Recovery of the Magnetic Adsorbent for Cs Separation from Liquid Waste by Using the Magnetic Liquid-Solid Separation Method

Hyo-Jeong Lee*, Jung-Weon Choi, Seung-Yeon Cho, Won-Zin Oh, and Sang-June Choi

Kyung pook National University, Dae-Hak ro 80, Buk-gu, Dae-Gu, Republic of Korea

*pinetree93@knu.ac.kr

1. Introduction

To remove Cs from waste aqueous solutions, traditional techniques such as ion-exchanges, adsorption and electrocoagulation are used. Among the mentioned methods, adsorption is one of the most popular methods for removal Cs in aqueous waste solution due to simplicity, selectivity and efficiency. Especially, nanostructured adsorbents have emerged as strong candidates for removal of contaminants in wastewaters because of large specific surface area and high adsorption capacities. However, it is difficult to recover. Therefore, the application of magnetic nanostructured adsorbents can overcome this weakness [1-3]. It is possible using magnetic force to recover the magnetic adsorbents instead of column.

In our previous works, we reported the synthesis method of adsorbents (magnetic MWCNTs-ZnFC-1 and magnetic MWCNTs-ZnFC-2) and their maximum adsorption ability (0.8951±0.0045 mmol/g (R^2=0.9989), 1.4476±0.0630 mmol/g (R^2=0.9702), respectively) [1]. However, with low recovery efficiency, it is not outstanding adsorbents. Therefore, in this paper, we prepared adsorbents with same synthesis method as previously. Then, we evaluate recovery efficiency with permanent magnet.

2. Experiments

2.1 Preparation of the adsorbents

In order to obtain magnetic MWCNTs, mixing reaction was carried out at 280℃ for 1 hours under Ar gas with 100 mg of $Fe(acac)_3$ (2,4-pentanedionate, 99%), pristine MWCNTs and TREG (Triethylene glycol, 99%). Then, washed with ethanol and DI-water, and dried. The next procedure for Zinc ferrocyanide functionalized magnetic MWCNTs was as follow. Firstly, shaking magnetic MWCNTs at 25℃, 100 rpm for 3 hours under N_2 gas with 0.1 M $K_4Fe(CN)_6{\cdot}H_2O$. Then, shaking at 25℃, 200 rpm for 3 hours under N_2 gas with 0.3 M $ZnCl_2$ (magnetic MWCNTs-ZnFC-1). For magnetic MWCNTs-ZnFC-2, 0.2 M $K_4Fe(CN)_6{\cdot}H_2O$ and 0.6 M $ZnCl_2$ are used instead of 0.1 M and 0.3 M respectively.

2.2 Measure the Particle Size

The particle size of magnetic nanostructured adsorbents is one of the most important things in magnetic separation. PSA (Particle Size Analyzer, N5/LS-13320, Beckman Coulter) measures particle size and their distribution by principles of diffraction.

2.3 Experiment of Magnetic Separation

The efficiency of separation is evaluated by batch magnetic process. The permanent magnet captured magnetic MWCNTs-ZnFC-1 and magnetic MWCNTs-ZnFC-2 while 700 mL DI water stirred with 250 rpm for 1 minute. Fig. 1 shows the separation procedure.

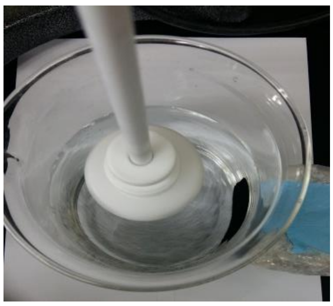

Fig. 1. Magnetic separation with permanent magnet.

The separation efficiency of permanent magnet was computed on Equations (1) :

$$E = \left(\frac{W_{captured}}{W_0}\right) \times 100(\%) \qquad (1)$$

where E is percent of separation, $W_{captured}$ is captured adsorbent mass (g) by permanent magnet, W_0 is the initial adsorbent mass (g) dispersed in the batch reactor.

3. Results

3.1 Particle Size Distribution

Particle size analysis result data of magnetic MWCNTs-ZnFC-1 and magnetic MWCNTs-ZnFC-2 is shown Fig. 2 and Table 1.

Table 1. Diameter Information of magnetic MWCNTs-ZnFC-1 and magnetic MWCNTs-ZnFC-2

	magnetic MWCNTs-ZnFC-1	magnetic MWCNTs-ZnFC-2
D10	23.604	17.940
D50	56.099	57.967
D90	233.547	238.510
Mean	111.725	105.620
Median	56.099	57.967

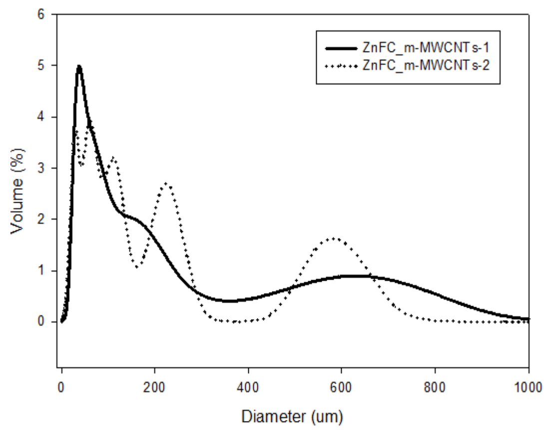

Fig. 2. Particle Size Distribution Curve of magnetic MWCNTs-ZnFC-1 and magnetic MWCNTs-ZnFC-2.

The sizes of magnetic MWCNTs-ZnFC-1 ranged from 0.6 μm to 1142 μm, magnetic MWCNTs-ZnFC-2 ranged from 0.375 μm to786 μm. The D10 of magnetic MWCNTs-ZnFC-2 is smaller than magnetic MWCNTs-ZnFC-1. However, their D50, D90 and mean diameters are similar.

3.2 Magnetic Separation Efficiency

Separation Efficiencies are shown Table 2. Efficiency of magnetic MWCNTs-ZnFC-1 is 95.81% and magnetic MWCNTs-ZnFC-2 is 91.01% for 1 minute.

Table 2. Separation Efficiency of Adsorbents

Adsorbent	Initial adsorbent mass [g]	Captured adsorbent mass [g]	Separation efficiency [%]
magnetic MWCNTs-ZnFC-1	0.2005	0.1921	95.81
magnetic MWCNTs-ZnFC-2	0.2003	0.1823	91.01

4. Conclusion

In the previous study about the magnetic MWCNTs-ZnFC-1 and magnetic MWCNTs-ZnFC-2, the latter with the two times higher ZnFC contents has higher adsorption ability than the magnetic MWCNTs-ZnFC-1 [1]. We obtained the following conclusion based on the recovery efficiency of the two adsorbents: increase in the Cs adsorption sites by ZnFC has little influence on the magnetic recovery efficiency due to little change in the particle size distribution.

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