CONSIDERATION OF NICKEL ADDITIVES AS A METHOD OF CONTROL OF SHS

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The traditional way of HLW isolation from the biosphere is their immobilization in phosphate and borosilicate glasses of different composition. However, glass does not completely satisfy the requirements to the matrices for the preservation of long-lived radionuclides for a long period of time [1].

There is about 560 million cubic meters of radioactive waste accumulated within the territory of Russian Federation; moreover, 50 % of it is located in temporary storages before further reprocessing. Besides that, 5 million cubic meters of radioactive waste is originated every year.

Along with the improvement of glasses material necessary for long-term HLW disposal in the geological environment, various types of ceramics based on the unique rock-forming minerals with high chemical, thermal and radiation stability are being developed. The basic idea of this method - the inclusion of chemically bound active atoms of radionuclides and toxic waste components in the form of a solid solution into the crystal lattice of the minerals' matrix similar to the stable natural minerals, where such radionuclides exist for thousands of years with the levels of radioactivity or toxicity hundreds of times smaller than if they were in free or mechanically blocked state. Nowadays over 20 compounds differing in capacitance depending on the elements mentioned, chemical and radioactive strength were proposed. These compounds include zircon, zirconolite, perovskite, yttrium-aluminum garnet (IAG), britholite, monazite, pyrochlore.

To prepare the mixture we used industrially manufactured PA-4 aluminum powders and neodymium oxide with a chemical purity grade TU 48 – 4 – 186 – 72.

The initial mixture was prepared for the exothermic reactions:

$$2Ni + 3Al = Ni_2Al_3$$

By heating the initial sample to a temperature of about 500-600 K (depending on the preparation of the initial mixture of components), the combustion wave was initiated at the ends' edges that spread over the sample volume. In this process the temperature increased rapidly, then stabilized, and burning continued almost isothermally under the temperature of 1000-1250 K. After the passage of the combustion wave along the sample volume, it cooled down to ambient temperature of the medium.

Table 1 presents comparative data of x-ray phase analysis of samples at different degrees of dilution of the initial charge.

Experiments have shown that the combustion temperature depends on the nickel additive amount in the initial mixture of reactants. Thus, when the content of additional components in a sample is about 25% wt. there is a significant increase in temperature (up to 2700 K) of the process; in case of 30% wt. – thermochemical degradation of the sample during synthesis for any stoichiometry considered due to significant heat release of the reactions in the mixture.

Thus, by increasing the content of additives amounts up to 25% wt. and compressing pressure of 30 MPa, the content of the modified aluminum-based perovskite based in the samples reaches almost 50 wt.%, and the amount of unreacted neodymium oxide is less than 5% wt.

Table 1. The effect of the degree of dilution of the initial charge on the phase formation.

Образец	**NiAl**	**Ni_2Al_3**	**$NdAl_2$**	**$NdAlO_3$**	**Al_2O_3**
NiAl+20%Nd_2O_3	56,6%	-	26,4%	17%	-
NiAL+30%Nd_2O_3	-	35,97%	13,27%	6,49%	44,27%
NiAL+40%Nd_2O_3	20.51 %	-	12,16 %	8.36 %	58.97 %
NiAL+60%Nd_2O_3	-	30.15%	12,16 %	8.22 %	49.57 %
NiAL+60%Nd_2O_3	-	18.09%	7.93%	8.19%	65.79%
NiAL+70%Nd_2O_3	-	16.67%	7.73%	10.73%	64.87%

References

1. Ahmed S. N. Physics and engineering of radiation detection. – Academic Press, 2007, p. 784.
2. M.I. Ojovan, W.E. Lee, An Introduction to Nuclear Waste Immobilization, Elsevier, London, 2005, pp. 229-232.