these stages. By using X-ray diffraction, the synthetic products are found to contain Na_2CO_3*H_2O, $NaHCO_3$, Na_2HPO_4*$2H_2O$, and Na_2HPO_4 $7H_2O$ at molecular ratios of Na_2O/P_2O_5 10.0. Sodium sesquicarbonate is produced when the Na_2O/P_2O_5 molecular ratio rises above 10.0; its mass proportion rises along with the concentration of Na_2CO_3 in the H_3PO_4-Na_2CO_3-H_2O system. It has been determined that as the H_2O/Na_2O molar ratio rises from 2.0 to 4.0, the mass proportion of Na_2CO_3*$NaHCO_3$*$2H_2O$ grows and the content of $Na_2CO_3H_2O$ declines [4].

A theoretical examination of the gas-liquid technique for producing sodium sesquicarbonate was conducted after studying the system (Na_2CO_3-$NaHCO_3$-H_2O). Sequences of technological processes have been established through laboratory research.

There are several ways to make sodium sesquicarbonate, including making a concentrated solution of sodium carbonate and combining soda ash and sodium bicarbonate from food. These techniques' drawbacks, which include using food-grade (purified) sodium bicarbonate and having a low concentration of the goal product, sodium sesquicarbonate, are demonstrated.

At a temperature between 70 and 95 °C, soda ash is dissolved in a recovered mother liquid to create a solution with a concentration of 115 to 130 n.d.

At a temperature of 95 °C, the prepared soda solution carbonizes as sodium bicarbonate progressively forms and reacts with sodium carbonate to create sodium sesquicarbonate. Crystalline sodium bicarbonate, which steadily dissolves in water and reacts with sodium carbonate to produce sodium sesquicarbonate, is sometimes added to the soda solution in some compositions. When the liquid component is saturated, sodium bicarbonate begins to dissolve more slowly and eventually ceases forming sodium sesquicarbonate. Due to the inadequate contact area between their crystals, full molecular interaction of sodium carbonates and bicarbonates is not guaranteed in this respect, leaving a significant quantity of unreacted bicarbonate and sodium carbonate in the final product.

It is possible to make sodium sesquicarbonate (a synthetic version of the mineral trona) by first creating a saturated solution of sodium carbonate, then combining it with soda ash and food sodium bicarbonate in an equimolar ratio, and finally processing the resulting mixture with the saturated solution of sodium carbonate [5].

The outcome is a non-hygroscopic, non-caking product with a bulk density of 0.7–1 g/cm^3, having no more than 80% of the primary component.

The disadvantages of this method include:

- ✓ low content of the target product - sodium sesquicarbonate;
- ✓ high bulk density - 0.7-1 g/cm^3;
- ✓ use of food (purified) sodium bicarbonate.

Conclusion.

Maintaining specific ratios, the ratio of the original components and the rate of carbonization, as well as chilling during the crystallization stage, are required to produce a sodium sesquicarbonate precipitate that is well-filtered. In order to prevent the formation of a significant number of nucleation crystals, it is essential to restrict the initial salt concentration and cooling rate in the zone of crystal formation and nucleation and work to keep a minimum supersaturation of the solution [6]. Supersaturated fluids are the only ones that can produce crystal centers. The degree of supersaturation, which is influenced by temperature and the ratio of Na_2CO_3:$NaHCO_3$:H_2O, is defined by the difference in salt amounts in supersaturated and saturated solutions. The bulk density values in well-known works are at least 0.65–0.7 g/cm^3, and crystallization processes are not controlled by keeping a specific temperature in the crystallization zone, so the content of the primary component in the product does not surpass 70–85%.

The thermogram and diffraction pattern confirm that the obtained product's chemical makeup almost exactly matches that of sodium sesquicarbonate, which has the chemical formula Na_2CO_3; $NaHCO_3$; $2H_2O$ [7]. The pH of the final product at 1% is 9.8, making it non-hygroscopic and non-cakeable.

Thus, the ideal technological parameters of the gas-liquid technique for producing sodium sesquicarbonate were established based on the theoretical study of the solubility diagram of the Na_2O-CO_2-H_2O system and the carried out experimental investigations.

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