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PREPARATION OF HIGHLY DISPERSED PYROCHLORE BY MICROWAVE METHOD OF POWDER SYNTHESIS

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Continuous developments in materials include a wide range of new metal alloys such as titanium alloys, aluminum-lithium alloys, magnesium alloys, as well as composite materials such as carbon fibers, 3D fabrics, thin layers, etc., as well as biodegradable materials. In addition to this work, one of the most pressing engineering challenges is the search for alternative production methods aimed at reducing energy consumption and production costs [1, 2]. This progress can be observed in many areas of the economy, such as transport and automotive, mechanical engineering, biotechnology and medicine, as well as in the energy or electronics sector. Moreover, development in the above sectors helps improve the quality of life of people and protect the environment, which is especially important in our time.

A promising direction in the development of materials in the nuclear industry is the production of composite materials based on ferritic-martensitic radiation-resistant steels. Such materials are oxide-dispersion-strengthened alloys, i.e. alloys with a steel matrix strengthened by nano-sized oxide particles dispersed inside it. Y-Ti-O nanoparticle-strengthened ferritic steels have recently attracted attention as leading candidates for fission and fusion reactor components due to their high tensile, creep and radiation resistance, which is much higher than other iron alloys [3, 4].

Nanoparticles mostly have an almost stoichiometric composition, for example $Y_2Ti_2O_7$ with a pyrochlore structure. In general, pyrochlore oxides of the type $A_2B_2O_7$, where A is typically a rare earth ion and B is a transition metal, have a specific lattice structure, active charge, spin, and orbital degrees of freedom. As a result, they demonstrate a complex interaction between geometric disorders, electronic correlations and spin-orbit coupling. Various pyrochlores are considered good matrix materials for the separation of actinides and other nuclear wastes. Pyrochlores are also refractory materials with important properties, including ionic conductivity, optical nonlinearity, high radiation resistance and others. Potential applications of pyrochlores include thermal and environmental protection coatings, high dielectric constants, solid electrolytes, anodes and cathodes in solid oxide fuel cells, transparent ceramics, etc. In addition, pyrochlores have potential applications as ceramic pigments due to their high melting points, high refractive index, and ability to absorb transition metals.

In the presented study, the main goal was to develop a technology for producing highly dispersed pyrochlore $Y_2Ti_2O_7$ at the lowest possible temperatures, possibly in a shorter time, without additional substances or solutions.

The results of DTA/TG analysis are presented in Fig. 1. This shows that weight loss, represented by the TG curve, gradually decreased with increasing temperature. This was attributed to evaporation and removal of ethanol residues from the heated powders.

