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ABSTRACTS BOOK

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ABSTRACTS BOOK

5th International Conference InterNanoPoland 2021

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Dear Colleagues,

The InterNanoPoland Conference hold on the 14-15th April 2021 is organized by The Foundation of Nanoscience and Nanotechnology Support NANONET, City of Katowice, University of Silesia in Katowice and Silesian Nano Cluster. The aim of the Conference is to emphasize the importance of cross-border capability of an innovative company and portray Poland as a country with world class nanotechnology and industry. During INP 2021 Conference, Polish enterprises and science institutes will present their cooperation and product offers, discussions, B2B meetings and seminars will be held. The companies participating in the will be in an excellent position to develop international contacts in the future. The InterNanoPoland brings together scientists and technology users who investigate or develop nanomaterials. The presents the state of the art. In preparation, characterization and usage of nanomaterils and devices in variou nanotechnology fields. I am grateful for sponsorships which have assisted us by providing some financial support. I wish to express my thanks to the members of the scientific committee and business advisory committee for their suggestions and we are also grateful to the members of the organizing committee for their effort and dedicated time during preparation of the Conference. I wish you to meet other people at our Conference and start new friendship and collaboration right here!

Adam Szatkowski

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Since the concept of "Magic Bullet" imagined by Paul Ehrlich at the beginning of the XXth century postulating the targeting of drug towards specific cells/tissues without affecting healthy ones, tremendous research works have been done for designing efficient site-specific nanomedicines [1]. Since then, numerous targeted molecules, such as monoclonal antibodies (mAbs), vitamins or carbohydrates, have been developed and studied [2]. Among them, short synthetic peptides have gained interest as targeting agents in the design of various site-specific nanomedicines for therapy and/or diagnosis of several pathologies, especially cancers.

In this context, our research work aims at developing tools for the diagnosis and/or therapy of hepatocellular carcinoma (HCC) based on two hepatotropic peptides, the GBVA10-9 and CPB peptides that have been grafted at the functionalized end of poly(benzyl malate), a biocompatible and degradable polymer, through a thiol/maleimide addition reaction [3]. Those peptides end-functionalized poly(benzyl malate) (PMLABe) have been formulated with either poly(benzyl malate) or poly(ethylene glycol)-*block*-poly(benzyl malate) (PEG-*b*-PMLABe), thus leading to a set of nanoparticles (NPs) varying by the nature of the peptide (GBVA10-9, CPB or their scrambled control counterparts, CTRLNeg19 and CPBscr, respectively) present at their surfaces and by the absence or presence of PEG. The obtained nanoobjects were characterized by dynamic light scattering (DLS), zetametry and transmission electron microscopy (TEM) highlighting a spherical shape, a hydrodynamic diameter lower than 150 nm and a negative surface charge. Moreover, a fluorescent probe (DiD Oil) has been encapsulated into these peptide-decorated NPs without affecting their characteristics. The NPs decorated or not with the peptides have been then evaluated into *in vitro* internalisation assays using hepatoma cell lines. Preliminary results showed that: *i)*. as expected, the fully PEGylated NPs were poorly internalized by the HepaRG cells whatever their composition, *ii)*. both GBVA10-9 and CTRLNeg19 peptides have no influence on cell internalization of the corresponding NPs, and *iii)*. NPs formulated from the mixture CPB-PMLABe/PMLABe were efficiently internalized into hepatoma cells in comparison to the similar NPs decorated with CPBscr, while the contrary has been observed with NPs prepared from the mixture CPB- or CPBscr-PEG-*b*-PMLABe/ PMLABe. These results showed that CPB may be a promising hepatotropic peptide, which can be used for the design of nanoobjects for the therapy and/or diagnosis of HCC.

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DETECTION OF MICRO AND NANOPARTICLES OF POLYSTYRENE IN TISSUES OF DROSOPHILA MELANOGASTER

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Plastic litter in the environment undergo ageing processes and degrade to smaller than 5 mm microplastics (MP) and nano plastics (NP) with dimensions smaller than 0.1 µm. In recent years' plastic' research were mainly carried on the marine environment. But novel studies reveal that MP contamination in the ground might be 4 to 23-fold more prominent than in the ocean. That fact, supported with data from the world literature, lead us to study both the effect of MP and NP on terrestrial organisms, as well as on their tissues and cells in vivo. In particular, our questions are linked to organism development and the potential trans-generational exposure and impact of plastic.

To address this problem, we chose common and globally distributed terrestrial organism that are also model species in biological studies: the fruit fly Drosophila melanogaster. The fruit fly is a model to study gametogenesis, egg formation and embryo development. It is also characterized by a short lifecycle and short development (10 days from embryo to adult in 25°C).

To properly plan our research, we have checked the accumulation of polystyrene MP and NP in the alimentary tracts and ovaries of the adult females and larvae of *D. melanogaster* feeding for 14 days with the yeast pasta mixed with MP and NP fluorescent particles with polystyrene core (0.04-0.06 µm fluorescent nile red particles – NP red; 0.4-0.6 µm fluorescent pink particles – NP pink; 1.0-1.9 µm fluorescent yellow particles – MP yellow; Spherotech; the final concentration = 0,001µl/ml).

TEM analysis has shown MP and NP's presence in the lumen of the alimentary tract of adults and larvae, which indicates that particles were taken with food. Moreover, NP red were detected between and inside the microvilli of enterocytes and also within the autophagosomes and autolysosomes. It indicates that plastic particles can intake into the cells and try to eliminate them via autophagy. The apoptosis and % ROS+ analysis has shown, in turn, that ovaries seem to be the most exposed tissue to the harmful effects of polystyrene particles. Surprisingly, no effect of MP and NP on the alimentary tract was noted. A significant increase in the percentage of apoptotic cells was found in the ovaries cells after they were treated with NP red and MP yellow compared to the control. The groups treated with NP red and MP yellow also showed significant decreases in % intracellular ROS+ compared to control in ovaries cells. The obtained results indicate MP and NP induced apoptosis in ovarian cells.

