J. At. Mol. Sci.
doi: 10.4208/jams.100809.112309a

Vol. **1**, No. 4, pp. 292-300
November 2010

Adsorption of cesium, thallium, strontium and cobalt radionuclides using activated carbon

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Received 8 October 2009; Accepted (in revised version) 23 November 2009
Published online 2 August 2010

Abstract. Adsorption studies of Cs^{+}, Tl^{+}, Sr^{2+} and Co^{2+} on activated carbons from aqueous solutions are reported. The carbon samples were characterized using different techniques. The chemical nature of the surface of the activated carbon was studied. Optimal conditions for adsorption of the metal ions have been identified. The comparative study for the metal ions was also considered in the presence of different anions. The data suggest the possible use of activated carbons for preconcentration and separation of some cations.

PACS: 07.88.+y , 07.89.+b, 68.43.-h

Key words: radionuclides, activated carbon, batch technique, adsorption

1 Introduction

Adsorption is a significant phenomenon in many physical, biological and chemical processes. It is a process in which the molecules or atoms of one phase interpenetrate nearly uniformly those of another phase to form a solution with it. The material that concentrated or adsorbed to surface is called the adsorbate while the adsorbing phase is termed the adsorbent. There are many substances which can be used as adsorbents such as fly ash [1], metal oxides, zeolites, biomass [2], goethite, pyrite fines, hydroxides [3], clays, peanut hulls [4], sand and active carbon [5, 6]. Because of their large surface area and their high degree of surface reactivity, active carbons are regarded as very good adsorbents for the removal of both organic [7–9] and heavy metal contaminants and can be used in a number of possible technological and analytical applications.

The presence of heavy metals in the environment is a major concern due to their toxicity to many life forms. In the past few years there has been a manifest interest in the

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adsorption process in solution because these processes play an important role in phenomena such as the environmental transport of heavy metals [10, 11], analytical separations [12] and preconcentration of metals present in trace amounts [13].With the increase in the number of nuclear power reactors, the radioactive pollution of water is growing, this problem could be alleviated by means of suitable adsorption processes, also activated carbons are used extensively as adsorbents of different compounds [14]. Factors affecting the adsorption process, e.g., pH, activated carbon dosage, contact time, initial metal concentration and solution temperature were studied [15]. Single copper and nickel adsorption from aqueous solutions onto a granular activated carbon were reported. The present paper reports the results of a study of the adsorption of Cs^{+}, Tl^{+}, Sr^{2+} and Co^{2+} radionuclides from aqueous solutions on three activated carbons, two of them were obtained from almond shells and the other one (sample M) was obtained from commercial sources.

2 Experimental work

2.1 Adsorbents

Two of the three activated carbons used as adsorbents in this study (samples A-8 and A-14) were prepared using almond shells as raw material. The activation step was carried out in a flow of carbon dioxide (75 $cm^3 \cdot min^{-1}$) during heating at 1123 K (heating rate= 5 $K \cdot min^{-1}$) for 8h (sample A-8) and 14h (sample-14). The activated carbons were characterized using various techniques such as surface area, pore volume and base neutralization capacity. Their textural properties were determined from adsorption measurements of CO_2 at 298 K. From adsorption data, surface area and micropore volume were obtained with aid of the Dubinin-Radushkevich equation [16]. The volume of mesopores and that of the macropores were determined independently using a Carlo Erba mercury porosimeter, model 200. The pH of the three carbon samples was measured in a suspension of 1 g of the carbon in 100 cm^3 of CO_2 free distilled water, the contact time was 48h and the temperature was 298 K. The base neutralization capacity of the carbons was determined with a 0.1 M NaOH solution. Ash contents were obtained after burning in air at 973 K for 3 h.

2.2 Adsorption measurement

The adsorption of metal ions by the activated carbons was followed by adding 0.1 g of carbon to a vial containing 4cm^3 of an aqueous solution of the corresponding radioisotope. The radioisotope (^{60}Co) used in this study were supplied by Hot Laboratories Centre-Egyptian Atomic Energy Authority and ^{82}Sr and ^{202}Tl radioisotopes was supplied by Cyclotron Project-Egyptian Atomic Energy Authority and in this study, I used inactive CsCl solution with concentration 7 M. The amount of carbon and the volume of aqueous solution in all adsorption measurements were kept constant except where