

## Uranium(VI) Removal from Dilute Aqueous Solutions by Nano-Structured Materials

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### 1. Introduction

Removal of radioactive elements from aqueous solutions has attracted intensive attention from many researchers due to the importance in environmental aspects [1,2]. Various materials including inorganic compounds, activated carbons and complexation polymers have been used as adsorbents for radioactive elements, particularly for uranium among actinide species [1,2]. For this purpose, surface modification technique on various adsorbents have been tried to increase adsorption capacity of uranium [2]. We present new materials with nanoporous structure for the removal of uranyl ions from water. In this study, two representative nanoporous materials, carbon and silica, were evaluated. Furthermore, surface modification of the materials by organic ligands was carried out to enhance adsorption performance.

### 2. Experimental

The ordered nanoporous carbon synthesized from ordered nanoporous silica as the template was used in this study. Detailed descriptions of the synthesis and characterization of the nanoporous carbons and silicas were reported in previous papers [3]. Adsorption capacity of uranyl ions by the carbons and silicas were measured under constant ionic strength of 0.1 M NaNO<sub>3</sub> at pH 3.5 and at 22°C. A stock solution of 1000 ppm U(VI) was prepared by dissolving uranyl nitrate in distilled water. U(VI) adsorption amount by adsorbents at equilibrium was calculated by measuring the final U(VI) concentration in the test solution by inductively coupled plasma atomic emission spectroscopy (ICP-AES, Horiba Ultima 2).

Surface modification of the carbons and silicas was carried out by mixing carbons or silicas and organic ligands for 24 hr. After the reaction was completed, the mixture solutions were filtered and then the resulting surface-modified adsorbents were thoroughly washed with a large amount of water. Amount of organic ligands in solution was analyzed by total organic carbon analyzer (TOC). The content of organic ligands coated on adsorbent was determined by subtracting the amount of organic ligands in solution from the initial amount of organic ligands.

Thus, we obtained surface-modified carbon with 15 wt% organic ligand content at pH 5 and surface-modified silica with 30 wt% organic ligand at pH 3.

Adsorption capacities of uranyl ions by the surface-modified carbon and silica were measured in the solution with various concentrations of uranyl ions at pH 3.5.

### 3. Results and Discussion

Fig. 1 shows the adsorption isotherms of uranyl ions on the carbon and the silica at pH 3.5. The amount of uranium adsorbed on the carbon increased with the uranium concentration. On the other hand, trend for the uranium adsorption capacity on silica converged to a specific value was observed.

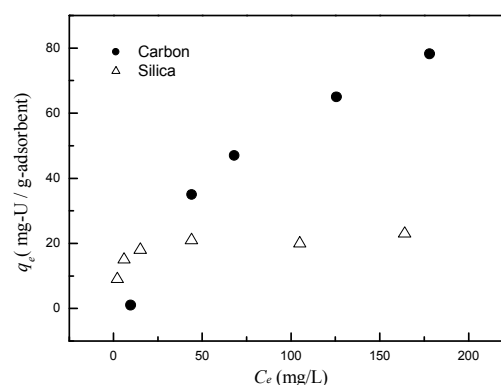


Figure 1. Adsorption isotherms of UO<sub>2</sub><sup>2+</sup> on the carbon and the silica at pH = 3.5.

Equilibrium adsorption isotherm of uranyl ions on the carbon and silica was analyzed using two adsorption isotherm models (Langmuir [4] and Temkin [5] isotherm models).

Fig. 2 shows the Temkin plot for the adsorption of uranyl ions on the carbon and the fitting result (solid line) by linear regression analysis. The Temkin isotherm shows excellent fits to the experimental adsorption data, yielding the extremely high correlation coefficients ( $R^2 = 0.9899$ ). This strongly supports that the adsorption of uranyl ions on the carbon follows the Temkin model.

Fig. 3 shows the Langmuir plot for the adsorption of uranyl ions on the silica and the fitting result of the correlation coefficients ( $R^2 = 0.9933$ ) by linear regression analysis. This isotherm shows excellent fit to the experimental adsorption data, indicating that the adsorption of uranyl ions on the silica follows the Langmuir model.

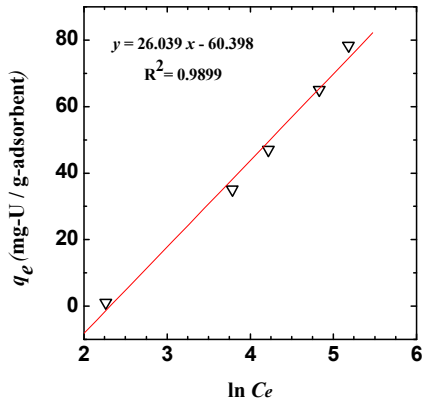


Figure 2. Temkin isotherm plot for the adsorption of  $\text{UO}_2^{2+}$  on the carbon at  $\text{pH} = 3.5$ .

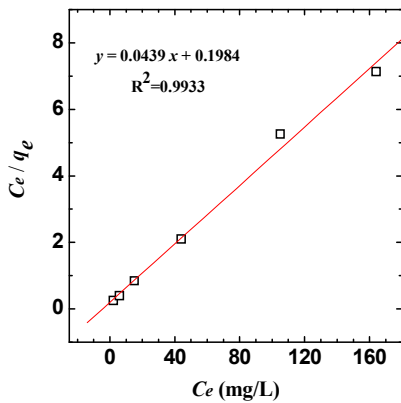


Figure 3. Langmuir isotherm plot for the adsorption of  $\text{UO}_2^{2+}$  on the silica at  $\text{pH} = 3.5$ .

### 3. Conclusion

We examined the adsorption characteristics of uranyl ion on carbon and silica and evaluated the adsorption isotherm using two adsorption models such as the Langmuir and Temkin isotherm. For the carbon, the Temkin isotherm provided the most satisfactory fits to the experimental data with the highest correlation coefficient, implying that the adsorption of uranyl ions on the carbons obeys the Temkin isotherm model. On the other hand, the Langmuir isotherm provided excellent fits to the experimental data for the silica.

### Acknowledgements

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