

# Electrosorption of the Uranium in Liquid Waste

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## 1. Introduction

For the removal and recovery of uranium(VI) from contaminated water and waste streams, a variety of physical and chemical methods such as a precipitation, coagulation, ion exchange and adsorption have been used. But these techniques have been restricted in application due to their limited capacity when the concentration of U(VI) in the waste water is relatively high[1-3]. As an efficient electrochemical method for the removal of a high concentration of uranium, an electrodeposition on carbon materials has been extensively investigated and used very effectively. For the uranium having a high reduction potential, electrodeposition is not a practical method[4]. An alternative to electrodeposition is electrosorption, which is an adsorption of the metal cations onto a negatively charged carbon surface[5].

In this study, column experiments were performed for an electrosorption of uranium ions in a liquid waste containing a high concentration of chemical salt on an ACF felt electrode. In a continuous flow-through cell, the adsorption behaviors were investigated, with a changing applied potential and pH. The results were compared with the adsorption behaviors when the potential was not applied.

## 2. Experimental

### 2.1. electrode and reagents

The electrosorption electrode used in this study was pitch-based ACF felts (Osaka Gas Co., FN-200PS-15) with a thickness of 4~6 mm.

A uranium solution was prepared by diluting a concentrated  $\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  solution with sodium nitrate and deionized water (over 16  $\text{M}\Omega\text{-cm}$ ). 1 M  $\text{NaNO}_3$  was used as the supporting electrolyte solution and the concentration of the uranium nitrate was 0.05 mM.

### 2.2. electrochemical cell

Flow-through adsorption experiments were carried out using a three-electrode electrochemical cell where the electric current flows parallel to the solution flow, as shown in Figure 1. ACF felts used as the working electrode were placed on a platinum mesh which was used as a current collector and ACF supporter. The counter electrode was platinum wire and an Ag/AgCl electrode was used as the reference electrode. All the potentials reported in this paper are relative to this

reference electrode. The electrochemical cell was connected with a potentiostat (Radiometer, PGP201).

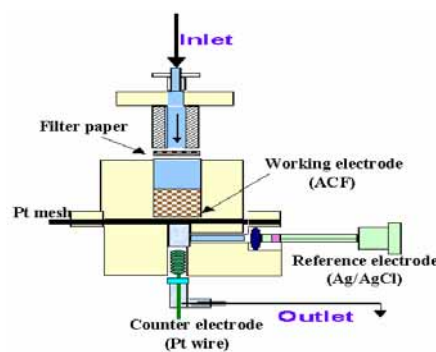


Figure 1. Experimental cell for flow-through electrosorption

## 3. Results and Discussion

A test for the electrosorption with a 100 mg/L U(VI) feed on to the ACF felt at various negative potentials in the range of  $-0.1$  to  $-0.9$  V(vs. Ag/AgCl) was carried out. The uranium concentration in the effluent from this test is shown in Figure 2. Effective U(VI) removal is accomplished at all the negative potentials. At a potential of  $-0.3$  V, the U(VI) concentration in the effluent is reduced to 1 mg/L in 2h and then increased continuously. At a potential of  $-0.9$  V, a complete removal (99.8%) of U(VI) is rapidly reached in 1h and maintained throughout the test. However, in the case of OCP the effluent concentration of U(VI) increased within 3h and finally reached the level of the feed, indicating a saturation of the sorption capacity by the ACF. From these results, it can be confirmed that the external negative potential exerted on the ACF electrode has a great impact on the adsorption capacity of the ACF.

