§20. Development of Lithium Recovery Technology for Resource Supply to Nuclear Fusion Reactor

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The deuterium-tritium (D-T) fusion reactor is expected to be a system to provide the main electricity in the future without any serous release of hazardous products such as a radioisotope of tritium, and it is the easiest fusion reaction to achieve. Lithium will be required in amounts dependent on the reactor design concept. When liquid lithium is used as a tritium breeder and a coolant, lithium inventories are large [1]. Lithium is now recovered from the mines and from salt lakes which contains about 14 millions tons of lithium. Although the amount of lithium in those resources is quite insufficient at this point, alternative resources should be found to satisfy lithium inventories for nuclear fusion plants and the increasing demand for battery and so on in the near future. Seawater, which contains 2300 hundred million tons of lithium in total, has thus recently become an attractive source of this element and the separation and recovery of lithium from seawater by co-precipitation, solvent extraction, adsorption, etc. have been investigated. Among these techniques, the adsorption method is suitable for recovery of lithium from seawater.

In this study, we prepared the $FePO_4$ as a lithium adsorbent using calcination methods, and the isotherm of the adsorbent for lithium ions was examined.

The mixture of $(NH_4)_2HPO_4$ and $FeSO_4 \cdot 7H_2O$ were prepared as starting materials. The mixed molar ratio of P/Fe is 1, and the mixture ground for 30 min in ethanol. The mixture was sintered at 700 °C for 3 h in an electric oven, and then cooled to room temperature. The sintered mixture was ground again for 30 min to obtain the adsorbent. The characteristics of the crystal structure of the adsorbents were recognized using a powder X-ray diffractomater (XRD, Rigaku, Rint-2500).

The obtained adsorbent (0.1 g) was added into 20 mL of LiCl solution with 0.5, 1, 5, 10, 25 mmol/L Li ion in 50 mL of polyethylene centrifuge tube, and the tube was shaken with reciprocal shaker at room temperature. After shaking for 24 h, the tube was centrifuged, and the concentrations of Li^+ in the supernatant were analyzed by inductively coupled plasma method (ICP, Seiko, SPS3000). The corresponding adsorption amounts (q_{Li} [mmol/g]) were determined from the material balance, as follows.

$$q_{Li} = (C_{Li0}-C_{Li}) \cdot L/w \qquad (1)$$

where C_{Li0} and C_{Li} are initial and equilibrium concentrations of Li^+ in the aqueous phase [mmol/L], L is volume of aqueous solution [L], and w is weight of adsorbent [g].

Fig. 1 shows the XRD patterns of the obtained adsorbents. The adsorbent is composed of $FePO_4$, which indicates that $FePO_4$ can be synthesized by this procedure.

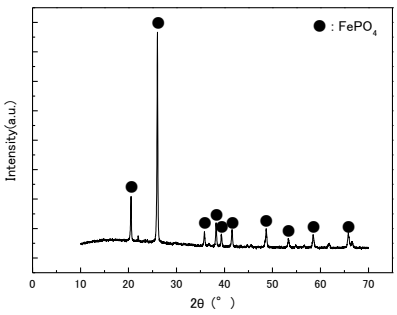

Fig. 1. XRD patterns of the obtained adsorbent.

Fig. 2 shows the isotherm of the obtained adsorbent for Li adsorption. With increasing the Li concentration, adsorption amount of Li in the adsorbent increases.

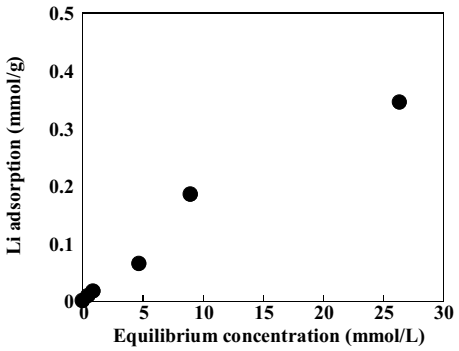

Fig. 2. Isotherm of the obtained adsorbent for Li adsorption.

Modeling of equilibrium data was done using most widely used Langmuir and Freundlich models. The liner forms of Langmuir and Freundlich models are given by:

$$C_e / q_e = 1 / (q_{max} \cdot K_L) + C_e / q_{max} \qquad (2)$$

$$\ln(q_e) = \ln(K_F) + 1/n \cdot \ln(C_e) \qquad (3)$$

where q_e is Li concentration on the adsorbent at equilibrium (mmol/g); q_{max} (mmol/g) is Langmuir constants related to the maximum adsorption capacity corresponding to complete coverage of available adsorption sites; K_L(L/mmol) is a measure of adsorption energy (equilibrium adsorption constant); K_F and n are Freundlich constants. These parameters and correlation regression coefficient (R^2) are shown in Table 1. The experimental data are found to fit Freundlich than Langmuir.

Table 1 Langmuir and Freundlich isotherm models parameters for Li adsorption by $FePO_4$.

Langmuir			Freundlich		
q_{max}	K_L	R^2	n	K_F	R^2
1.27	0.015	0.407	1.082	0.0184	0.9874

1) Hartley, J. N. et al.: Energy **3** (1978) 337.