# Preparation and properties of hierarchical nanocomposite structures: carbon nanofibres/carbon nanotubes with transition metal nanoparticles

In his famous lecture from 1959 entitled "There's Plenty of Room at the Bottom" American theoretical physicist Richard Feynman presented the idea of a nanotechnological approach for the first time, thus providing conceptual basis for the future development of new field of technology and science. He noted that reduction of the scale of devices and materials to the nanometric range causes a significant changes in the ascendancy of physical phenomena determining their macroscopic properties. Due to that, such a materials exhibit a number of extraordinary electrical, thermal, mechanical and catalytic properties, etc. These unique features enable to investigate the unprecedented phenomena and obtain a new generation of materials outclassing those commonly used. Thanks to their outstanding properties and relatively low costs, carbon nanomaterials, such as, e.g. graphene, carbon nanotubes, carbon nanofibers, fullerenes, etc. have been the subject of constant interest of researchers from around the world for years. Recently, it has become possible to obtain increasingly complex nanometric structures consisting of one or more chemical substances. An example of such a materials are carbon hierarchical nanocomposites that resemble the trunk of a tree (carbon nanofibre) with the branches growing out of it (carbon nanotubes terminated with a transition metal nanoparticles). Due to the fact that the carbon nanotubes are connected with the core nanofibre with strong, covalent bonds, interfacial connection is characterized by high mechanical strength and favourable electron transport properties. Such a nanocomposite also have a very high porosity and large specific surface area per unit of weight. Combination of these specific properties causes that, such structures have a very high potential of application in photovoltaic cell elements, supercapacitors, in analytical chemistry, as a material for filters, and as a reinforcing filler improving the mechanical properties of polymeric materials.

This project is aimed at study the influence of the conditions of synthesis on the physicochemical properties of hierarchical carbon-metal nanocomposites (carbon nanofibres-carbon nanotubes with metallic nanoparticles). In particular, the impact of new bimetallic catalysts and electrical and electrocatalytic properties of nanomaterials will be investigated. Optimisation and insightful analysis of the conditions of synthesis will provide knowledge enabling the design of the strictly desired material properties. Complementary analysis of their output properties will allow to recognise the characteristic relationships linking the internal structure with the electrical conductivity and electrocatalytic properties of nanocomposites. It is anticipated that the combination of such material features as: hierarchical structure, controlled degree of structural ordering and presence of bimetallic nanoparticles will allow obtaining high quality electrochemical catalysts. In addition, studies aimed at the basic verification of the application potential of the obtained materials in the pro-ecological field of energy storage and conversion have been planned. The realisation of the project should significantly extend the current state of knowledge on the synthesis, electrical and electrocatalytic properties of carbon hierarchical nanocomposites. Furthermore, bringing new knowledge and popularising this topic will allow easier design of this type of materials, or other, made by using them (polymer nanocomposites, biomaterials, materials for energy, filters, etc.).