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Development of Segregation Method for the Mixed Ion-exchange Resin using the Fluidized Bed Segregator

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1. Introduction

It was very difficult to dispose the mixed ion-exchange resin generated from pressurized heavy water reactor(PHWR, CANDU type) by the conventional methods because the concentration of C-14 in the mixed spent ion-exchange resin(IRN 150) is over the disposal concentration limit(NRC, 10CFR61, $8\ Ci/m^3$; $296\ GBq/m^3$). Therefore C-14 should be treated and disposed after selectively segregating the cation or anion ion-exchange resin from mixed spent ion-exchange resin from waste water according to the management plan of the spent resin(IRN 150).

This study is concerned with the segregating effectively C-14 from the spent resin and reducing the volume of secondary waste. In this study, we were investigated the effects of segregation efficiency on the operation variables such as liquid velocity and the material of wastes in the fluidized bed segregator.

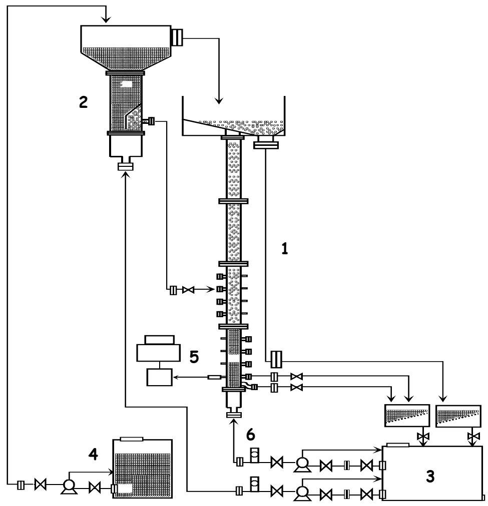
2. Segregation Process

There are many methods such as sieve segregation method, centrifugal segregation method and sedimentation-floating segregation method to segregate a cation ion-exchange resin or anion ion-exchange resin from the mixed ion-exchange resin. But those methods were not used to segregate the mixed ion-exchange resin because of the narrow size distribution and the similar density value between the cation and anion ion-exchange resins. In the sedimentation-floating method, sucrose was very useful to segregate the mixed ion-exchange resin because of the non-toxicity, non-corrosion for the segregation process, and low cost. But the microorganism and gas appearance were not suitable to the long-term storage and disposal of the mixed spent ion-exchange resin generated from nuclear power plants.

But the novel segregation method by using the fluidized bed segregator overcomes the disadvantages of the conventional segregation method and it is more effective and safe to perform the segregation process of the mixed spent ion-exchange resin.

3. Experiment

As shown in Figure 1, experiments were carried out in the riser of liquid-solid fluidized bed, composed of three main sections such as the riser segregator, loop-seal system, and liquid and solid recycle devices. The riser whose diameter and height were 0.06 and 2.0 m respectively was constructed of several pieces of acrylic column to survey the flow phenomena inside of the riser.



1	Riser	2	Loop seal	3	Water T/K
4	Resin T/K	5	Sensor	6	Flow meter

Figure 1. Schematic diagram of the fluidized bed segregator.

The loop-seal system in the downcomer supplied the mixed ion-exchange resin as constantly mass flux. The liquid velocity was measured by flow meter and regulated by means of valves on the feed and bypass lines. The supplementary devices consisted of resin reservoir, desalt water reservoir, pressure sensor, data acquisition system, water pump, sludge pump and flow meter. For sampling the mixed resin, the taps were installed with a distance of 0.1 m from the liquid and gas distributor.

The resins used in the experiment were IRN 150 as the mixed resin, IRN 77 the cation resin as well as IRN 78 the anion resin. The mixed resin, IRN 150 which was mixed IRN 77 and IRN 78 as the equivalent ratio(1:1) was the products of Amberlite company. The physical and chemical properties of the IRN 77 and IRN 78 resin were summarized in Table 1.

