

ADSORPTION OF STRONTIUM ON CARBON-MINERAL ADSORBENTS

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INTRODUCTION

In recent years much attention has been devoted to environmental problems. For Ukraine this issue became vitally important especially after the Chernobyl accident, when large territories were contaminated with radioactive elements and heavy metals. Now long-lived radioactive isotopes of cesium and strontium are most hazardous pollutants for human. Continuous entrapment of these isotopes in human organism leads to decrease of immune system and sharp increase of ecologically dependent diseases. One of the most effective methods of improvement of ecological situation is sorption technology applied for cleaning of drinking water, physiological liquors or foodstuffs. Efficiency of these methods is crucially dependent on selectivity of adsorbents. Most selective adsorbents for strontium binding are various compounds of antimony, zeolites, oxides of titanium etc.

In present paper the strontium binding properties of new titanium-silicate carbon-mineral adsorbents were studied.

EXPERIMENTAL

Carbon-mineral adsorbents used in this study were prepared by impregnation of synthetic (SCN) and fruit shell (KAU) active carbons with solutions of titanium and silica compounds. These modifying compounds have been chosen for their low expected toxicity and good adsorptive properties of titanium oxides.

Strontium binding on carbon-mineral adsorbents have been investigated in physiological solution (NaCl - 154 mM) and in Ringer solution (NaCl - 154 mM, KCl - 5.63 mM, CaCl₂ - 2.16 mM, NaHCO₃). Solid : liquid ratio was 1 : 200. Strontium concentration was measured either titrimetrically (EDTA) or radiometrically (⁹⁰Sr).

RESULTS AND DISCUSSION

Introducing of titanium and silica oxides into active carbon changed the porous structure of adsorbents (Fig.1, 2). Mineral part was deposited mainly in pores having the radius less than 500 nm for both types of active carbon. Modifying of active carbon resulted in decreasing of porosity. Sorption volume of pores (V_g) was decreased on ca 30%. Most pronounced changes were observed for surface area (Tab.1). Total quantity of mineral part in carbon-mineral adsorbents amounts 11-12 %.

Tab.1. Characteristics of active carbons and carbon-mineral adsorbents.

Adsorbent	V_g , cm ³ /g	Ash, %	Bulk density, g/cm ³	Surface area, m ² /g
SCN	0.98	0.4	0.40	682
SCN-mod	0.68	11.5	0.50	196
KAU	0.73	0.4	0.45	615
KAU-mod	0.5	12.4	0.50	89

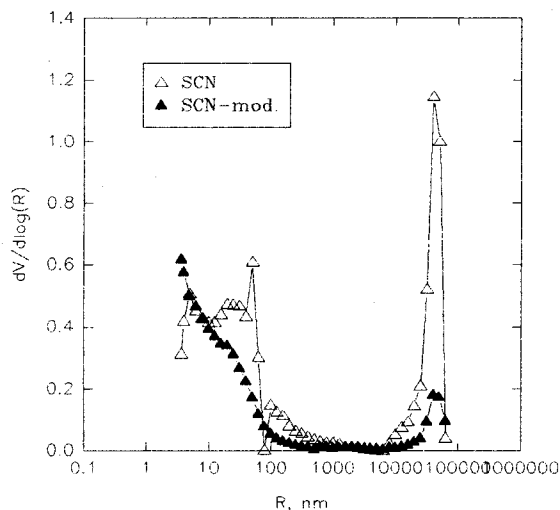


Fig.1. Pore size distribution in synthetic active carbon SCN and carbon-mineral adsorbent SCN-mod obtained by mercury intrusion method.

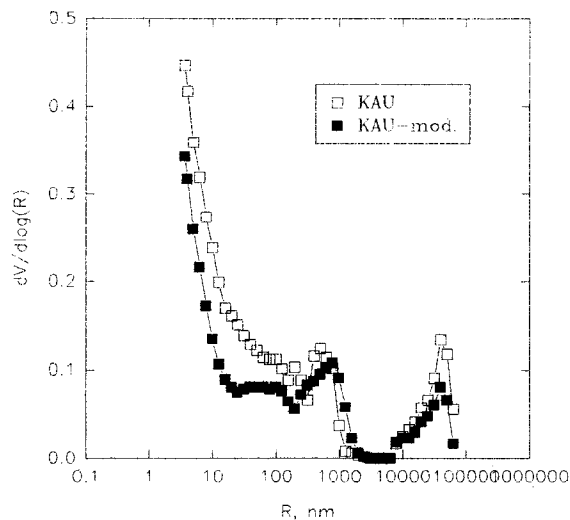


Fig.2. Pore size distribution in fruit shell active carbon KAU and carbon-mineral adsorbent KAU-mod obtained by mercury intrusion method.

