ADSORPTION OF CESIUM AND COBALT ONTO NANOCOMPOSITE BASED ON CLAY, GRAPHENE OXIDE AND MAGNETITE/MAGHEMITE

Raman Novikau, Galina Lujanienė, Vidas Pakštas, Martynas Talaikis,
Audrius Drabavičius, Arnas Naujokaitis, Sergej Šemčuk

Lithuania, Vilnius, Savanoriu Str. 231, raman.novikau@ftmc.lt

CENTER FOR PHYSICAL SCIENCES AND TECHNOLOGY

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Introduction

Nuclear weapons tests, man-made disasters, for example, at the Chernobyl and Fukushima-Daiichi nuclear power plants, as well as unintentional leaks, spills during the operation of nuclear facilities lead to environmental pollution with radionuclides and, as a consequence, a violation its integrity and negative impact on human health. It is assumed that clay minerals and their composites play an important role in protecting the environment from the negative effects of radionuclides. Nowadays, clay minerals in terms of adsorption efficiency are not inferior to commercial adsorbents, and in some cases even surpass them. Clays are actively modified in order to increase their efficiency and selectivity in relation to pollutants.

Aim. The aim of this study was to develop a Clay-Graphene Oxide (GO)-Magnetite (MG)/Maghemite (MGH) nanocomposite, as well as to study the adsorption behaviour of cesium and cobalt on this nanocomposite.

Study design

The synthesis:

1.The **GO** was obtained by the Hummers method;

2.The **MG/MGH** by a co-precipitation reaction of ferrous and ferric ions.

3.The synthesis of nanocomposites (**Clay-GO-MG/MGH**). The triassic clay (Šaltiškiai in North Lithuania) was treated with 0.5 M HCl solution while for synthesis both treated and untreated clays were used. The synthesis of the composite included dispersing GO and MG/MGH in an ultrasonic bath for 2 h, followed by the addition to acid-treated (ATC) or untreated clay (UTC) to the solution, keeping the mixture under constant stirring in a flow of argon for 1.5 hours, at 60 °C. Then this mixture is centrifuged, the resulting composite is taken and dried in vacuum for 24 hours.

Four composites were obtained, (%):

Sample 1 - ATC (43.48)-GO (13.04)-MG/MGH (43.48);
Sample 2 - ATC (66.67)-GO (16.67)-MG/MGH (27.78);
Sample 3 - UTC (43.48)-GO (13.04)-MG/MGH (43.48);
Sample 4 - UTC (66.67)-GO (16.67)-MG/MGH (27.78).

The characterized of composites: X-ray diffraction analysis (**XRD**); X-ray fluorescence analysis (**XRF**); Scanning electron microscope (**SEM**); Transmission electron microscope (**TEM**); Fourier-transform infrared spectroscopy(**FTIR**).

Condition of primary adsorption test of Cu(II): Copper concentration 0.001 mol/l; adsorbents dose - 0.01 g; the volume of each sample is 10 ml; pH = 6.5; T = 19 °C; time of adsorption: 24 h. Analyzing the concentration of copper in solution after adsorption was by the inductively coupled plasma optical emission spectrometer **(ICP-OES).** Analyzed volume – 8 ml.

The test for the adsorption behaviour of Cs(I) and Co(II) on composite included: Depending on the concentration of the adsorbent and adsorbate, pH, temperature, contact time, as well as the adsorption of these metals in a binary system. Analyzing the concentration of Cs(I) and Co(II) after adsorption, a gamma spectrometer was used. Previously, 1 ml of radioactive tracers was added to the samples before adsorption. Analyzed volume – 8 ml.

Note: Adsorption tests were carried out on sample 4.

Results

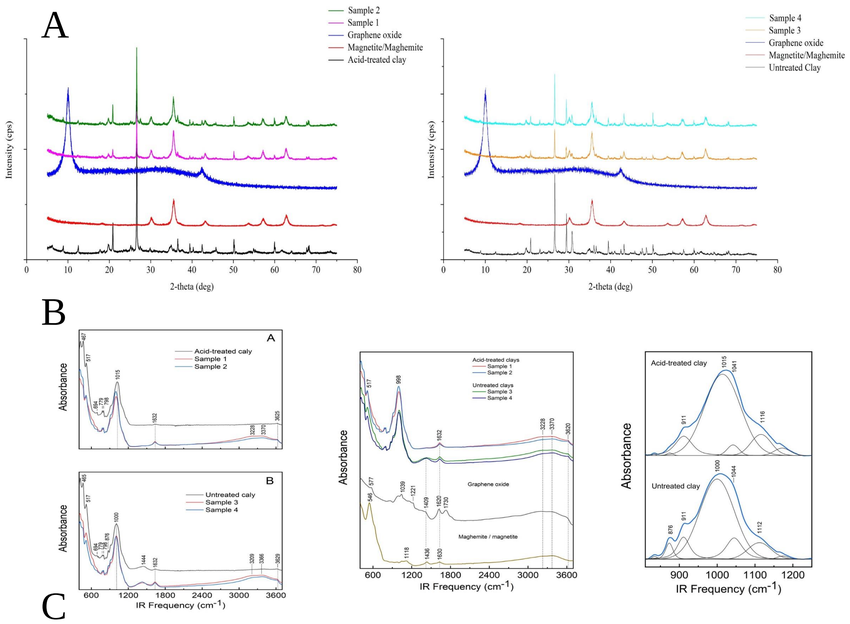

Fig. 1. Characterization of composite : A – XRD spectra; B – FT-IR spectra; C – SEM (a), TEM (b).

