

Some aspects of the synthesis and application of nanomaterials

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This paper presents the results of some investigations into the production of various nanoscale materials that have been carried out at the Institute of Combustion Problems in recent years.

1. Synthesis of hydroxyapatite and potential biomedical applications.

Although bone fractures are a major public health concern worldwide, their incidence and costs have not been thoroughly investigated. Fractures are the main issue with bone illness, especially osteoporosis, and may be the patient's first obvious symptom. For example, an estimated 2 million people in the US annually experience a fracture. It was discovered that the crystalline HA powder obtained from an aqueous solution through chemical precipitation using a biological eggshell waste has a purity of ~95%. According to EDX analysis, the Ca/P ratio is 1.5, which is suitable for medical uses and improves the osteogenesis properties of scaffolds. The experimental data confirm that obtained polymer-based fibers by electrospinning with the addition of HA particles are well-qualified candidates for use as biological matrixes and drug delivery agents in TE and can reduce the convalescence period. According to the results, among the TPMS structures, the Gyroid structure is the best in Top-load/Crush test, and the Lidinoid structure is the best in Tensile tests. However, it was found that adding the resin reinforce precursors to the matrix positively affects the mechanical properties, enhancing osteogenesis and reducing the convalescence period. In addition, obtained data from actual mechanical tests agree with the simulation data and confirm the method. Producing resin reinforce precursors by ultrasonic method led to the formation of nanomaterials with suitable size, morphology, and surface properties for medical applications.

2. Obtaining nanostructured fibers modified by nickel oxide particles and their use in chemoresistive sensors.

Electrospinning is a widely used process for producing fibres with diameters ranging from nanometres to micrometres. One critical factor in electrospinning is the choice of polymer, which can affect the morphology, structure and properties of the resulting fibres. While polyacrylonitrile (PAN) is a popular polymer for electrospinning, coal tar pitch (CTP) has attracted attention as an alternative due to its unique properties. The use of CTP instead of PAN in electrospinning

has great potential to produce fibers with improved properties. The obtained fibres have been modified by nickel oxide nanoparticles. As a result, the nanostructured fibres can be effectively used as gas-sensitive materials. Carbon/NiO fibers with a diameter of 100-300 nm were obtained. It was established that sensitivity to acetone equal to 73% is achieved by doping carbon fibres with nickel oxide nanoparticles of average size 48 nm, thereby increasing the surface area for gas adsorption and detectable gas reacts chemically with nickel oxide nanoparticles, resulting in changes in the electrical conductivity of fibres.

3. Synthesis of composite pyrotechnical materials and optimization of effective conditions for their practical application in the destruction of rock formations.

The effect of different types of carbon powders on the combustion of gasifying compositions based on sodium nitrate and magnesium were investigated. A preliminary thermodynamic analysis of gasification processes of multi-component compositions was carried out using the TERRA software package for modelling phase and chemical equilibria. The methodological basis of the calculation included an evaluation of the fundamental laws of thermodynamics together with the laws of conservation of mass, energy and charge. The TERRA software is linked to a database of properties of individual substances (about 3500 substances in gaseous, ionised and condensed states), which allows simultaneous consideration of systems containing up to 25 chemical elements. The condensed compounds and gas phase components to be considered in the calculations are automatically selected from the database. Up to 200 condensed compounds and up to 500 gaseous substances can be calculated as possible components of a given equilibrium state. In order to find the optimum ratio between oxidant (NaNO_3) and fuel ($\text{Mg} + \text{C}$), systematic calculations of the thermodynamic equilibrium properties were performed by varying the mixture composition. Experimental measurements of the combustion rate, flame temperature and composition of the combustion products for two types of carbon were carried out to better evaluate the characteristics of the investigated mixtures. The measurements were carried out in air to obtain preliminary information on the feasibility of layer-by-layer combustion for the selected compositions. Also it is planned to carry out similar measurements at higher pressures.



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