Characterization of SiO_2-KCoFC composite ion exchanger for Cs removal in radioactive waste solution

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1. Introduction

An inorganic composite ion exchanger of SiO_2-KCoFC was prepared by sol-gel method for a removal of Cs in the radioactive waste solution. The prepared SiO_2-KCoFC composite ion exchanger was characterized with surface analysis such as SEM, EDX and BET measurements, and was evaluated its Cs adsorption capacity. The effect of HCl/TEOS ratio on sol-gel process was also investigated.

2. Methods and Results

2.1 Sample descriptions

The preparation method of inorganic ion exchanger (KCoFC) and the sol-gel process were described in our previous study [1].

2.2 Morphologies

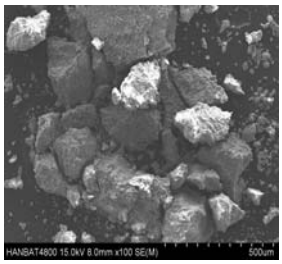
The prepared SiO_2-KCoFC composite ion exchanger was used for the measurement of surface observation by using SEM analysis. KCoFC powder was also used for the comparison with SiO_2-KCoFC composite ion exchanger. It was observed that the composite was prepared with particles over 0.1mm in size (Fig. 1(a)) and thousands of pores existed on the surface (Fig. 1(b)). It was also observed that the size of a micro-pore varied between 0.01 and 1 ㎛ (Fig. 1(c)). It was also found that in the drying stage after the completion of sol-gel reaction, where the remaining ethanol and water evaporated, the condensation of the composite took place, resulting in a great many of cracks or pores.

2.3 Cs adsorption isotherm

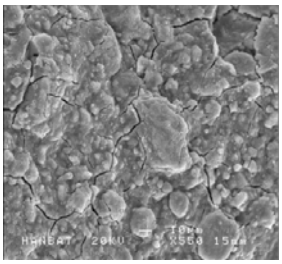
For the evaluation of Cs removal capacity, an experiment of Cs adsorption equilibrium was carried out by using a simulated Cs waste solution. After 0.1g of the composite was put into 10mL of the simulated Cs waste solution by using CsCl (Yakuri co.) with various different concentrations (Cs concentration: 100~5,000 mg/L), and it was shaken for 24 hours and filtered (0.2 ㎛ syringe filter, Whatman co.) only to measure the concentration of Cs with AA (AAnalyst400, Perkin-Elmer co.). By using the results of this experiment, it was possible to obtain Q_m (maximum adsorption capacity), meq/g) suggested by Langmuir isotherm out of the adsorption isotherms. Table 1 shows the experimental conditions.

$$Q_e = \frac{Q_m b C_e}{1 + b C_e} \quad \text{----------(1)}$$

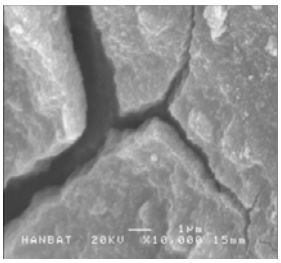
Q_e & C_e : equilibrium concentration of metal in solid and liquid phase
Q_m : saturation concentration of metal in solid phase (maximum adsorption capacity)
b : langmuir constant



(a) *100



(b) *550



(c) *10,000

Fig. 1. SEM images of SiO_2-KCoFC (80% KCoFC) composite ion exchanger

Table 1. Experimental conditions of Cs exchange isotherm

V (ml)	100
Cs conc. (mg/l)	100~5,000
Kinds of exchanger	KCoFC powder Composite (80% KCoFC; HCl ratio 0.025)
Exchanger (g)	0.1
L/S ratio (mL/g)	1000
Speed (rpm)	150
Shaking time (hr)	24

As a result of carrying out a Cs adsorption test by using an 80%-contained composite and KCoFC powder, a graph plotting the test results with Langmuir isotherm could be provided as shown in Fig. 2. In addition, the results of calculating with Langmuir isotherm are shown in Table 2. As shown in Fig. 2, both KCoFC powder and SiO_2-KCoFC composite ion exchanger were found to be well-simulated with Langmuir isotherm.

The maximum adsorption capacity (Q_m) of KCoFC powder was investigated to be 1.38 meq/g. It was found to be higher than 0.747 meq/g of the maximum adsorption capacity of KCoFC, which Valsala et al. (2009)[2] reported, and lower than 1.72 meq/g of the maximum adsorption capacity of KCoFC, which Moon et al.(2004)[3] reported, but it was found to show results in a similar range in general.

Meanwhile, the maximum adsorption capacity (Q_m) of a 80%-contained composite was found to be 1.07 meq/g. Compared to 1.10 meq/g corresponding to 80% of the adsorption capacity (1.38 meq/g) of KCoFC powder, it shows almost the same value. The little difference can be supposed to be caused by silica materials, which accounted for 20% of the composite, screening the ion exchanger, aside from fixing the ion exchanger.

In Mardan et al.'s study on the preparation of a composite through the thermal treatment of silica powder and KCoFC powder, it was reported that the Cs adsorption capacity was 0.38 meq/g in the composite containing 57.6% of KCoFC (1.36 g-KCoFC/g-SiO_2) [4], but the Cs adsorption capacity of the 80% KCoFC-contained composite for this study was found to be about 2 times higher.

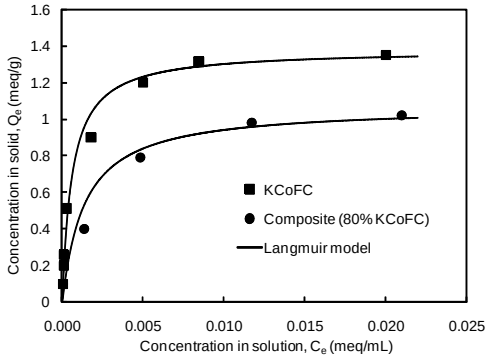


Fig. 2. Langmuir isotherm for KCoFC and SiO_2-KCoFC (80% KCoFC) system

Table 2. Langmuir isotherm modeling results for Cs ion exchange with inorganic (KCoFC) and composite ion exchanger (SiO_2-KCoFC; 80% KCoFC)

Ion-exchanger	Q_m(meq/g)	R^2
KCoFC powder	1.38	0.99
80% SiO_2-KCoFC	1.07	0.97

3. Conclusions

By using sol-gel reaction, this study could confirm the possibility of immobilizing KCoFC powder and evaluate the efficiency of its composite. It was found from pictures of observing the surface of SiO_2-KCoFC that immobilizing KCoFC powder was possible and there existed a great many of micro-pores on the surface of the composite. It was also investigated that the Cs adsorption capacity of SiO_2-KCoFC was 1.07 meq/g.

REFERENCES

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