Prested data came from preliminary studies and are still during experimentation. Despite this, we firmly believe that the presented results give us a piece of knowledge about the potential risk of MP and NP (at least polystyrene studied) on terrestrial organisms, or vice versa – de-demonize the impact of plastic.

NANOTECHNOLOGY IN MEDICINE AND ENVIRONMENT

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Nanotechnology has great potential to make significant impact in many areas. In agriculture, nanotechnology can be used in many ways including crop production (e.g. use of nanofertilizers, nanopesticides) and crop protection with emphasis on nano-enabled remediation strategies for polluted environment [1]. Nanotechnology in medicine is focused on application of different nanomaterials in a development of novel therapies and diagnostic techniques. Recently, the use of silver nanoparticles has attracted attention in wound management [2]. In addition, there has been increasing interest in adenoviral vector anti-cancer therapy. Significant efforts have been focused on the development of poly gamma glutamic acid (γ-PGA)-based micro/nanoparticles used as a vector [3]. The biopolymer γ-PGA is biodegradable, non-toxic and non-immunogenic. In this study, γ-PGA was used to protect bacteriophage from harmful environmental conditions. Also, we introduced an antibody-blind polymer-coated viral vector. Bacterial synthesis of γ-PGA was performed in a fermenter. Isolated polymer was identified by Fourier Transforming Infrared Spectroscopy (FTIR) and Nuclear Magnetic Resonance (NMR). The number-average molar mass (Mn) was determined by conventional aqueous based gel permeation chromatography (GPC). Different methods were performed to evaluate the possibility of using these micro/nanoparticles as viral vector. Bacteriophage formulated with 1% γ-PGA showed significant increase in survival rate compared to non-formulated phage. Adenovirus was successfully encapsulated inside the biopolymer with encapsulation efficiency of 92%. The cytotoxicity study showed that the particles were not toxic. The results obtained in this research could provide reference for coating and controlled release of viral vector used in anti-cancer therapy.

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PHASE DIAGRAMS OF CONJUGATED POLYMER SOLUTIONS AND BLENDS FOR ORGANIC PHOTOVOLTAIC NANOTECHNOLOGY

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The bulk-heterojunction organic polymer solar cells have a light-harvesting active layer composed of electron-donating polymer and electron-accepting molecule (fullerene or non-fullerene accepter, NFA). Here NFA could be polymer or small molecule. Usually, the π-conjugated molecule, so called organic semiconductor, has a limited exciton diffusion length (~10 nm) due to its low dielectric constant, indicating that the domain size of a donor/acceptor layer should be controlled within ~10-20 nm. Hence, it should be very important to study the phase behaviour and phase diagrams of polymer-fullerene, polymer-NFA, polymer-solvent, polymer-fullerene-solvent, and polymer-NFA-solvent systems.

In this work, we demonstrate the correlation of phase behaviour and electronic/optoelectronic properties (e.g., charge transport and photovoltaic performances) for binary polymer-fullerene systems. Furthermore, based on the Flory-Huggins theory, we constructed the phase diagrams of not only binary conjugated polymer solutions and blends, but also ternary polymer-fullerene-solvent and polymer-NFA-solvent systems as a function of temperature solvent species, molecular weight, processing additive, electron acceptors (fullerene and NFA), and other polymers. Here in the case of ternary systems, the binodal, spinodal, tie line, and critical point were calculated in details.

Importantly, the π-conjugated polymer solutions may undergo phase separation through liquid-liquid (L-L) and/or liquid-solid (L-S) phase transition. Here L-L demixing can be subdivided into nucleation and growth (NG), and spinodal decomposition (SD), whereas L-S demixing could be crystallization, gelation, and vitrification. In this study, we address these demixing processes occurring in binary/ternary photovoltaic blends and solutions, providing a rational background for controlling a bicontinuous interpenetrating network nanostructure. Finally, we believe that our finding may advance the organic photovoltaic nanotechnology in the field of conjugated polymer science.

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STRUCTURAL CHARACTERIZATION OF QUASICRYSTALLINE $Al_{71}Ni_{24}Fe_5$ ALLOY PREPARED BY RAPID SOLIDIFICATION

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Rapidly solidified Al-Ni-Fe alloys are promising group of metals because of many favourable properties compared to conventional crystalline alloys [1]. The unique properties of these alloys can be achieved through the possibility of obtaining nanocrystalline, amorphous or quasicrystalline structure. For example, Inoue et al. [2] produced an amorphous Al–Ni–Fe alloys with using melt-spinning method. The literature data [3] indicates an occurrence of thermodynamically stable decagonal quasicrystalline phase in the narrow range of $Al_{71.1-71.7}Ni_{24.6-23.0}Fe_{4.3-5.3}$ alloy composition. Moreover, current studies [1] describes the possibility of applying thermodynamic parameters to possibility of quasicrystalline phases formation in Al–Ni–Fe alloys.
The aim of the studies was to characterize the structure and the crystallization mechanism of $Al_{71}Ni_{24}Fe_5$ alloy. The alloying composition was calculated by thermodynamic approach with optimization of Gibbs free energy of the solid solution formation. The samples were prepared with using two different methods and cooling rates by induction melting (slow solidified ingots) and high-pressure casting (rapidly solidified plates). The structure was investigated by using X-ray diffraction, Mössbauer spectroscopy and high resolution transmission electron microscopy. Differential scanning calorimetry was performed to characterize thermal properties and mechanism of crystallization of studied ingots and plates.
On the basis of the conducted structural studies, the quasicrystalline phase D–$Al_{70.83}Fe_{9.83}Ni_{19.34}$ for samples in the form of plate was identified. Additionally, crystalline phases of Al_3Ni_2 and B2 Fe(Al,Ni) were present in the structure. The HRTEM and FFT images indicated the nanometric size of crystalline and quasicrystalline phases.