If the above results are replotted as the cumulative uranium sorption amount vs. time as shown in Figure 3, the kinetics of the uranium sorption can be examined. The specific sorption rate can be obtained from the cumulative uranium sorption divided by the time interval and by the weight of the activated carbon fiber. At OCP, the rate of uranium sorption starts at 0.12 mg/g-min and decreases with time, approaching zero within 3h. It represents a typical adsorption breakthrough curve in which a saturation occurs. When the potential is  $-0.3$  V or more negative, the cumulative uranium adsorption plots are essentially straight lines, indicating a constant specific sorption rate within the

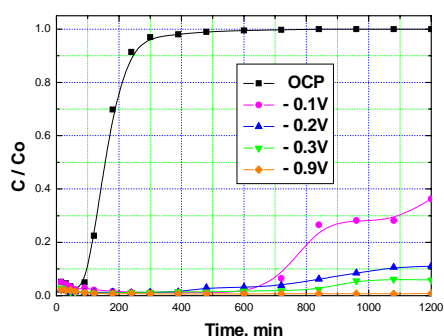


Figure 2. Electroadsorption of U(VI) with a variation of the potentials at pH 4.

time of the test. Extension of the constant sorption rates can be expected over a longer time. It is clear that the magnitude of the negative potential applied to the carbon electrode controls the uranium, sorption rate. Especially, in a long-term test conducted with a 100 mg/L U(VI) feed at  $-0.9\text{ V}$ , the effluent concentration is maintained at less than 1 mg/L, corresponding to a specific sorption rate of 1.68 mg/g·min. The cumulative uranium amount within 20 h is about 250 mg uranium/g carbon.

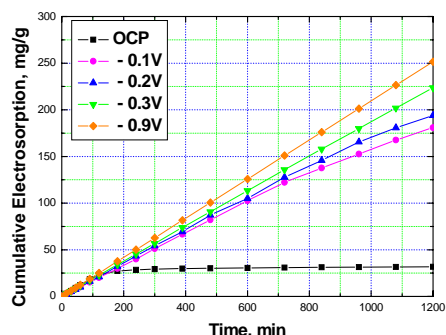


Figure 3. Cumulative electroadsorption of U(VI) with a variation of the potentials at pH 4.

The influence of the solution pH on the electroadsorption of U(VI) at  $-0.9\text{ V}$  (Figure 4) indicates that the adsorbed uranium decreased as the pH was lowered. At pH 2.0, the effluent uranium concentration rapidly reached the level of the feed. In a pH 3.0, the effluent concentration starts to increase after 6h, showing an extremely low uranium sorption capacity. The electroadsorption at pH 4 and 5 shows a very low U(VI) effluent concentration below 1mg/L and similar results were found for the others except a slightly higher uranium removal during the first hour of electroadsorption at pH 5. The electroadsorption results replotted as the cumulative uranium sorption amount vs. time indicate a constant specific sorption rate at pH 4 and 5. The cumulative uranium amount within 20 h is about 240 mg uranium/g carbon at pH 4.

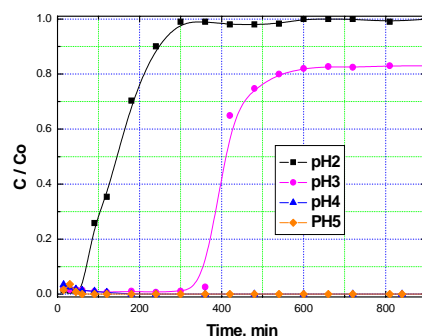


Figure 4. Electroadsorption of U(VI) with variation of solution pH at  $-0.9\text{ V}$ .

#### 4. Conclusions

An electroadsorption with activated carbon fiber(ACF) electrode was carried out to treat liquid waste containing U(VI). The result of the continuous flow-through cell electroadsorption experiments showed that the applied negative potential increased the adsorption kinetics and capacity in a comparison to the open-circuit potential(OCP) adsorption for uranium ions. Effective U(VI) removal is accomplished when a negative potential is applied to the activated carbon fiber electrode. For the feed concentration of 100 mg/L, the concentration of U(VI) in the cell effluent is reduced to less than 1 mg/L. In the electroadsorption process, the optimum conditions for the electroadsorption of uranium ions are at potentials of  $-0.9\text{ V}$  and a pH of 4~5.

#### REFERENCES

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