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Synthesis of Iodine-containing Sodium Chloride Crystals using a Mechanochemical Method

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Summary

Iodine is an essential trace element for the synthesis of thyroid hormones in humans and plays an important role in maintaining growth and metabolism. Iodine deficiency is known to cause various health disorders related to the thyroid gland. Currently, in Japan, sufficient iodine is obtained through the intake of seaweed, and deficiency is rare, but it remains a major nutritional issue worldwide. In particular, in landlocked and developing countries, the iodine concentration in soil and water is low, and residents' intake is insufficient. Therefore, since the 1990s, international organizations have promoted the spread of iodized salt as a countermeasure against iodine deficiency. However, conventional iodine addition methods such as spraying and mixing potassium iodide or sodium iodide have problems with the actual intake amount being reduced due to the sublimation of iodine components into the air during storage or uneven distribution in the container. Therefore, the development of salt products that can retain iodine for a longer period and more stably is required. Therefore, in this study, we investigated a method to form a homogeneous and stable solid solution by incorporating iodine compounds into the crystal lattice of sodium chloride, thereby reducing the risk of sublimation and segregation. We focused on the NaCl–NaI system and attempted to synthesize a solid solution at room pressure and temperature by mechanochemical processing (high-energy ball milling). This is because even in the NaCl–NaI system, where a solid solution is thermodynamically difficult due to the difference in ionic radius, it is possible to obtain a new solid solution phase by using mechanical energy.

First, we used a NaCl–NaBr system sample, which is known to have a complete solid solution, as a comparison, and performed mechanochemical processing and evaluated it by powder X-ray diffraction (XRD). As a result, the shift in the diffraction peak confirmed the change in lattice constant due to the formation of a solid solution, and the formation of a solid solution was confirmed in all concentrations. Next, we performed the same processing on the NaCl–NaI system, and the peaks of NaCl and NaI, which were clearly separated in the untreated sample, changed to peaks indicating the formation of a solid solution after processing in the low NaI concentration region, and a non-equilibrium solid solution was formed by the mechanochemical method. However, when the NaI composition became high, the formation of a solid solution throughout the sample became impossible under the milling conditions used in this study. In the future, we plan to optimize the operating conditions and use it in combination with the LAG method, as well as to consider a two-stage substitution from the NaBr solid solution, in order to investigate how to form a solid solution with a higher concentration of NaI.