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GEOPOLYMER FROM DOMESTIC WASTE PRODUCTS FOR THE MANAGEMENT OF LIQUID RADIOACTIVE WASTES.

L. FUKS, I. HERDZIK-KONIECKO, A. MIŚKIEWICZ, G. ZAKRZEWSKA-KOŁTUNIEWICZ

Institute of Nuclear Chemistry and Technology, Dorodna 16, 03-195 Warsaw, Poland

Geopolymers (GPs) are inorganic materials formed by reacting aluminosilicate sources (metakaolin, fly ash, slag) with alkaline activators. The simple process consists of mixing liquid waste with aluminosilicate materials (fly ash, metakaolin, slag) and alkaline activators before curing. They form three-dimensional networks of Si-O-Al bonds in an amorphous to semi-crystalline structure. Unlike traditional cement's calcium-based chemistry, geopolymers rely on silicon-aluminum chemistry and cure at ambient temperatures while providing excellent thermal stability, chemical resistance, and mechanical strength.

Benefits of the geopolymers' production:

- ✓ 80% less CO_2 than cement
- ✓ Recycles industrial waste (fly ash, slag)
- ✓ Low energy (ambient curing i.e. below 1450°C)

Geopolymers manage liquid radioactive waste by developing stable aluminosilicate networks that immobilise radionuclides.

Their advantages include chemical durability and compatibility with diverse waste streams, including those with high salt content. Compared to conventional cement, geopolymers offer higher waste loading capacity, better leaching resistance, and reduced final waste volumes while maintaining strong mechanical integrity without requiring high-temperature treatment.

Synthesizing geopolymers from sand and liquid glass

Materials:

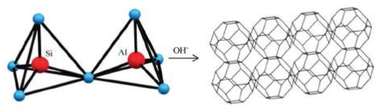
- ✓ sand (SiO_2)
- ✓ liquid glass (sodium silicate/Na_2SiO_3)
- ✓ alkaline activator (NaOH or KOH)
- ✓ aluminum source (metakaolin, fly ash, or $Al(OH)_3$)

Process:

- ✓ mix fine sand with an aluminum source
- ✓ prepare activating solution (liquid glass + alkaline solution)
- ✓ combine materials and mix thoroughly
- ✓ allow to cure (room temperature or 60-90 °C for ~24 hours)

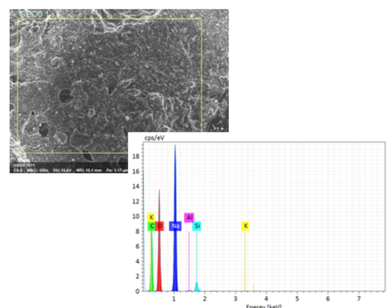
Key Points:

- ✓ sometimes pure sand alone does not work (lacks aluminum)
- ✓ Si/Al ratio, alkali concentration, and curing conditions affect quality
- ✓ an aluminosilicate 3D network is formed from the Si-O-Al and Si-O-Si clusters with a Si/Al ratio of 1:1 to 1:3



Schematic of the spatial geopolymer network

Analytical confirmation of synthesis



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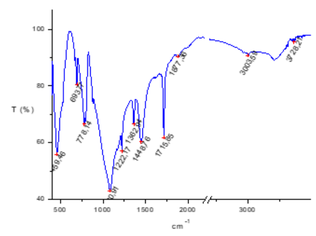


IR spectrum

Sample	Zeta potential [mV]	
Geo Na	pH = 5.7	pH = 10
	- 49.0	- 51.5

Zeta potential

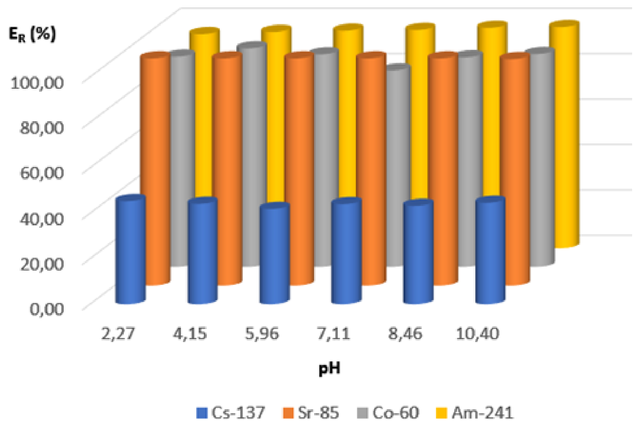
Sorption tests of the geopolymer

The geopolymer obtained under optimum conditions was subjected to the tests of the radiometal binding ability.

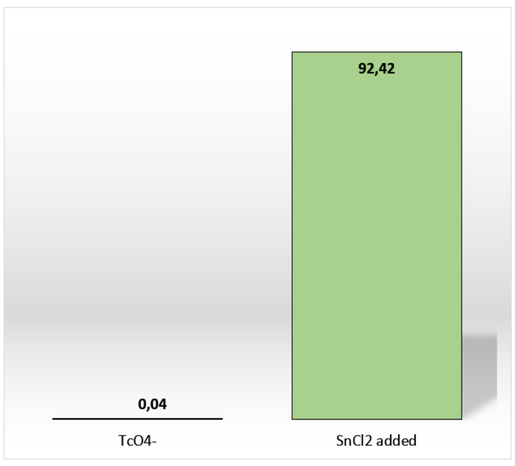
- ✓ Sorption tests consisted of spiking the working solution with the radionuclides forming the carrier-free concentration and adjusting it to the desired pH.
- ✓ Except for the sorbent mass dependence experiments, 50 mg of the zeolite placed in the polyethylene test tubes was mixed at room temperature with 5 mL of the radioactive solutions by shaking for 3 hrs.
- ✓ In the following, the suspensions were separated by centrifuging, and the aqueous phases were withdrawn for measurement of the specific concentration of the radionuclides.

Results

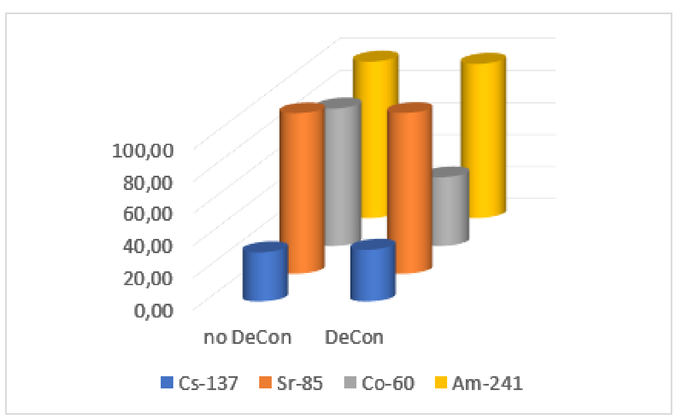
- ✓ Mono-, di-, and trivalent metallic radionuclides were represented by Cs-137, Sr-85, Co-60 and Am-241 cations.
- ✓ We have also tested the affinity of our GP towards technetium-99m, occurring as TcO_4^- anion in aqueous solutions.
- ✓ In addition, the influence of the solution acidity and salinity, the presence of metal complexing agents always present in the decontamination liquids, was also checked.



Water purification from the radionuclides (%) by batch sorption with Na-GP



Water purification from TcO_4^- (%) by batch sorption with Na-GP



Water purification from the radionuclides (%); influence of the decontamination liquor

Conclusions

The results show that GP obtained from the easily available domestic materials can be successfully used as a matrix for storing liquid radioactive waste. Long-term tests of leaching radionuclides from the matrix are ongoing under the IAEA procedure. Preliminary results are promising.

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