Magnesium Silicate Functionalized with Sodium-β-Glycerophosphate used for Sr(II), Cs(I), Tl(I) Adsorption

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Abstract
In this research Sr(II), Cs(I), Tl(I) were removed through adsorption using a functionalized solid support, magnesium silicate with sodium-β-glycerophosphate. The influence of the initial concentration of metal in the solution and of the contact time were investigated. The adsorption process runs quickly obtaining the highest adsorption capacity for Sr(I) 7 mg/g.

Introduction
One important problem in using nuclear energy are the nuclear waste, because they contain radioactive elements that are very harmful for the environment and for humans. Two of those elements are the metals Sr(II) and Cs(I). Sr-90 and Cs-137 have long half-lives, 28 years, 30 years, respectively, and are contained in acidic high level liquid waste [1]. Being heat emitting nuclides [2] and a source of β-radiation [3] it is necessary to remove them from the radioactive waste. Advantages of removing Sr(II) and Cs(I) are: stability of vitrified waste, reduction in the need of redundant cooling of the waste solution [2]. Removal treatments frequently used for removal of radionuclides from liquid radioactive waste include chemical preparation, evaporation solvent extraction and ion exchange process [4].
Another toxic metal is thallium. Tl(I) is widely distributed in all environmental media [5]. It is used in many industries like: manufacture of imitation jewelry, thermometers, ceramic semiconductor material, alloys and electronic devices [5]. Thallium compounds are very toxic and are used as insecticides and rodenticides [6]. Its toxic effects are more severe than other metals like mercury, lead, copper and cadmium [6].

Experimental
Adsorption experiments were carried out in other to determine the equilibrium concentration of the metals on the adsorbent material and to study the influence of the contact time between the metal solution and the solid material.
For this, the adsorbent material was functionalized using the dry method. For 24 h, 5 g magnesium silicate were kept in contact with 0.01 g sodium-β-glycerophosphate dissolved in 25 mL ethyl alcohol. It was dried at 323 K for 24 hours. The obtained functionalized adsorbent material was characterized by energy dispersive X-ray analysis (EDX) and scanning electron microscopy (SEM), using a scanning electron microscope Quanta FEG 250, equipped with energy dispersive X-ray quantifier.
The influence of the initial metal (Sr(II), Cs(I), Tl(I)) concentration and of the contact time on the adsorption capacity was investigated. Solutions with different metal concentration (10, 50, 100, 150, 200 mg/L) were prepared through dilution from a stock solution of the concentration 1 g/L. 25 mL of each solution with different concentration with were put over 0.1 g adsorbent material and mixed for one hour using a Julabo SW23 mechanical shaker bath at 200 rot/min and 298 K. The samples were filtrated and the metal concentration was analyzed.
For the influence of the contact time samples of 0.1 g adsorbent material were mixt with 25

mL metal solution having the concentration of 10 mg/L. The concertation of the metal in the filtrate was analyzed after 15, 30, 60, 90, 120 minutes of mixing. The metal concentration was analyzed using an inductively coupled plasma mass spectrometry ICP-MS Bruker Aurora M90.

Results and discussion

Characterization of the functionalized material support

In other to ascertain if the solid support used, magnesium silicate, was successfully functionalized with sodium-β-glycerophosphate, the obtained adsorbent material was characterized by energy dispersive X-ray analysis (EDX) and scanning electron microscopy (SEM). Figure 1 and Figure 2 show the morphology and the EDX spectrum of the functionalized material, respectively.