Variations of the strontium capacity with the equilibrium pH at relatively high concentration of strontium (<5 meq/l) in physiological solution is shown on Fig.3. The adsorption capacity was steadily increased with increase of pH, which is characteristic for weakly acidic ion exchangers. Maximum adsorption amounts up to 0.5 meq/g.

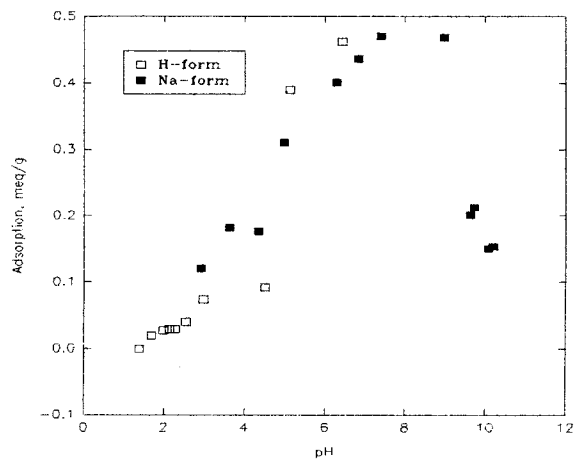


Fig.3. pH-dependence of Sr adsorption on carbon-mineral adsorbent SCN-mod from physiological solution ($C_0=5$ meq/l) on carbon-mineral adsorbents.

The distribution of ion species present at low concentrations, when another ion species is present in large excess is of great interest in adsorption of tracer amounts. The adsorption of strontium at tracer conditions has been analyzed using equation:

$$\log K = C + n \cdot \text{pH}$$

where K_d - distribution coefficient, C - constant, n equal to charge of adsorbed ions. This equation implies that the distribution coefficient for the trace ion [Sr] is independent of its concentration for a given concentration of the gross component [H^+]. This means that the uptake of the trace ion is directly proportional to its concentration in the external solution, i.e., the sorption isotherm is linear under trace conditions.

pH-dependences of strontium distribution (K_d) between carbon-mineral adsorbent and solution at trace conditions are presented in Fig.4. As might be expected, the K_d values steadily increased with the increase of pH. Calculated charge of adsorbed strontium ions was equal to 0.67 on SCN-mod and 0.76 on KAU-mod. This implies multiple types of strontium adsorption like ion exchange, formation of surface complexes probably with participation of carbonate-ion.

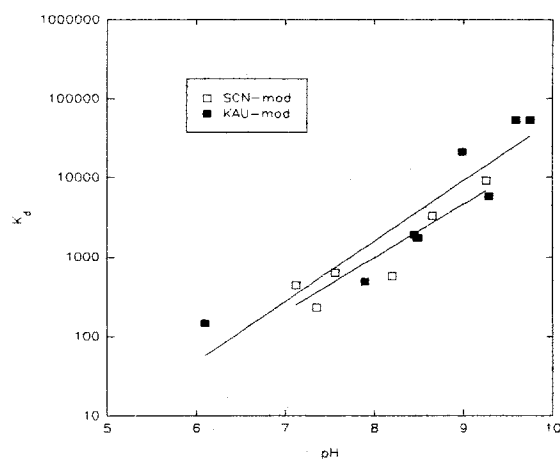


Fig.4. pH-dependence of Sr adsorption at trace conditions from Ringer solution on carbon-mineral adsorbents.

Carbon-mineral adsorbents also showed a high adsorption toward copper from 0.1 M CuSO_4 . Adsorption of copper on carbon-mineral adsorbent KAU-mod was 10 times greater (2.20-2.44 meq/g) than those on oxidized carbon KAU_0 (0.23 meq/g).

CONCLUSIONS

Titanium-silicate carbon-mineral adsorbents may be regarded as promising binding materials for radiostrontium. These adsorbents, having low expected toxicity, could be used for decontamination of drinking water, biological liquors and liquid foodstuffs from strontium and heavy metals.