PREPARING ACTIVATED CARBON FROM CHARCOAL AND INVESTIGATION OF THE SELECTIVE URANIUM ADSORPTION

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INTRODUCTION

Preconcentration and separation procedures based on adsorption phenomena are important in nuclear and especially radiation chemistry, industry, medicine and daily life. Adsorption of uranium onto various solids is important from purification, environmental and radioactive waste disposal points of view (1). The treatment of aqueous nuclear waste solutions containing soluble metal ions requires concentration of the metal ions into smaller volume followed by recovery or secure disposal. For this purpose, many processes are being utilized such as precipitation, ion-exchange, solvent extraction and adsorption on solids etc. Interest in the adsorption of metal ions for recovery purposes has increased manyfold in recent years, because of its simplicity, selectivity and efficiency (2). The main advantage of adsorption is the separation of trace amount of elements from large volumes of solutions. In recent years, several studies have been made to recover radionuclides by adsorption using natural and synthetic adsorbents.

Adsorption on charcoal is one of the most efficient techniques used in water treatment processes for the removal of organics and micropollutants from wastes and drinking waters. Adsorption processes have long been used in the removal of color, odor, and organic pollution. These processes are usually based on the use of activated carbon (3, 4).

Activated carbon consists mainly of carbon (5) and is produced from every carbonaceous material. Activated carbon characterized by its high surface area and its wide distribution of porosity. The textural properties (surface area and porosity) of activated carbons play an important role in determining the capacity of the material in adsorption from aqueous solution. Chemistry of the surface is also important (6). Generally, activated carbons are mainly microporous, but in addition to micropores they contain meso- and macropores, which are very important in facilitating acces of the adsorbate molecules to the interior of carbon particles. Due to its selective adsorption, high radiation stability and high purity, activated carbon is often used for the separation of metal ions from solutions in nuclear industry (1, 7). Using the activated carbon for separation of some fission products, radon measurements and removal of some radioisotopes has been the subject of several investigations. The preconcentration of uranium based on adsorption is important because it has found many applications in nuclear industry and from the environmental and waste disposal point of view (2). In view of the anticipated exhaustion of terresterial uranium reserves in the near future, further research has been made directed to recover uranium from nonconventional resources such as natural waters, seawater, industrial waste waters and in addition that other waste sources cause environmental pollution (8).

Activated carbon can be prepared from a variety of materials such as coal, lignite and polymers. A large variety of agricultural byproducts and wastes such as rice husks, peach stones and almond shells also have been used to prepare activated carbons. Depending on the raw materials, activated carbons have different surface characteristics with surface functional groups, surface area, porosity and pore size distribution (9-12).

Activation involves two fundamentally different processes: (i) Chemical activation using chemicals such as phosphoric acid and zinc chloride applied to the initial uncarbonized material (ii) Physical activation using gases such as steam, carbon dioxide, carbon monoxide applied to the carbonized materials (5).

In comparison with physical activation, advantage of chemical activation is the lower temperature in which the process is accomplished (13). Practically, the type of raw material and the method of activation are important parameters which may influence the type of porosity (14).

EXPERIMENTAL

Chemical activation was employed in this study. Among the numerous dehydrating agents, zinc chloride is the widely used chemical agent in the preparation of activated carbon. Preparation of activated carbon by chemical activation principally consists two consequtive steps: Impregnation and carbonization (13). In this study, charcoal was used as the starting material and chemical activation was performed with zinc chloride. The used experimental procedure in the activation process is shown in Figure 1.

In the first step of our study, the parameters which are important for producing activated carbon; starting material/activating agent ratio, carbonization time and temperature have been investigated. We have found that 1:1 ratio and 600°C carbonization temperature were convenient for the adsorption experiments.

In order to determine adsorption capacity, uranium stock solution was prepared by dissolving $UO_2(NO_3)_2.6H_2O$ (Merck). The experiments were carried out by batch techniques. The amount of adsorbed uranium was determined from the difference between the initial and final concentrations of uranium in aqueous solution by using Shimadzu UV-Vis 260 Recording Spectrophotometer. The uranium adsorption capacity of activated carbon was determined as 0.21 UO_2^{2+} mmol/g. In the second step, we have investigated the parameters which effect the uranium adsorption; such as pH, uranium concentration, shaking time, particle size, temperature, amount of adsorbent,. For this purpose, TOPO/DBM method was used to determine uranium in aqueous solution.

1. Activation with $ZnCl_2$ (w/w 1:1 and 1:2)
2. Carbonization (500-600-700°C)

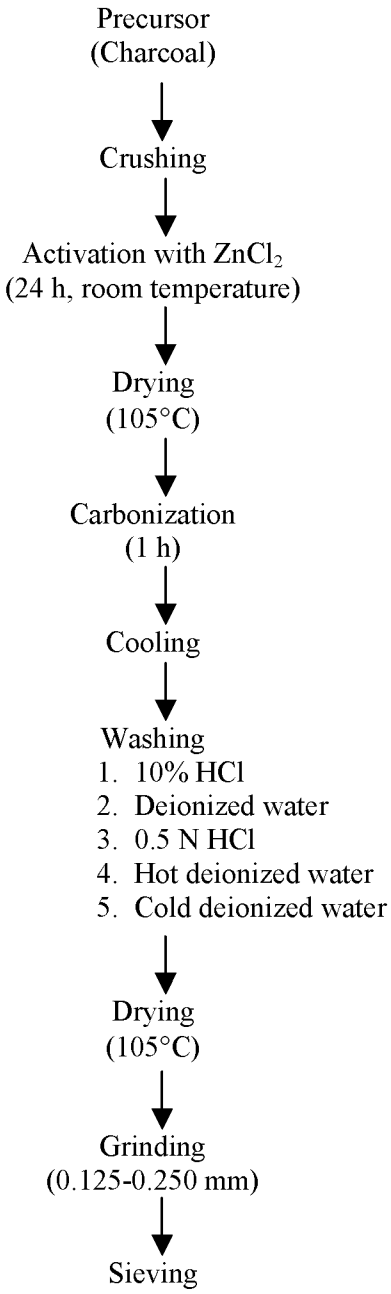

Fig. 1. Flow sheet of preparing activated carbon.

RESULTS AND DISCUSSION

The parameters which effect the uranium adsorption were investigated by using activated carbon prepared in determined laboratory conditions. First, the most important parameter for the adsorption experiments, effect of pH was examined in the pH range of 2 to 8. Then, the effect of concentration was studied by using five different uranium solutions varying initial concentrations from 50 to 200 ppm. Different intervals of time ranging from 5 minutes to 8 hours were examined to determine the effect of shaking time. After that, the particle size and temperature effect were studied. 30, 50 and 70°C were applied to observe the effect of temperature. Lastly, amount of adsorbent was examined for 0.1, 0.5 and 1.0 g. As a result of these experiments, the optimum conditions were found as: pH=5, 50 ppm uranium concentration, 4 hours shaking time, <0.125 mm particle size, 30°C temperature, 0.1 g charcoal. These determined conditions were applied and the uranium recovery efficiency was found as 92.10±4.32%.

These results show that activated carbon which is prepared in our laboratory conditions can be treated for uranium recovery from aqueous solutions. We are of the opinion that, further studies are necessary for the determination of the applicability the method on the real solutions. For this purpose, matrix effects and the desorption behavior of uranium adsorbed on activated carbon should be studied.

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