POPULAR SCIENCE ABSTRACT (IN ENGLISH)

The goal of the project

The aim of the project is to investigate the effect of preparing the surface of carbon micro and carbon nanofibers with various polysiloxane-based resins to obtain new, functional ceramic-matrix composites and nanocomposites.

The reason for undertaking research into combining the fibrous carbon phase with the polysiloxanes-derived carbides was to find new solutions to improve the oxidation resistance and corrosion resistance of fibrous carbon. The polysiloxane resins used are precursors of ceramic compounds that crystallize under the conditions of pyrolytic decomposition in a porous carbon microstructure, forming ceramic materials with unique physicochemical properties.

One of the open issues regarding the possibility of using this group of polymer with carbon, which is the subject of the project's research is to understand the mechanism of interaction of the polymer with the surface of the carbon component on the impregnation stage and during the heat-treatment leading to the conversion of the preceramic polymer to the carbide phase.

Research planned in the project

Two types of carbon fibers, i.e. carbon microfibers and carbon nanofibers, will be used for research. As part of the project tasks, various methods will be used to modify the surface of both fibrous carbon forms, i.e., chemical surface treatment and modification of the degree of crystallinity before coating the fibers with a polysiloxane resin. The ceramic component will be obtained by impregnating the carbon substrate with a selected polysiloxane resin with different Si/C ratio, during controlled heat-treatment of the carbon/polymer composition to 2000°C. Analysis of fibrous carbon/carbide composites and nanocomposites obtained by pyrolysis of carbon/polymer fibrous composite, will allow to determine the effect of surface state and crystallinity on the physicochemical, electrochemical and mechanical properties of the obtained ceramic composites and nanocomposites.

The project plans to study the mechanism of the polysiloxane resin decomposition in the presence of two types of carbon fibers obtained from polyacrylonitrile and to determine the effect of the carbon phase on the structural and microstructural changes of the pyrolyzed resin. In addition, investigation will be carried out on selected properties relevant to the possible applications of developed carbon materials containing polysiloxane-derived ceramic residues, i.e. resistance to oxidation, electrochemical, electrical and mechanical properties.

The reason for taking up the subject matter and the expected results

The literature review of the topic indicates lack of knowledge regarding the chemical and physical interactions between the polysiloxane precursor and fibrous carbon substrate and the lack of knowledge about the possibility of controlling the physic-mechanical properties of such ceramic matrix fibrous composites, depending on the character of the interface between the carbon and the silicon-containing polymer. Also to a much lesser extent, research was conducted on understanding the impact of carbon micro/nanofibers, their structure, chemical surface state, phase composition on the polysiloxane resin decomposition mechanism and forms of carbide phase precipitation above 1700°C.

The research results will provide knowledge on the relationship between the crystal structure of carbon and its chemical surface state, which affects the formation and type of bonding with the polysiloxane matrix. The obtained results will also allow to determine possible differences during decomposition of polysiloxane resins in the presence of two types of fibers, i.e. micro and carbon nanofibers differing in the size of crystallites and the degree of their ordering, i.e. crystallinity. These studies will provide knowledge about the conditions of crystallization of carbide phases with different morphologies in contact with carbon microfiber or carbon nanofiber, e.g. silicon oxycarbide (SiOC) or silicon carbide (SiC), SiC nanofibers, SiC polycrystalline grains with nanometric dimensions or continuous ceramic layers (coating). The obtained results of these specific tasks will determine the desired chemical surface state of the carbon component and its crystalline structure, with optimal properties, to obtain composite/nanocomposite C/carbide, which in the future will find application in modern electrochemistry (Si-doped carbon matrices; anodes for lithium-ion batteries), and as nanoelectronic devices (semiconductor materials, micro-electro-mechanical systems).