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DIRECT COVALENT COUPLING OF FLUORESCEINE TO SWCNT – INCORPORATING VIS PL WHILE ENCHANCING NIR EMISSION

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Near-infrared (NIR) fluorescence (PL) imaging, especially in II NIR imaging window from 1000-1700 nm (NIR-II) becomes an attractive imaging technique for both biomedical and clinical applications due to high imaging resolution, deep tissue penetration of NIR photons, low autofluorescence and reduced light scattering in living tissue. Currently nanoparticles such as Single Walled Carbon Nanotubes, Quantum Dots and very few organic fluorophores are utilized as imaging probes in that region.[1] In 2009 Single Walled Carbon Nanotubes (SWCNT) were used for the first time as a probe for intravital imaging of mice in NIR-II.[2] Since then, SWCNT achieved well-established position in NIR-II imaging, but issue of low PL quantum yield or tuning of PL properties is still a great challenge. One of the chemical solutions for this issue is an introduction of local sp^3 defects on SWCNT surface through diazonium salt chemistry. Although, great improvements in that regard were made in the last decade, only very few reports appeared about introduction of more complex organic molecules such as fluorophores or biomolecules through this kind of chemistry.[3]

In our pursuit toward enhancing PL properties of SWCNT for NIR-II imaging we aimed on introduction of organic fluorophores. Here, we report the first functionalization of (6,5) SWCNT with fluoresceine-5-diazonium tetrafluoroborate (5-FluDz). As a result we not only achieved enhancement of NIR-II PL emission through introduction of local sp^3 defects, but also we introduced Vis PL emission originating from fluoresceine molecule. Fluoresceine functionalized SWCNT (Flu-SWCNT) show bright NIR-II E_{11}^* emission with peak at 1180 nm, while the PL emission peak in Vis is strongly blue-shifted from 675 nm to 520 nm in comparison with fluoresceine in solution. We interpret this as an outcome of immobilization of fluoresceine xanthene ring and its parallel alignment to SWCNT surface.

Thanks to unique dual Vis-NIR-II fluorescence we started investigation of Flu-SWCNT as dual imaging probe for cancer tumor painting, although these studies are on very early stage of the development. Our results indicate that local functionalization of SWCNT directly with fluorophores might bring new intriguing features to SWCNT in a fairly simple manner.

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INVESTIGATIONS ON THE NANOSTRUCTURAL HYBRID LAYERS FOR DYE-SENSITIZED SOLAR CEL (DSSC)

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One of the most important element in the DSSC architecture is the photoanode. Nowadays the most popular photoanode construction is based in meso-porous semiconducting titanium dioxide (TiO_2) layer with attached dye molecules through bonds between the hydroxyl group of the oxide material and the carboxylic group in the dye structure [1]. The current scientific reports indicate that the most popular structure of the semiconducting photoanode layer is consist of micro- and nanoparticles of TiO_2 [2]. However studies also present some limitations in use of TiO_2 as high surface states density and low electron mobility which increasing recombination of the charge. Therefore, the continued development of DSSC requires searching for new materials and structures for applications in photoanodes.

Considering above the authors focused on the production of DSSC with hybrid photoanodes consist of TiO_2 nanoparticles with 1D semiconducting structures ensures archiving high surface area with small recombination of the interfacial electron with fast electron transport.

The research involved the testing of hybrid nanostructural photoanode layers manufactured through the screen printing method as well as their impact on the efficiency of DSSCs in form of: glass substrates with a fluorine doped tin oxide (FTO), **semiconducting hybrid layer** - commercial dye Di-tetrabutylammonium cis-bis (isothiocyanato) bis (2,2'-bipyridyl-4,4'-dicarboxylato) ruthenium (II) - N-719 dye, EL-HSE high stability electrolyte and platinum paste. The research included determining the structure and surface morphology of the hybrid layers with use scanning electron microscope (SEM), and atomic force microscope (AFM), qualitative studies of the chemical composition using the Energy Dispersive Spectrometer (EDS), X-ray structural studies. Investigations of optical properties have been realized with use spectrophotometer equipped with a xenon lamp with a wavelength range from 200 to 800 nm. The basic electrical properties and efficiency of the cells were measured under Standard Test Conditions (AM 1.5, 100 W/m^2).

Analysis of the obtained results confirmed the homogeneous structure of produced layers as well as dimensional and structural repeatability. The research on optical properties (absorbance) proves that semiconductor layers adsorb the dye, however, it depends on the degree of surface development and the nanoadditives used. The results of electrical properties research suggest that the efficiency reaches a value in the range to 5% and it is possible to enlarge it further by optimizing the photoanode structure and selecting other dyes.

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STUDY OF OPTICAL PROPERTIES OF 1D SnO_2 PREPARED BY ELECTROSPINNING

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Currently, scientists are focused on the study of one-dimensional (1D) metal oxides due to their unique optical and electrical properties. Nanostructured 1D tin oxide semiconductors has been well studied with regard to its synthesis methods. One of them may be simple, inexpensive electrospinning [1,2]. Thus, the aim of this work was to manufacture one-dimensional SnO_2 nanostructures using a facile electrospinning and heat treatment method. First, composite PVP/$SnCl_4$ nanofibers with different polymer to precursor ratio in a spinning solution of 2:1, 1:1, 1:2, 1:3 were electrospun and then calcined at two temperatures of 500 and 600 °C to obtain nano-grained polycrystalline SnO_2 nanowires. In order to examine the morphology and structure of obtained SnO_2 nanostructures a scanning and transmission electron microscopes (SEM, TEM) were used. The chemical composition and structure of the prepared nanomaterials was carried out using energy dispersive spectrometry (EDX) and Fourier-Transform Infrared spectroscopy (FTIR). The analysis of the optical properties and the energy band gap of the prepared nanowires was determined by spectral analysis using a UV–Vis spectrophotometer.
The SEM analysis showed that the average diameter of SnO_2 nanowires increased with the increase in the concentration of the precursor in the spinning solution. In addition, the use of a higher calcination temperature allowed to obtain nanowires with a smaller diameter, and thus with a smaller band gap. The above considerations indicate that the electrospinning and calcination parameters have a significant effect on the morphology and, consequently, on the optical properties of SnO_2 nanowires, which in the future may be used to construct modern solar cells, gas sensors and other devices requiring good optoelectronic properties.