Table 1. The properties of IRN 77 and IRN 78 resin

Characteristics	**IRN 77**	**IRN 78**
Sipping weight	800g/L	690g/L
Harmonic mean size	650±50 ㎛	630±50 ㎛
Relative density	1.10-1.40	1.04-1.12
Ionic form as shipped	H^+	OH^-
Total exchange cap.	1.9eq/L	1.2eq/L
pH	3.0-5.0	8.0-10.0

4. Result and Discussion

4.1 The Measurement of Terminal Velocity

It is important for fluidizing the solid materials to measure the terminal velocity(U_t) in the fluidized bed system. The equations(1-3) were the calculating equation suggested by Kunni[1]. The Table 2 shows the comparison data with calculated and experimental values.

$$d_p^* = d_p \left[\frac{\rho_g(\rho_s - \rho_g)g}{\mu^2} \right]^{1/3} \quad (1)$$

$$u_t^* = u_t \left[\frac{\rho_g^2}{\mu(\rho_s - \rho_g)g} \right]^{1/3} \quad (2)$$

$$u_t^* = \left[\frac{18}{(d_p^*)^2} + \frac{0.591}{(d_p^*)^{0.5}} \right]^{-1}, \phi_s = 1 \quad (3)$$

Table 2. The comparison data with calculated and experimental values

		Calculated value	Experimental value
U_t (m/s)	IRN 77	0.033	0.033
	IRN 78	0.013	0.0129

4.2 The Characteristics of Bed Expansion

Figure 2 shows the results of the bed expansion according to the variation of flow rate and the weight of resin in the fluidized bed segregator. As shown in the figure, the bed height increases exponentially with increasing the flow rate and weight of the charged resin. The bed expansion of the IRN 78 was larger than that of the IRN 77 because it was due to the difference of the terminal velocity.

At the weight of the charged IRN 78 such as 250, 500, and 750 ㎖, the IRN 78 was easily fluidized and segregated. Also, if the bed height of the fluidized bed lessen a half of the original height, the separation of the mixed ion-exchange resin will be easier and efficient.

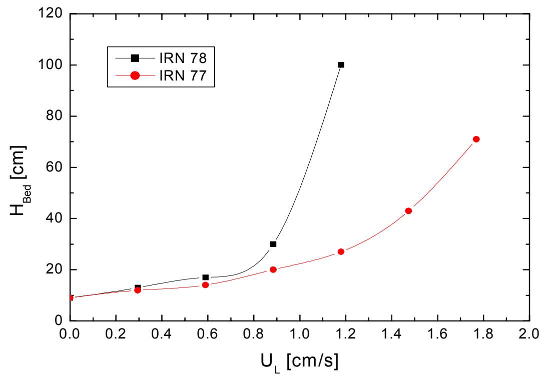


Figure 2. Effects of the flow rate on the bed expansion

4.3 The Characteristics of Segregation

The results of the segregation efficiency are shown in Figure 3. The separation efficiency was obtained to measure the sampling resin acquired from the tap installed in the fluidized bed segregator. Note in this figure that the segregation efficiency of the IRN 78 resin attain nearly up to 100%. It was due to the difference of the terminal velocity and the characteristics of the bed expansion.

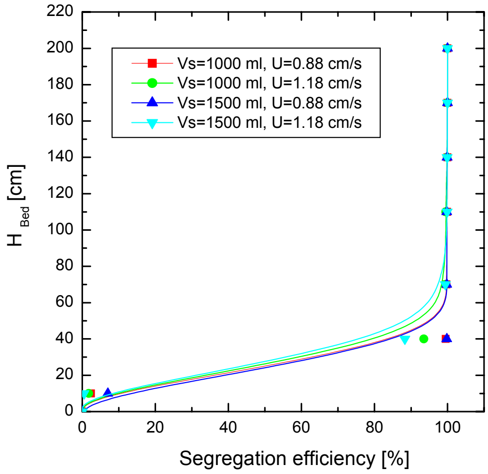


Figure 3. Effects of the segregation efficiency on the bed height.

5. Conclusions

This present study has yielded the following conclusions by means of the measurement such as the terminal velocity, the bed height and the segregation efficiency in the fluidized bed segregator of mixed ion-exchange resin.

- The terminal velocities between the calculated and experimental value of the IRN 77 and 78 resins are nearly alike.
- The height of bed was expanded with increasing the flow rate and the weight of the resin. It was due to the difference of the terminal velocity.
- The segregation efficiency of the IRN 78 resin was close to 100% near the terminal velocity
- In consideration of the characteristics of the bed height and the segregation efficiency, the suitable height of the segregation equipment would be one meter.

REFERENCES

[1] Daizo Kunii and Octave Levenspiel, Fluidization Engineering, 2nd ed., Butterworth-Heinemann, Boston, USA, , p. 80-81(1991).