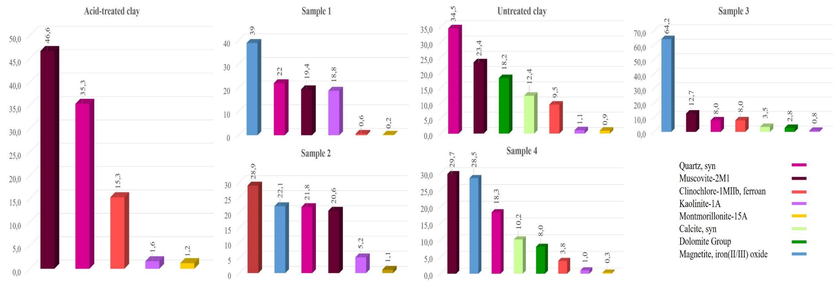

Fig. 2. Mineralogical composition of clay and composites, %.

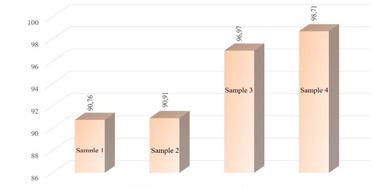

Fig. 3. Adsorption efficiency of Cu(II) onto composites, %.

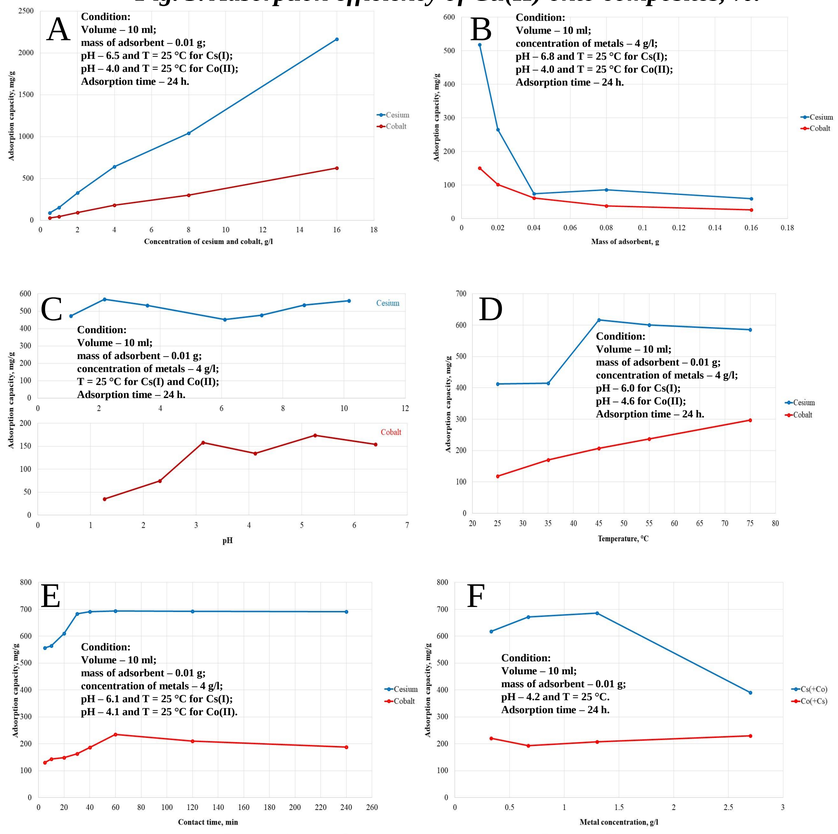

Fig. 4. Adsorption of Cs(I) and Co(II) depending on: A – concentration; B – mass of adsorbent; C – pH; D – temperature; E – contact time. F – adsorption of binary-metal system.

Conclusion

According to the results of the study, we found that the best adsorption of Cs(I) was in acidic and alkaline media, the maximum adsorption of Co(II) achieved at pH 5, and at pH > 5, the complexation process prevails. In addition, the adsorption process is endothermic, the adsorption equilibrium is reached within 30 minutes, also in a binary-metal system, at equal concentrations of Co(II) and Cs(I) in the medium, Co(II) reduces the adsorption of Cs(I), while Cs(I), in turn, does not affect the adsorption of Co(II). Thus, the resulting composite proved to be effective in adsorption of Cs(I) and Co(II), where the maximum adsorption capacity was 2165 mg/g and 627 mg/g.