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ULTRA-PRECISE DEPOSITION OF NANOMATERIALS FOR FLEXIBLE PRINTED ELECTRONICS

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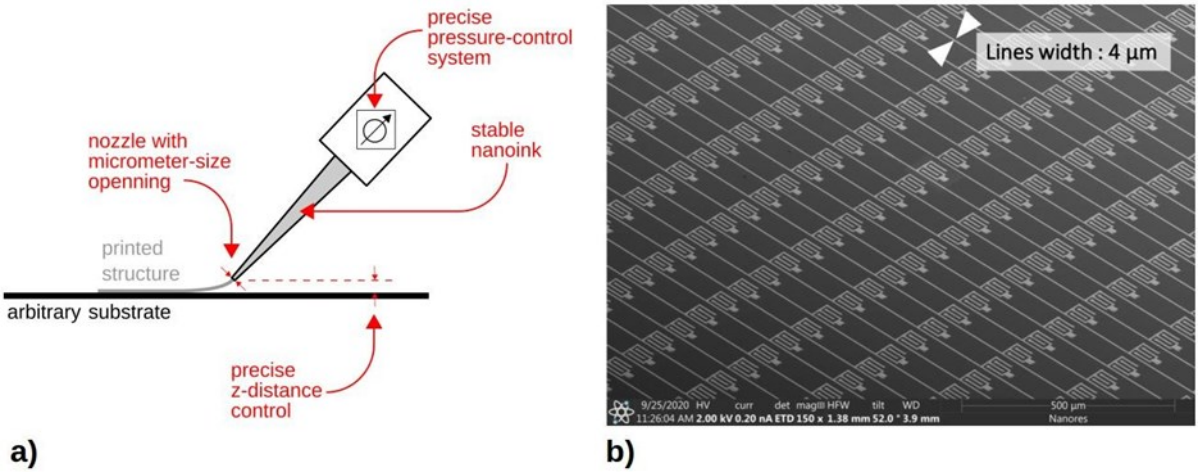
We demonstrate a novel ultra-precise deposition (UPD) technology for printed electronics. UPD allows maskless deposition of highly-concentrated silver inks (even 85% wt. of solid content) on complex substrates. The printed feature size is as small as 1 micrometer with the electrical conductivity up to 45% of bulk silver. In Fig. 1a) we sketch the UPD process: high-viscosity silver or copper ink (10'000 to 1'000'000 cP) is directly deposited on the substrate. The ink is extruded through a nozzle with the diameter in the range from 0.5 to 10 µm, which gives the printed feature size in the range from 1 to 10 µm. The combination of high-viscosity inks and fine printed features defines a unique operating range for the UPD technology and allows to make arbitrarily-shaped conductive structures on challenging substrates. The printed structures remain uniform regardless of the wetting properties of the substrate. Therefore, it is possible to print on materials with very different wetting properties, such as oxides (e.g. SiO2), nitrides (e.g. SiNx), metals, glass, and foils (e.g. PI, Kapton), as well as to print on junctions (metal/semiconductor/insulator) and cover vertical steps. In Fig. 1b) we demonstrate the capabilities of the UPD technology for mass production. The figure shows 7500 automatically printed segments for a thin-film transistor array with the line width of 4 µm. The key feature of UPD in this case is not only the line width, but also the ability to reduce the interline distance to single micrometers and below.

Figure 1: a) Sketch of the ultra-precise deposition (UPD) process; b) 7500 printed segments for a thin-film transistor array with the line width of 4 µm.



BLACK IS THE NEW GREEN: CARBON NANOSTRUCTURES AT THE HEART OF SUSTAINABLE DEVELOPMENT

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Methane, carbon dioxide, and coal brought ill fame to carbon-based materials. For a long time, avoiding solutions based on this element was a somewhat accurate rule of thumb on how to make technology appear more eco-friendly.

The discovery of carbon nanomaterials such as fullerenes, carbon nanotubes, and graphene at the turn of the 21st century revolutionized the way we perceive this building block. Exceptional electrical, thermal, optical, and mechanical properties convinced the R&D environment that, under the right circumstances, carbon could be the solution, not the problem. Ever since these structures were first synthesized, more and more evidence comes to light that they can outperform many classical materials used for hundreds of years. Importantly, they can also be obtained from renewable resources [1].

In this talk, the key merits of carbon nanostructures for sustainable development will be presented. First, a selection of methods for synthesizing and tuning the properties of nanocarbon by modifying its properties will be illustrated. Then, straightforward techniques of transforming these powder materials into macroscopic networks will be shown [2]. Finally, an outline of the most mature applications in the field of energy management will be described [3].

