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Electro-Winning of Magnesium from Chloride Metal Using the Diamond Coating Electrode

Susumu Ikeda, Shintaro Tao

Analytical Research Center, Saga University

Summary

With the worldwide strengthening of regulations on the export of resource materials such as rare metals, Japan has investigated the suitability of technologies for collecting useful resource materials from high -concentration salt water discharged from desalination plants using seawater. The target resource materials have so far been lithium, magnesium, potassium, and uranium. However, only lithium has been focused on in the full-scale technological development for resource collection as part of a national strategy, and technologies for other metal resources have not yet been developed. For magnesium, the target of this investigation, Japan has been completely dependent on overseas suppliers (particularly from China, where the prices are low) for its supply of magnesium. It is urgently required for Japan to develop innovative technologies for collecting magnesium to become more self-sufficient in terms of magnesium supply. In the future, magnesium will become an essential material for use in key industries, such as the automobile, electric, and airplane industries, as well as a reducing metal in titanium production and a cathode material used in next-generation secondary cells. As a means of smelting magnesium, the thermal reduction method, currently adopted in China, can reduce the production cost but produces a huge amount of CO_2, which is considered to adversely affect the environment. Meanwhile, the Dow process, an electrolytic smelting method used to obtain magnesium in the USA, requires extremely expensive refinement processes including the sintering of limestone and the condensation of seawater. In the development of technologies for electro-winning magnesium, the reduction in environmental impact and power consumption should therefore be focused on. Previously, we collected salt from high-concentration salt water, a by-product of the desalination of seawater, and extracted magnesium chloride hexahydrate ($MgCl_2$ $6H_2O$) crystals from bittern, a filtrate, by low-temperature crystallization. We found that dehydrated magnesium chloride ($MgCl_2$), used as a raw material for electrolysis, can be extracted by adding ammonium chloride or introducing chlorine gas in the dehydration process. In molten salt electrolysis, it is also essential to develop electrodes with desirable properties such as high temperature stability, chemical resistance, mechanical strength, and conductivity. We successfully developed a diamond-coated electrode as a candidate electrode. In this paper, we report the results for the electro-winning of magnesium using the diamond-coated electrode and the evaluation of the properties of the extracted magnesium.