APPLICATION OF POLYSILOXANES FOR THE TREATMENT OF RADIOACTIVE WASTE TO GUARANTEE SAFE LONG-TERM STORAGE

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ABSTRACT

The application of tailor-made "Silicon-based Geopolymers" for the treatment of radioactive waste seems to be a good choice to guarantee a safe long-time storage under the special demand of a fire resistant, radiation resistant, non corrosive and environmental clean material. Special materials from the group of the "Polyorganosiloxanes" showed high physical, chemical, radiological and mechanical stability under different conditions and have been considered.

Investigations were carried out at different base materials of Polyorganosiloxanes which supplied results with regard to thermal stability, radiation resistance, mechanical properties (adhesion, cohesion), permeability of Radon and other relevant properties for the acquirements concerning interim storage and final disposal. The results are encouraging further activities in technological application of these materials.

INTRODUCTION

The policy of the German Federal Government orientates onto an interim storage of all radioactive waste (approx. 40 a) until a final repository will exist. The interim storage of low and intermediate level waste requires a stable conditioning of the waste packages, so that a safe handling and transportation into a repository will be possible in 2030 or later.
Demands on the materials and packages for the conditioning result from requirements during waste handling, interim storage, transportation as well as from limiting conditions as they will be expected during a possible final disposal.

Materials from the group of the "Polyorganosiloxanes" show high physical, chemical and mechanical stability under different conditions. These qualities (Fig. 1) point out that Polyorganosiloxanes appear suitable for a conditioning for special application [1].

BASIC SCENARIOS FOR MATERIAL APPLICATION

Reflections on basic demands of material properties under consideration of the scenarios and conditions of safe treatment, handling, interim storage (30 ... 40 a), public transport and final disposal of low and medium level radwaste expected the following parameters:

maximum dose ~35 kGy in material (max. 0.1 Sv/h)
temperature stability (fire simulation 800 °C for 90 minutes)

Special materials from the group of the "Polyorganosiloxanes" show high physical, chemical and mechanical stability under different conditions. The investigated materials (Fig. 2) are free of water, hydrophobic, stable under irradiation, flame resistant and thermostable, resistant against acids and bases, non-toxic and environmental clean. The qualities of the Polyorganosiloxane point out that these materials for a conditioning appear well suitable and promising for special application.

Fig. 1 Main properties of tailor-made Polysiloxane materials
(some properties can be changed in a wide range)

RESEARCH & DEVELOPMENT

The temperature regime for container with radioactive wastes was calculated for wastes containment and sealing. The specific unique properties of Polysiloxanes allow to solve the decontamination, long-term storage and transportation problems of nuclear waste.

Carried out investigations and testing of the Polysiloxane materials have shown that it has the following characteristics and parameters:

In the case of an interim storage time of 40 a we can expect 37 kGy as a maximum dose at low and medium level waste. Investigations with a 1.5 MeV Electron beam with doses between 50 kGy and 800 kGy show no significant mechanical changes in material properties (temperature range of -40 … +20 °C) and no mass loss up to 150 °C. At 400 °C the mass loss is in the range of 2…5%.

Density of 0.3 … 1.5 g/cm^3. Foam has mostly (from 60 to 90 %) closed porosity with the dimensions of pores in the range of 2 … 6 mm.

Material is not ignited and does not burn in open fire, holding its initial shape and dimensions. There is no softening of the material at higher temperatures. In the case of a heat flow with a flame temperature of about 800 ^oC for 1 hour which is supplied to a hypothetical sample behind a metal sheet there will be temperatures in the region of 500 $\pm$ 50 °C.

Polysiloxane are corrosion resistive to decimolar solutions of acids, alkalis and to organic solvents (such as gasoline, benzene, hexane, carbon tetrachloride).

Polysiloxanes does not become radioactive after a long irradiation.

The material does not posses sorption properties in relation to radioactive nuclides.

Due to its chemical structure, the material is hydrophobic and waterproof. It does not swell in the water.

Polysiloxanes has different adhesion properties to concrete, metal, glass. In the case of high adhesion the break-off from a surface is of cohesion character.

The material can be disposed easily after using it. The final product of utilization is SiO_2 powder. Density, plasticity, the duration of film/foam formation and other properties of Polysiloxane material can be varied depending on the requirements for specific applications. The mechanical properties can also be varied over a range from an easily compressible foam-type elastomer to a rubber like solid film.

The synthesis of the material is simple, being realized on the site of application by mixing preliminary prepared components. The polymerization proceeds spontaneously at ambient temperatures (-20 °C … +60 ^oC).

The components of Polysiloxane materials are biologically inert (some application in food industry).