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MODIFICATION OF ELECTRICAL AND MECHANICAL PROPERTIES OF COMPOSITES USING THERMOPLASTIC NANOCOMPOSITE NONWOVENS

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Summary

The main aim of our work is the improvement of Carbon Fiber Reinforced Polymers (CFRP) electrical conductivity and selected mechanical properties by implementation of the novel thermoplastic nonwovens doped with carbon nanotubes. For this, different types of nonwovens, based on different thermoplastics doped with multi-wall carbon nanotubes were produced using two methods: extrusion of fibers and their thermal pressing or melt-blown. Nonwovens were placed between each layer of carbon fabrics and next CFRP were fabricated by infusion method. It was found that implementation of nonwovens doped with multi-walled carbon nanotubes resulted in improved both surface and volume electrical conductivity in all directions. By the application of CNT-doped nonwovens it was possible also to increase fracture toughness and impact resistance of CFRP. The thermoplastic nanocomposite nonwovens are easy in handling and can be applied in different processes of fibre reinforced composites.

CARDIAC SURGERY BY NANOTECHNOLOGY AND MEDICAL ROBOTS – LECTURE BASED ON PERSONAL EXPERIENCE

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Introduction. Every year, hundreds of thousands of heart valve and blood vessel prostheses, pacemakers and blood pumps are implanted in order to improve the efficiency of the circulatory system and to restore health in approximately one million patients. Device and material implantation is becoming an increasingly common element of the treatment process. Dysfunctions and biodegradation are the main causes of reoperation and prosthesis replacement as well as an inspiration for the search for better materials and technological solutions. **FRK**. The artificial heart, prosthetic heart valves, biomaterials, modern advisory systems and now also robots and other minimally invasive surgeon's tools are the result of works carried out by the Foundation of Cardiac Surgery Development (FRK) created by Professor Religa in Zabrze - a city renowned for a major breakthrough in Polish medicine: the first successful heart transplant. Nanotechnologies play an important role in the design of artificial organs and mechatronic tools at the FRK Institute of Heart Prostheses because they allow for the preparation of the surface for long-term, safe operation in physiological conditions, contact of the device with tissues, blood and proteins. Appropriate modification of the contact surfaces of structural parts that have dynamic contact with tissue or blood allows achieving the desired biotolerance or even bioactive properties, but most of all the durability of the obtained features. Work at FRK in this area was stimulated mainly by prof. Stanisław Mitura and research groups cooperating with them from the Silesian, Łódź and Koszalin Universities of Technology - on the use of the NCD nanodiamonds layers and DNP (diamond nanoparticles). Other inspirations were related to plastics (CMPW) and pharmacy (SUM). Carbon, titanium and biopolymer (Ti, TiOx, DLC) based materials were examined. A main concept of this work was to improve the surface-blood cell interaction. Some of these achievements have been described in books [1,2,3]. Biologically beneficial applications of NCD as a layer on polyurethane in POLVAD, on heart valves, on vascular stents, in cannulas and other cardiac support fixtures, and on the tips of the Robin Heart surgical robot instruments have been successfully investigated.

Future. I see the future of nanotechnological advances for the development of cardiovascular treatment in the creation of replacements for morphotic components of blood, tissue elements and for the heart - restoration of calcified vessels. Building microstructures by supervising positioning element by element create spatial conditions for biological organ culture, new vessels, repair of cells, proteins, chromosomes, genes. Robots, big, small and nano -, will be necessary to accomplish these tasks in order to accurately reach the right places, perhaps stimulating dynamically or using various chemical or physical phenomena (electric/magnetic fields/lasers...) biological processes, the environmental conditions for the right pace and quality of the tissue culture process.

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ROLE OF SHAPE, SIZE, AND SURFACE MODIFICATION ON THE ELECTRONS TRANSPORT IN MAGNETITE NANOPARTICLES DETERMINED BY BROADBAND DIELECTRIC SPECTROSCOPY

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Dielectric spectroscopy is widely used in the description of electrical properties of different inorganic materials and composites. Many studies are focused on the dielectric properties and charge carrier transport in ferrites. The influence of doping of the oxides on the dielectric permittivity and other factors, such as dielectric losses were studied in the details [1,2]. It is well known, that three main processes can be observed in dielectric spectra. Generally, in frequencies below the MHz region, the two electrical processes related to the conductivity in grains and through grain boundaries can be observed. Above this frequency region (especially at GHz region) the processes related to the vibration of ions and defects polarization can be observed. However, sometimes other processes such as polarons formation and polaron-phonon scattering also can be observed in ferrites.
In the performed studies, it was stated, that the introduction of different organic molecules on the surface of nanoparticles can change the charge carrier transport by the grain boundaries, especially by stabilization of Fe^{2+} or Fe^{3+} ions. Moreover, the passivation of the highly reactive surface of Fe_3O_4 NPs and the formation of the Fe_2O_3 layer can be observed and monitored using dielectric spectroscopy by analysis of the imaginary part of the electric modulus. The presence of this oxidized layer is responsible for ultralow conductivity in the Fe_3O_4@Fe_2O_3 system. On the other hand, isothermal annealing can be used to obtain magnetite nanoparticles with ultrahigh electrical conductivity, which can be related to the formation of the homogenized structure without well-formed grain boundaries. As was confirmed, in these materials the conductivity can be described by a combined universal power law and Drude model. According to this approach, the high frequency conductivity is related to the formation of large polarons, whereas in low frequency regions electrons can be treated as virtual free electrons gas [3].

Acknowledgements
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THE HIDDEN WORLD: EXPLORING A REAL 3D MICROSTRUCTURE IN AN SEM-FIB MICROSCOPE

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Scanning electron microscopy (SEM) has been long known to provide invaluable information on variety of samples and at a large magnification range, augmented with microanalysis and other complimentary data [1]. This toolset of techniques, indispensable for materials and life sciences, has been originally employed to provide 2D data or (rarely) 3D surface rendering. However, apart from some special cases, the interest of researchers in both scientific and industrial laboratories is naturally focused on a bulk structure which is obviously of three dimensions. This 3D world, normally hidden for SEM, reveals the real content like the spatial structure of grains, the location of precipitates, defects and voids with respect to other microstructure components, and the intricate interplay between organelles.