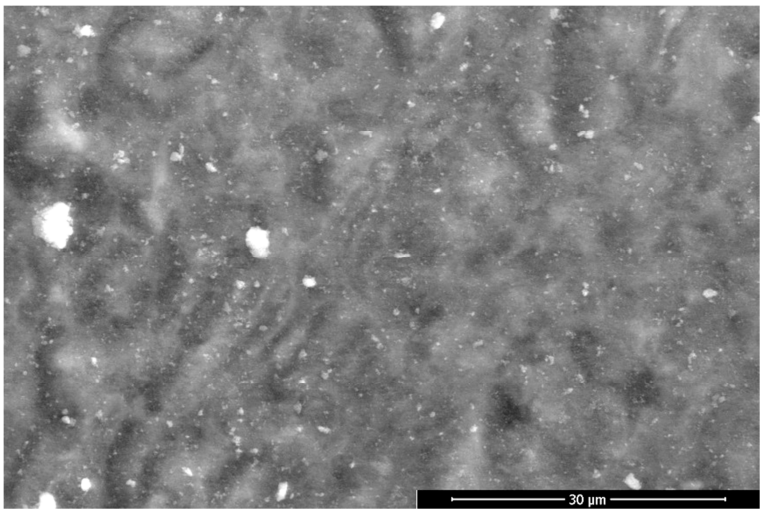

Figure 1. SEM image of the obtained material

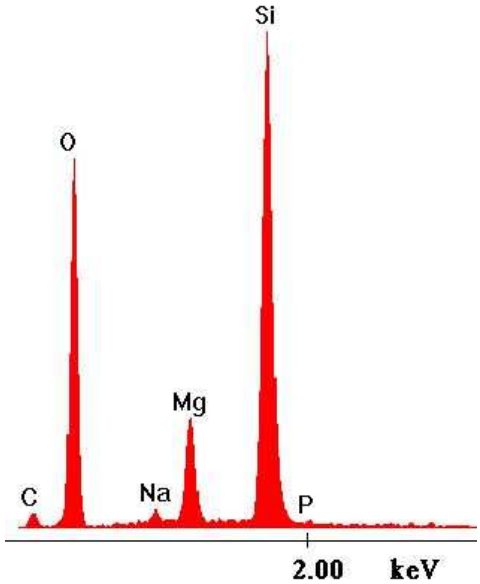

Figure 2. EDX spectrum of the obtained material

On the surface of the solid support with spots are to be observed. These are associated to the extractant used for improving the adsorbent proprieties of the material. Peaks of specific elements of the extractant, like Na, P, C are also visible on the EDX spectrum.

Influence of the initial metal concentration and contact time

The experimental data regarding the influence of the initial metal concentration and the contact time on the adsorption capacity of the functionalized material were collected and described in Figure 3 and 4, respectively.

The adsorption capacity was calculated from the experimental data using the following equation:

$$q = \frac{(C_0 - C_t)V}{m} \quad (1)$$

where C_0 is the initial metal concentration (mg/L), C_t the equilibrium concentration of the filtrated at time t (mg/L), V is the volume of metal solution (L), m is the amount of solid support (g).

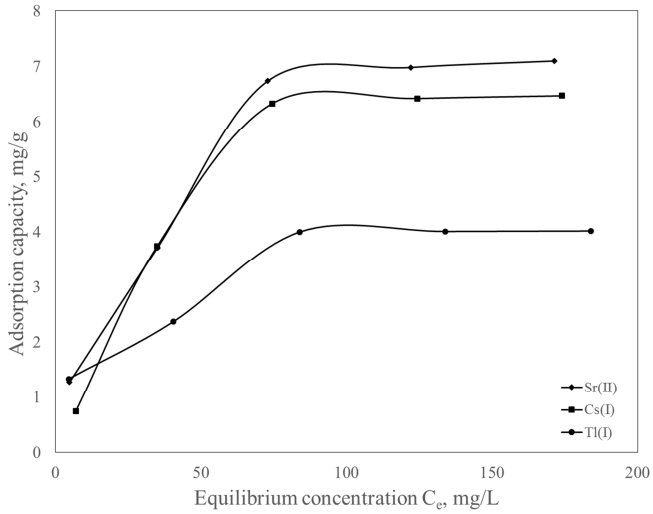

Figure 3. Adsorption isotherm of the studied metal ions on the functionalized material

It can be observed from Figure 3 that by increasing the initial concentration the adsorption capacity increases until reaching a constant value. The highest adsorption capacity obtained was for Sr(II) 7 mg/g, then Cs(I) 6.4 mg/g and the lowest for Tl(I) 4 mg/g.

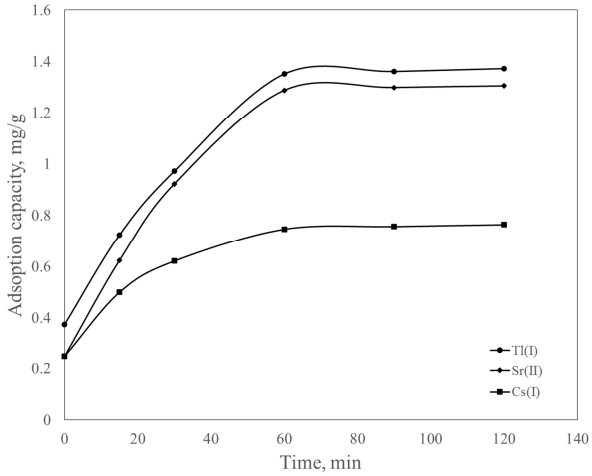

Figure 4. Influence of the contact time on the functionalized material

The influence of the contact time was also investigated. It occurs that the adsorption capacity

increases with increase of the contact time of the solid support with the metal ion solution (Figure 4). The equilibrium adsorption capacity is reached after 60 minutes of contact, which means that the adsorption process of the studied metal ions (Sr(II), Cs(I), Tl(I)) for the obtained functionalized material happens relatively quickly.

Conclusion

The metal ions Sr(II), Cs(I), Tl(I) were removed from aqueous solution using the adsorption method. A new adsorbent material was used namely magnesium silicate functionalized with sodium-β-glycerophosphate. The SEM and EDX analysis reveal a successfully functionalization of the solid support. High adsorption capacities were obtained for Sr(II) 7 mg/g, then Cs(I) 6.4 mg/g and lower for Tl(I) 4 mg/g. Studying the influence of the contact time between the adsorbent material and the metal ion solution results that the adsorption process of the studied metal ions runs quit quickly, reaching the equilibrium adsorption capacity in 60 minutes.

References

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