

ADSORPTION OF URANIUM FROM AQUEOUS SOLUTIONS USING ACTIVATED CARBON PREPARED FROM OLIVE STONES

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ABSTRACT

Adsorption of uranium from aqueous solutions using activated carbon was investigated. Olive stones were selected as a starting material for the preparation of activated carbon. Adsorption experiments were carried out by batch technique. Starting material/activating agent (ZnCl_2) ratio of 1:2 and 600°C carbonization temperature were used for the preparation of adsorbent. The adsorption of uranium was studied as a function of shaking time, pH, initial uranium concentration and temperature. The optimum conditions were found as 5 minutes shaking time, pH 6, 25 ppm uranium concentration, and 30°C temperature. The uranium adsorption efficiency was found to be 94±5 % applying these determined optimum conditions.

INTRODUCTION

Separation and purification processes based on adsorption technique are important in nuclear industry where activated carbon is often used for the separation of metal ions from solutions, due to its selective adsorption, high radiation stability and high purity [1]. Activated carbons are unique adsorbents because of their extended surface area, microporous structure, high adsorption capacity and high degree of surface reactivity [2].

Aegean Region of Turkey is famous with its olive trees. Therefore, there is considerable amount of olive stones as an agricultural by-product. Activated carbon can be produced using every kind of carbonaceous material including agricultural by-products. Taking into consideration of its importance as an agricultural by-product, it can be widely used as starting material for the preparation of activated carbon.

EXPERIMENTAL

The starting material was mixed by stirring with ZnCl_2 solution in the ratios of (starting material/activating agent) 1:1 and 1:2. The resulting chemical-loaded samples were heated to

different carbonization temperatures in the range of 500-700°C and held at that temperature for 1 hour [3-8].

The adsorption of uranium was studied as a function of shaking time, pH, initial uranium concentration and temperature. Adsorption measurements were carried out by batch technique. Uranium solutions were prepared using uranyl nitrate hexahydrate ($\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$) (Merck). Before and after adsorption, the concentration of uranium was determined by the Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES).

RESULTS AND DISCUSSION

In this study olive stones were used as the starting material for the preparation of activated carbon. Effects of carbonization conditions on the properties of the resulting activated carbon were examined. Figure 1 shows the preparation conditions and adsorption capacities of the activated carbons. From the results of figure 1, starting material/activating agent (ZnCl_2) at ratio of 1:2 and 600°C carbonization temperature were used for the preparation of adsorbent.

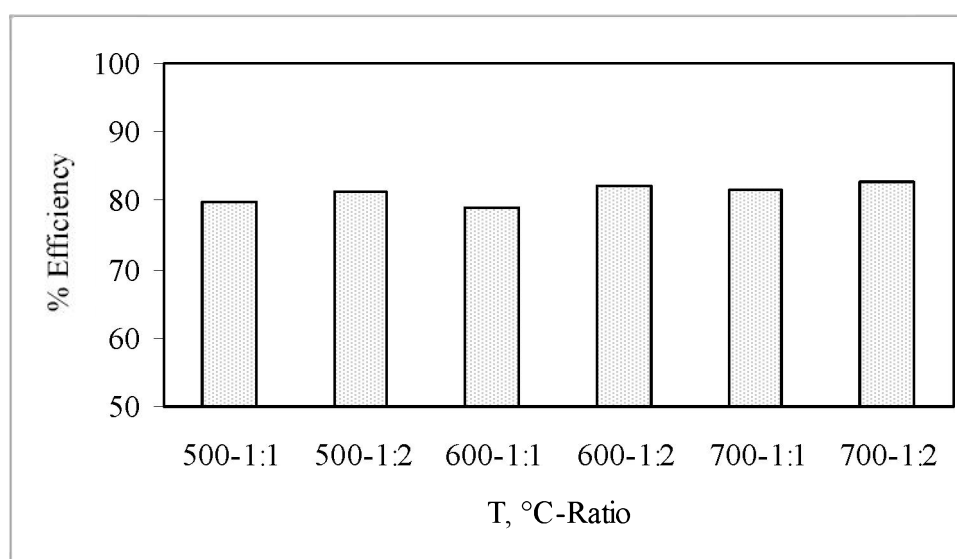


Fig 1. Adsorption Efficiencies of Activated Carbons

The parameters which affect the uranium adsorption were investigated by using activated carbon prepared in determined laboratory conditions. Different intervals of time ranging from 5 minutes to 240 minutes were examined to determine the effect of shaking time. Effect of pH was examined in the pH ranges of 2 to 7. Then, the effect of concentration was studied by using five different uranium solutions, varying initial concentrations from 25 to 300 ppm. 15, 30, 40, 50 and 60°C were applied to observe the effect of temperature. As a result, the optimum conditions were found as: 5 minutes shaking time, pH 6, 25 ppm uranium concentration, and 30°C temperature. These determined conditions were applied and the uranium recovery efficiency was found as $94 \pm 5\%$.