In order to access 3D bulk data in SEM the sample material is progressively removed and the resulting block face is sequentially imaged. Additionally, EDS and EBSD maps can be also recorded in a similar manner. The material removal is accomplished by a knife (cutting), an ion beam (sputtering) or a laser (ablation) depending on an instrument, the required volume and the intended resolution. The acquisition process must be fully automated due to lengthiness and strict prerequisites for image post-processing. The volume is firstly built by stacking the images and maps, then it is segmented and visualized.

Here, we address mainly the approach based on focused ion beams (FIB) available in an SEM-FIB microscope and we shortly include some laser capabilities. Although the SEM-FIB with Ga^+ ions is already a well-established technique for 3D [2], it has been recently vastly extended with other ion beams (Xe, Ar, O, N) [3]. These developments together with the ever-increasing automation provide not only greater volumes, robust process control, better block face quality, but also allow 3D imaging of previously inaccessible materials. Furthermore, the addition of a laser pushes the volume size to the limit.

In the presentation we discuss the current status of the SEM-FIB technique together with its prerequisites. We show applications for materials ranging from hard matter through soft matter to biological ones which were targeted at various volumes and for different purposes.

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New-old electron microscopy – an SBEM technique in the study of mitochondria dynamism

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Mitochondria are dynamic organelles that are changeable and adapting to the cell requirements, conditions, and ongoing processes. The dynamism of mitochondria is related to the two opposing processes – fusion and fission, that merge individual organelles into more extensive mitochondrial networks or split the networks into the individual mitochondria. The morphology of mitochondria depends on the balance between these processes. It is generally accepted that mitochondria play a significant role in oogenesis – the process in which future gametes (egg cells) are formed by delivering the energy (ATP synthesis) to eggs development and by their inheritance for the future embryo.

Here, we have studied mitochondria in syncytial groups of germ cells forming in oogenesis, an attractive model to study mitochondrial dynamism. Using the SBEM (serial block-face scanning electron microscopy) technique, we prepared three-dimensional (3D) ultrastructural reconstructions of germ-line cysts. SBEM is based on installation of the ultramicrotome inside the SEM chamber, which enables sequential ultrastructural micrographs of analyzed structures to be obtained with EM resolution, which is the basis for the 3D visualizations.

We visualized the selected compartments of cysts at subsequent stages – the earliest cysts composed of 2, 4, 16 cells, and cysts at the advanced oogenesis, containing one developing oocyte (future egg cell) and 15 specialized nurse cells. Subsequently, based on these reconstructions, we have prepared numerous measurements and calculations, including mitochondria numbers, density, and locality within the cyst compartments. We have also measured the level of mitochondrial connectivity to show if and to what extent they fuse into the mitochondrial networks and how mitochondrial dynamism changes during oogenesis.

We revealed that mitochondria formed extensive and branched mitochondrial networks. These networks fused hundreds, thousand, or even up to ten thousand individual organelles. Individual organelles were also observed between networks, which stated about 0.5 % of the measured total mitochondria volume. We classified this mitochondrial arrangement as a dynamic hyperfusion state.

In conclusion, the formation of extensive mitochondrial networks can keep the mitochondria in oogenesis in good condition and prevent mitochondrial damages or mtDNA mutations. Simultaneously, more damages or mutations may lead to the split mitochondria from the networks (mitochondrial fission), and finally to their elimination from the cell in the way of programmed cell death.

HOW NANOMEDICINE CAN IMPROVE BREAST CANCER TREATMENT

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Breast cancer is the most prevalent cancer among women and is the second most frequent cancer worldwide which alone accounts for 30% of female cancers.[1] The breast cancer causes are still not fully understood. Among other the risk factors of breast cancer include mutations in genes such as HER2, p53, CHEK2, BRCA1, BRCA2, hormones, environmental factors and age.[2] Depending on the location and the stages of the tumor the current breast cancer treatments includes chemotherapy, radiotherapy and surgery. Unfortunately, these clinical approaches are invasive, have low specificity and could cause many side effects. Thus, none of them are ideal for cancer treatment. Although, significant progress has been made to improve the breast cancer treatment over the past decade and the reductions slowed for female breast cancer, the medicine is still waiting for new treatment breakthroughs.

The rapidly growing field of nanomedicine could overcome many drawbacks of the currently used breast cancer treatments. Particularly the use of nanoparticle delivery systems as breast cancer drug vehicles may overcome biological barriers, allows prolonged blood circulation time, permits tumor targeting by accumulation of drugs in tumor side which all together could enhance the breast cancer treatment.

This review presents how nanomedicine can improve breast cancer treatment by pointing out the recent advances in breast cancer nanomedicines appeared in scientific peer reviewed published studies, approved by the FDA and under different stages of development in clinical trials.

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NANOCOMPOSITES FOR POLYMERIC WAVEGUIDES WITH LOW-REFRACTIVE INDEX INORGANIC NANOPARTICLES

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MgF_2 and SiO_2 nanoparticles were successfully integrated into polymer matrices (acrylic resins) and used for the fabrication of planar optical waveguides.[1] The introduction of the nanoparticles into polymer matrix is performed by direct mixing, copolymerization with nanoparticles modified by monomer, and *in situ* sol-gel formation of SiO_2 during photochemical cross-linking and annealing catalyzed by photoacid generator, Figure 1.
Additionally, optical layers without visible scattering were successfully prepared utilizing the nanocomposites. A decrease in refractive index and also of the thermo-optic coefficient of nanocomposite materials is clearly demonstrated, while some formulations exhibit an increase of the glass transition temperature. The possibility of using these nanocomposite materials to fabricate waveguiding layers with low optical
propagation losses at telecommunication wavelengths around 1550 nm is also shown for SiO_2 containing nanocomposites, Figure 2. Contrarily, MgF_2 nanoparticles increase substantially the optical propagation losses. Finally, the nanomaterials can find an application in optical microchips on polymer platforms