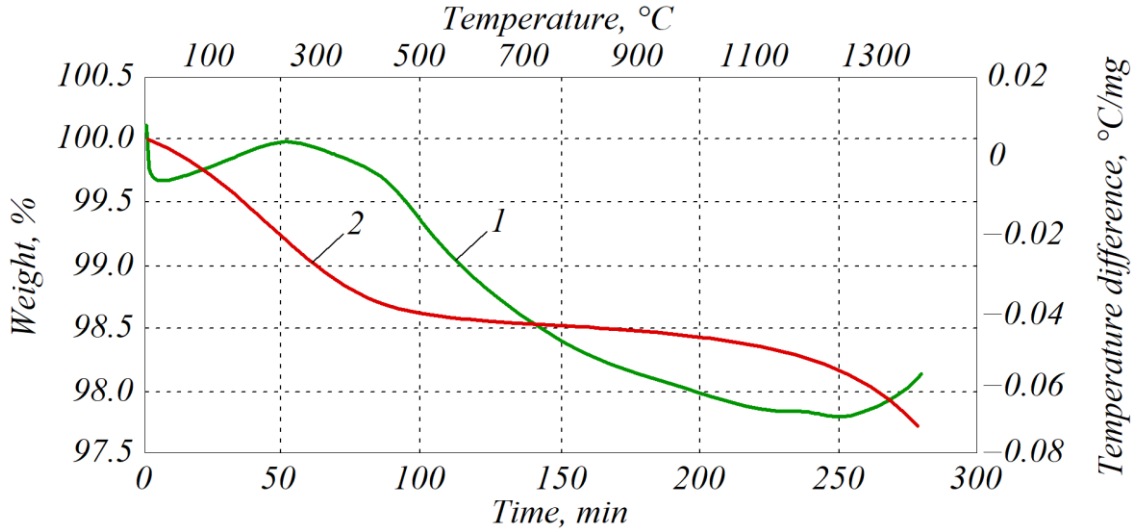

Fig. 1. DTA (*1*) and TG (*2*) curves of Y_2O_3–TiO_2 powder mixtures

The initially rapid weight loss slowed down markedly after the temperature reached 500 °C. The endothermic peak in the DTA curve after 50 min was presumably due to water loss. In general, the mass loss was insignificant, since even at 1300 °C it was less than 2%, but for laboratory experiments it was there.

Samples of cold-formed yttrium titanate were placed in a corundum crucible and sintered in a firing furnace at a temperature of 1150 °C for 7 hours. X-ray diffraction analysis of these samples revealed the presence of both the original oxides and the pyrochlore phase of $Y_2Ti_2O_7$. The maximum amount of pyrochlore phase was about 20 wt.%.

The samples were repeatedly mechanically crushed, mechanically homogenized, compacted, and additionally calcined at a temperature of 1150 °C for 10 hours to increase the amount of pyrochlore. Thus, the total calcination time was 17 hours.

After the second stage of calcination, according to X-ray diffraction analysis, the samples became almost single-phase. The main phase was yttrium titanate $Y_2Ti_2O_7$, its mass content in the sample was more than 96.8 wt.%, the lattice parameter was 10.091 Å. Some of the samples were again mechanically crushed and mixed, then compacted again and calcined for another 8 hours, the total heat treatment time reached 25 hours. Additional calcination of these samples increased the $Y_2Ti_2O_7$ content to 98 wt.%. Thus, the desired structure of pyrochlore $Y_2Ti_2O_7$ with a dominant component was obtained in the sample after 25 hours of calcination at 1150 °C.

Thus, modification of the traditional technology of direct solid-phase synthesis with microwave radiation has significantly reduced the synthesis time and reduced energy costs.

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ЕЛЕКТРИЧНИЙ ОПІР ЗАЛІЗОБЕТОННИХ ШПАЛ ТА ЙОГО КОНТРОЛЬ У ВИРОБНИЧИХ УМОВАХ

ELECTRICAL RESISTANCE OF REINFORCED CONCRETE SLEEPERS AND ITS CONTROL IN PRODUCTION CONDITIONS

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Рейки залізничних колій крім безпосереднього кочення ними колісних пар рухомого складу є складовими електричних кіл – сигнальних струмів систем сигналізації, централізації і блокування (СЦБ), а також тягового струму на електрифікованих ділянках залізниць. Для надійної роботи цих кіл рейки мають бути електрично ізольовані одна від одної та від землі. Звичайно це досягається ізолюючими деталями проміжних рейкових скріплень. Проте старіння, знос, засмічення гумових і полімерних ізолюючих деталей у вологу погоду спричиняє падіння електричного опору ізоляції і, як наслідок – збої у роботі систем СЦБ через протікання струму між рейками крізь шпали, втрату частини тягового струму від його стікання через шпали та баласт у землю, електрокорозію металевих і залізобетонних конструкцій цим струмом витоку. Тому підрейкові основи – шпали, бруси, плити безбаластного мостового полотна та їх бетон мають бути не тільки стійким до механічних впливів, а й надавати свій внесок у забезпечення електричної ізоляції рейок між собою та від землі. Разом з тим електричний опір шпал та їх бетону до 2016 р. в Україні не нормувалися.

В УкрДУЗТ виконано дослідження, метою яких було обґрунтування потрібних показників електричного опору залізобетонних шпал і їх бетону. В результаті аналізу джерел [1–3], теоретичних та експериментальних досліджень [4] показано, електричний опір бетону визначається його структурою як дисперсною системою (капілярно-пористим тілом) з фазою із заповнювачів та продуктів гідратації цементу і дисперсійним середовищем – поровим електролітом, а на нього додатково впливають вологість, температура, наявність добавок-електролітів тощо. У [6, 7] досліджено вплив умов