In order to understand the adsorption capacity of the adsorbent, the equilibrium data were evaluated according to the Langmiur isotherms. Fig. 2 shows the Langmiur isotherm of uranium adsorption on activated carbon prepared from olive stones. The Langmuir equation, which has been successfully applied to many adsorptions, is given by [9]

$$\frac{C_e}{Q_e} = \frac{1}{bn_m} + \frac{C_e}{n_m} \quad (1)$$

where C_e is the equilibrium concentration (mg/L), Q_e is the amount absorbed at equilibrium (mg/g), n_m and b is the Langmuir constants related to monolayer capacity and energy of adsorption. A linearised plot of C_e/Q_e versus C_e is obtained for activated carbon as shown in Fig. 2. The fits are well for the activated carbon (correlation coefficient is 0.99). n_m and b was found as 57.8 mg/g and 0.095 L/mg, respectively.

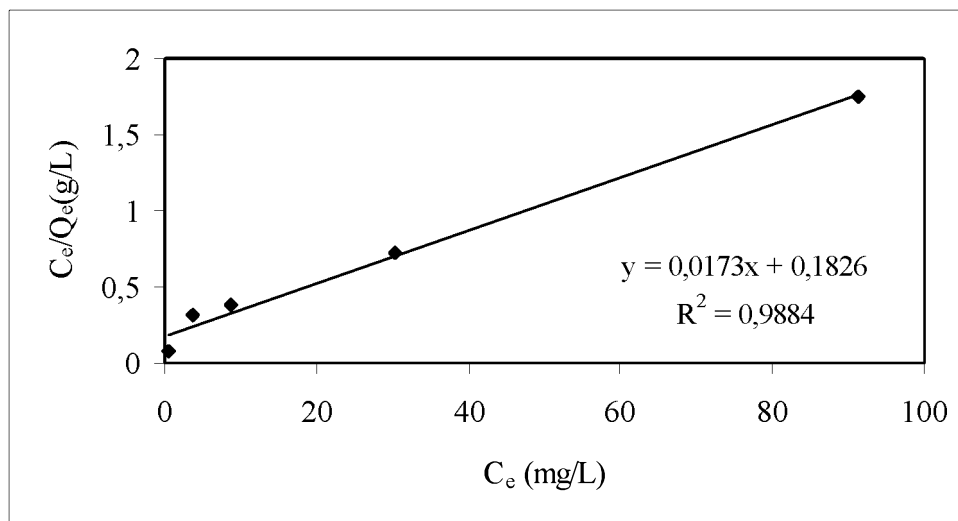


Fig 2. Langmuir plots for the adsorption of uranium on activated carbon.

The results show that activated carbon prepared from olive stones in our laboratories can be treated for uranium recovery from aqueous solutions. In addition, matrix effects and desorption behaviour of adsorbed uranium on activated carbon should be studied. We are of the opinion that the method can be used for preventing environmental contamination and adsorption of uranium from wastes in various stages of nuclear fuel production depending on uranium fuel cycle.

REFERENCES

1. Qadeer R., Hanif J., Saleem M., Afzal M., Journal of Radioanalytical and Nuclear Chemistry, Letters, 165, 243 (1992).
2. Galiatsatou P., Metaxas M., Kasselouri-Rigopoulou V., Journal of Hazardous Materials B91, 187–203 (2002).
3. Teng H., Yeh T-S., Industrial and Engineering Chemistry Research, 37, 58 (1998).
4. Teng H., Hsieh C., Industrial and Engineering Chemistry Research, 37, 3618 (1998).
5. Ullmann's Encyclopedia of Industrial Chemistry, VCH, Federal Republic of Germany, Fifth Completely Revised Edition (1986).
6. Gergova K., Eser S., Carbon; 34, 879 (1996).
7. El-Nabarawy Th., Mostafa M.R., Youssef A.M., Adsorption Science and Technology, 15, 59 (1997).
8. Ahmadpour A., Do D.D., Carbon, 34, 471 (1996).
9. Gregg S.J., Sing K.S.W., Adsorption, Surface Area and Porosity, Academic Press, Second Edition, London, 303p (1982).