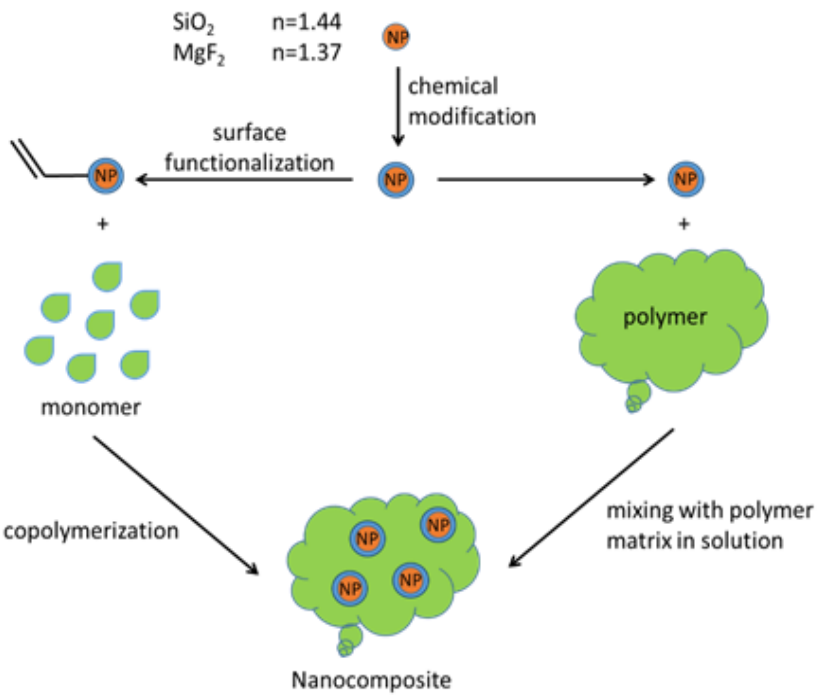

Figure 1. Schematic representation of the preparation process for optical nanocomposites.[1]

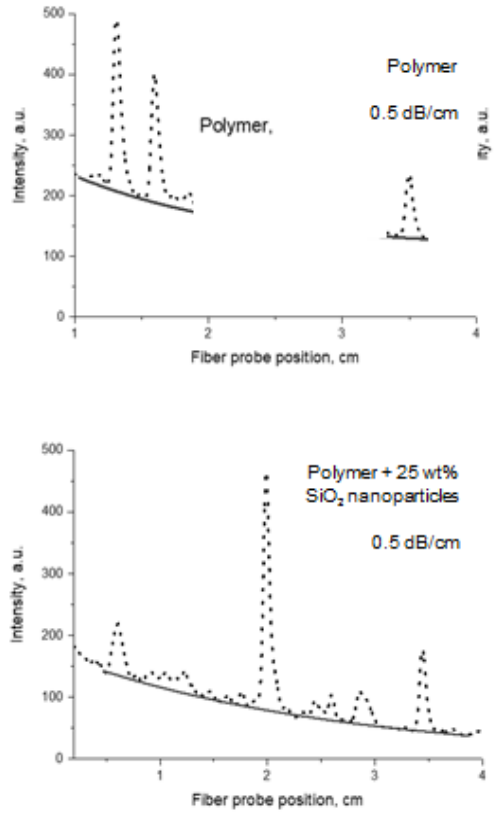

Figure 2. Propagation loss of thin layers; top: optical polymer; bottom: optical polymer with SiO_2 nanoparticles.

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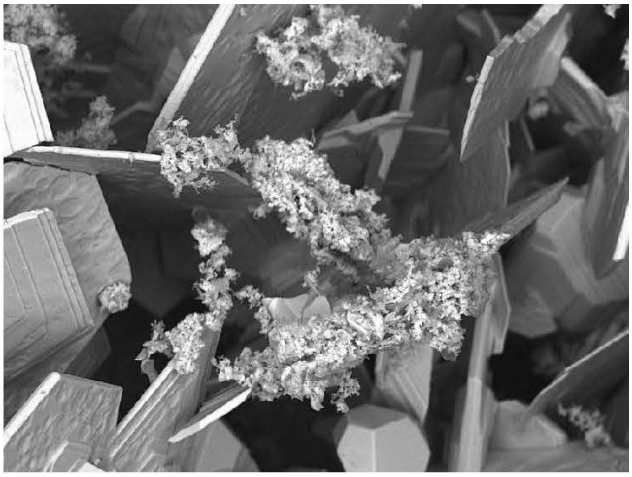

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HYDROTHERMAL MICROWAVE SYNTHESIS FOR MEDICAL APPLICATIONS – THE SERIES OF MSS REACTORS

S. Dąbrowska[1,2*], A. Chodara[1,2], J. Wojnarowicz[1], T. Chudoba[1], W. Łojkowski[1]

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Nowadays more and more bioactive materials are used in medical applications, which can support osseointegration. Bioactive hydroxyapatite (HAP) is one of the inorganic component of hard tissues, which is manufactured in the Institute of High Pressure Physics (IHPP PAS) and it is called GoHAP™. Microwave synthesis is an example of microwave assisted wet chemical synthesis process and nowadays it is counted as one of the most popular chemical methods of obtaining nanomaterials, like HAP.
Microwave heating enables a better control of the reaction time, fast heating and reducing the thermal gradients. The morphology, grain size and specific surface area can be controlled by the microwave reactor and the high pressure consolidation technology, this also results in a better crystallinity comparing to the precipitation process. At the Laboratory of Nanostructures, IHPP PAS, we have been developing new type microwave reactors for nanomaterial synthesis for more than 15 years. The use of the microwave radiation and the unique design of the reactors permit precise pressure control during the quick synthesis processes, controlled with the accuracy of even one second.
The MSS2 reactor presents a control system which allows for an automatic operation in the stop flow mode or use the batch (closed vessel) mode in bigger production scale than in other commercial equipment. [1,2] The MSS4 reactor is a new reactor manufactured by co-operation of IHPP PAS and Łukasiewicz Research Network – The Institute for Sustainable Technologies and it is a bigger device consisting of two independent microwave systems to made two batch syntheses in one time. The MSS4 reactor has also a connected robotic system, the device is plugged in with a robot from Universal Robots Company which is connected to the Labview software that controls MSS4 from a control cabinet and from the PC.

