ATALANTE 2016 – Nuclear Chemistry for Sustainable Fuel Cycles

Structural characterization of geopolymers for the safe disposal of the fission products ^{137}Cs and ^{90}Sr

Simone Weigelt[a,*], Hartmut Schlenz[a], Anna König[b], Henrike Heise[b], Dirk Bosbach[a]

[a]*Forschungszentrum Jülich GmbH, Institute of Energy and Climate Research, IEK-6: Nuclear Waste Management and Reactor Safety, D-52425 Jülich, Germany*

[b]*Forschungszentrum Jülich GmbH, Institute of Complex Systems, ICS-6: Structural Biochemistry, D-52425 Jülich, Germany*

Abstract

Geopolymers are inorganic materials owning a high variability in structure and composition. Their resistance against heat and chemical attacks implies a high potential regarding their use as nuclear waste forms. First irradiation experiments by Lambertin *et al.* (J. Nuc. Mat. 2013, 443, 311-315) and Deng *et al.* (J. Nuc. Mat. 2015, 459, 270-275) confirmed a relatively high radiolysis resistance.

Metakaolin based geopolymers are aluminosilicates with structural features of a three-dimensional network. The negative charges arising from partial substitution of tetravalent Si by trivalent Al are preferably balanced by alkaline and alkaline earth cations. Therefore a durable encapsulation and immobilization of the extremely mobile radionuclides ^{137}Cs and ^{90}Sr is anticipated.

For structural characterization we synthesized geopolymers with varying chemical composition by mixing different metakaolin and kaolin powders with amorphous silica and alkaline solutions containing Na, K, Rb and Cs, or Ca and Sr, in different ratios, respectively. Additionally the water amount used for the syntheses was varied, as well as temperature and duration of thermal treatment during sample setting. Samples were characterized by XRD, Raman, IR and MAS-NMR spectroscopy, as well as SEM (EDX) and TG-DSC. MAS-NMR data show an evolution of the geopolymers' structure that depends strongly on synthesis parameters and composition. Inversion recovery studies reveal two different Cs species with very similar signal positions, but different longitudinal relaxation times and therefore different magnetic vicinities. This might suggest mobile as well as immobile cation species.

Keywords: Geopolymer; inorganic polymer; fission products; structure

* Corresponding author. Tel.: +49-2461-61-9358; fax: +49-2461-61-2450.
E-mail address: s.weigelt@fz-juelich.de.