Inhibition of Spent Ion Exchangers in Geopolymer Matrix

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Definition of the problems

- Spent radioactive ion exchangers are gathered in area of nuclear power stations in storage tanks under water level.
- Limited capacity requires their further deposition.
- Spent ion exchangers change their volume when dried and expand when watered.
- Storage of spent ion exchanger after their solidification and inhibition should be economically reasonable which means that one important condition is to fix maximum quantity of spent ion exchangers into the solid matter.

Previous proves and tests

- Hanzlicek T., Steinerova M., Straka P.: „**Immobilization of Toxic Metals in Solidified Systems of Siloxo-Sial Networks**“ Journal of American Ceramic Society, Vol. 89 (11) pp. 3541-3543, 2006.

- The main aim of the above mentioned paper was to verify that the metals could be chemically bound to the geopolymer network and even the samples were finely crushed (< 0.2 mm) the leaching water did not contain detectable quantities of metals.

- The study employed radioactive tracers of ^{152} **Eu**, ^{134} **Cs**, ^{60} **Co** and ^{59} **Fe** in soluble forms applied directly to the formatted geopolymer.

- Leaching tests in water prove that 99,9 % of radioactive tracers are incorporated into the geopolymer netting. Leaching in sulfuric acid conditions (0,25 M) - the inhibition of radioactive tracers is about 40 %.

Following control tests

- The geopolymer matrix acquired by alkali aqueous reaction with activated clay was tested when soluble form of sodium or potassium was substituted by cesium carbonate:

- The solidified stabile geopolymer was obtained by cesium instead of commonly used sodium or potassium,
- That means that cesium is chemically bind to the alumina-silicate network and equilibrate the electro-negativity of aluminum tetra-coordinated ions.

Complementary proves

- Solidification of geopolymer matrix was proved also by use of D_2O instead of water, when alkali aqueous solution was alternated by alkali solution in D_2O.
- Samples of a solidificated matter are insoluble in water with very hard surface and as in cases with water any separated liquid or partially decomposition of a solid was observed.
- Means that eventual presence of deuterium in radioactive wastes will not bother the solidification of geopolymer matrix.

The assays with spent ion exchangers

- Spent ion exchangers with 50 % of water were added directly to the geopolymer mixture in quantities starting at 10 wt.% and ended at 50 wt.%.
- In all cases the solidification is successful but immediately when submerged in water the samples were disintegrated into the small particles of matrix with visible ball shaped ion exchangers.

- Problems are:
  - in homogenous distribution which is caused by different specific weight of geopolymer matrix and ion exchanger,
  - changes in volume of ion exchanger (dried x watered).

Offered solution

- The problem of shrinkage and extensions of a spherical shaped exchangers was resolved by their disintegration by friction mill.
- The homogenization of disintegrated particles in geopolymer matrix was reached more effectively.
- The prepared series containing 14.8 wt.% ,17.2 wt.% and 22.7 wt. % of milled spent ion exchanger in geopolymer matrix resist the water submersion – no crack or fissures were observed.
- Next series of samples were prepared with foamed geopolymer matrix with idea to allow the extended volume of spent ion exchangers penetrate into the free space of foamed matrix. In that case there is no disintegration of submerged samples but its necessary mentioned the growth of volume of the final material.

Conclusion

- Even the tests proved inhibition of radioactive metals, deuterium and cesium instead of water and instead of common alkali metals in geopolymer matrices the laboratory knowledge were not transferred to the industrial exploitation.
- The offered inhibition of spent ion exchangers is blocked by the recognition that after waste inhibition the products are also radioactive and 5 times over weights the original quantity of radioactive waste.
- Even the leaching tests were successful and geopolymer is more efficient in encapsulation of radioactive metals (proved by ^{134}**Cs**) than commonly used concrete, the applied norms do not recognize geopolymers.

Thank you for attention