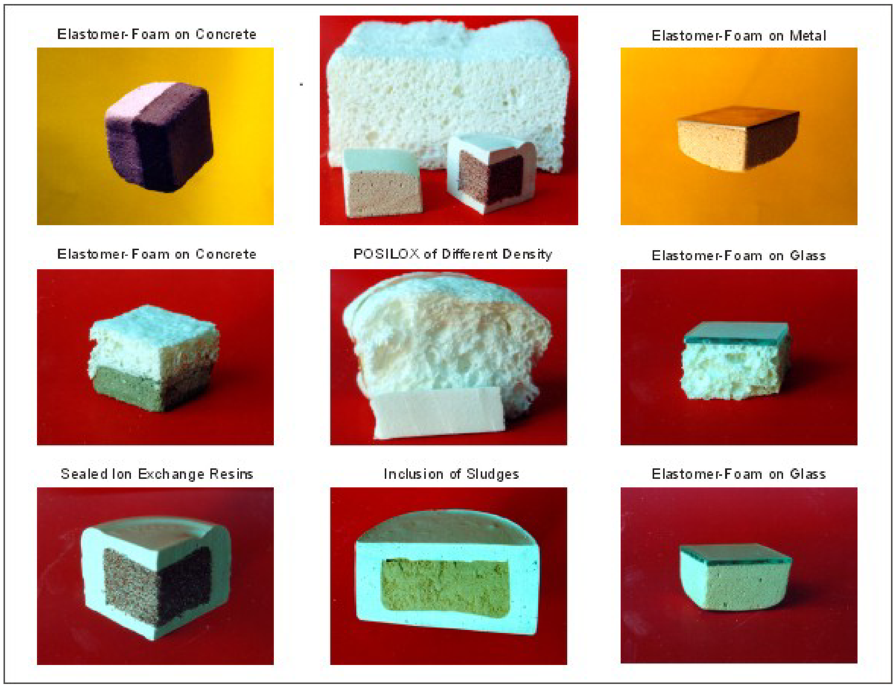

Fig. 2 Different application forms of Polysiloxane samples (rigid, flexible; film, foam, coating, encapsulation, conditioning)

CONCLUSION

The final Product of Polysiloxane application can exist in two specific forms:

foam of a variable density with and without closed pores; in flexible and rigid states;
film of varying thickness.

Polysiloxanes are unique radiation-resistant silicon-organic film/foam-type materials (elastomers) and seems to be a innovative material for treatment, interim storage, transportation, isolation and final disposal of radioactive wastes.

Material synthesis is simple and is achieved at the site of application by mixing of shop prepared components. Film/foam formation and polymerisation of the material proceeds spontaneously “without“ increasing temperature. Time of the final formation can be varied depending on requirements for concrete application of the applied material (from several minutes to 2 days). The material consists of two components and can be prepared for application on or off-site.

Polysiloxanes maintain in the temperature range of –30°C to +200 °C structural and mechanical long-term-stability or flexibility, it does not disintegrate and preserves its structural properties under radiation, incl. alpha-, beta-, n- and gamma-rays, with the absorbed dose up to 1 MGy and higher. Material does not inflame and does not burn, keeping its initial form and dimensions. It is not toxic under the impact of flame.
The long-term-stability is guaranteed in the temperature range of –30°C to 150 °C, at higher temperatures until 500 °C the material mass-loss is less than 10% (in an application case of fire protective measures over a time period of 90 minutes).

The temperature regime for container with radioactive wastes was calculated for wastes containment and sealing. The specific unique properties of Polysiloxanes allow to solve the decontamination, long-term storage and transportation problems of nuclear waste.

The material is ecologically clean, can be easily utilised and easily disposed – no groundwater influence can be expected. The final product of possible degradation results in SiO_2 powder. All the results are encouraging further activities in technological application of these Geopolymers (Fig. 3).

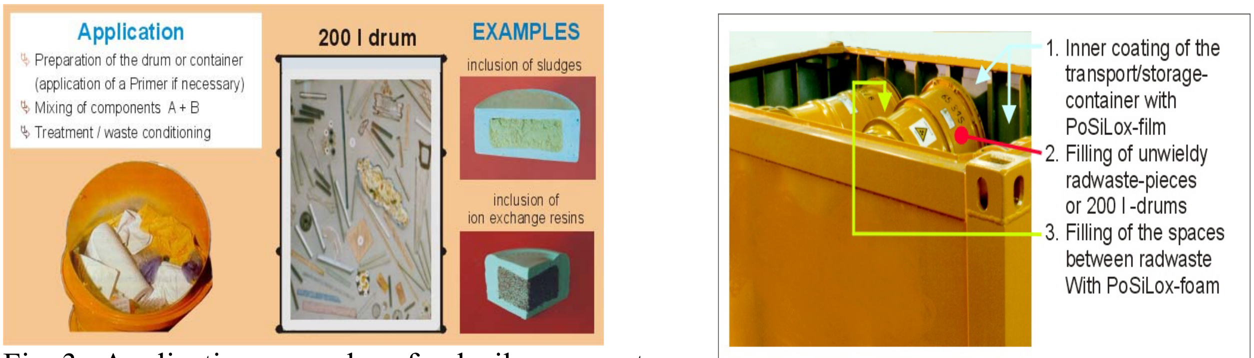

Fig. 3 Application examples of polysiloxane materials for radwaste conditioning

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