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The MSS4 reactor was constructed as a part of the CePTII project, reference: RPMA.01.01.00-14-8476/17, financed by the European Regional Development Fund

PREDICTION OF MODEL DISTORTION BY SIMULATION IN 3D PRINTING (SLM) OF MARTENSITIC STEEL

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Additive manufacturing (AM), namely selective laser melting (SLM) technology, allows to create complex components that can be customised in different ways (topological optimization, lightweight construction, lattice structures, etc.). Components manufactured by SLM are near full density and also have mechanical properties almost the same as bulk material [1]. SLM technology works on the basis of melting the individual layers to each other (layer-by-layer) directly from metallic powder, which creates thermal gradients that permeate the previously molten layer. The material expands and contracts, resulting in residual stress (RS) [2, 3]. RS then leads to part distortion, delamination and cracks. Process parameters and scanning strategies can be varied to reduce the impact of RS. SLM process simulation was done prior to 3D printing via the selective laser melting method and the subsequent separation of a printed sample from a base plate in software program MSC Simufact Additive.

Practical verification of the simulation was performed on a 3D printed topologically optimized part made of M300 martensitic steel. The paper emphasizes the role of simulation software for additive production and reflects on their weaknesses and strengths as well, with regard to their use not only in science and research but also in practice. This study presents a typical workflow from designing to manufacturing and finally quality control (QC) of parts fabricated with the SLM technology. In particular, a part was designed and topologically optimized. Subsequently, commercially available software program, namely MSC Simufact, was utilized to evaluate the deformation of the optimized part caused by the printing process.

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NANO-SIZED SILICA MATERIALS AND ITS APPLICATION IN TRYBOLOGICAL SYSTEMS: A LITERATURE STUDY

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The poster presents results of the literature study in the field of application of the nano-scale silica materials. Over the last years, nanomaterials become an important additive for various new materials and processes. There is also growing researchers' interest about silica nanomaterials. One of the still not widely reported applications of nanosilica is using it as lube oils additive. Due to their excellent enhancement of tribological properties [1], high stability and green chemistry features, silica nanomaterials are an interesting group of oil additives.

There are four proposed mechanisms of lubrication improvement by nanomaterials [2]: protective film effect, rolling effect, mending effect, polishing (smoothing) effect. The first and the second mentioned mechanisms explains the improvement of anti-wear properties for lubricant which contain nanomaterials. The other ones keep parts of tribology system in a good condition preventing seizure of the machine.

Despite silica's great properties providing considerable power savings [3], the main problem reported in the literature is their low stability when dispersed in the oil phases [1]. Because of nanoparticles' high surface area to volume ratio and therefore its high surface energy, the agglomeration of nanoparticles is often reported [2].

A possible solution for this problem is a chemical functionalization of silica nanoparticles with various substituents, which makes nanosilica more compatible with oil and furthermore enable improvement of its lubricating performance.

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ADVANCED NANOSTRUCTURED CARBON-BASED MATERIALS FOR RECHARGEABLE BATTERIES

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Graphitic materials are still under intensive investigation to improve their specific capacity and cycle life in anodes of Li-ion or Na-ion batteries [1]. Some non-graphitizing carbon materials prepared by pyrolysis of hydrogen-rich precursors have demonstrated a capacity of more than 1000 $mAhg^{-1}$, but they have a high irreversible capacity in the first cycle and short cycle life [2]. Therefore, attempts have been made to modify their structure towards better electrochemical properties.

We developed glassy carbon and sucrose-based carbon materials modified with Si nanoparticles. Glassy carbon and sucrose carbon are considered to be non-graphitizing carbons. However, the nanoparticle additives have a catalytic effect on their structural transformation during the graphitization process. Moreover, the nanoparticles are completely removed from the carbon matrix during the heat-treatment at 3000°C.

The micro- and nanoscale structure of the obtained graphite-like materials were studied using X-ray diffraction, Raman spectroscopy, scanning and transmission electron microscopy, BET surface area and helium pycnometry. The obtained structures have atypical fiber-like morphology, high degree of graphitization, low surface area and high density, compared with the properties of coke-based graphite, commonly used as anode material on the market. They are interesting candidates for use as anode materials for rechargeable batteries.

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COPPER-NICKEL NANOCOMPOSITES ORIGINATING FROM INDUSTRIAL WASTES AS A MODERN APPROACH IN RECYCLING

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Industrial process and waste solutions are a growing issue. High toxicity for the environment enlarges the need for advanced treatment of wastes and by-products. Particularly, appropriate handling of acidic wastes is mandatory. Development of modern methods for utilizing these complex mixtures should be a priority. However, selective removal of desired elements is often challenging and expensive[1]. Mixtures enriched with heavy metals such as nickel and copper are especially interesting due to global demand for resources in electronic field.

In this work, we present a convenient solution for transforming industrial process wastes into nanomaterials of high added value[2]. Based on aqueous chemical reduction involved during copper nanowires synthesis[3] we developed a method for obtaining bimetallic anisotropic nanostructures from a complex mixture containing 14 different metallic elements. Appropriate dilution followed by in-depth optimization allowed obtaining copper-nickel composite nanowires. Furthermore, applying an external magnetic field improved anisotropic morphology even more due to nickel self-assembly mechanism during nanowires growth. EDX measurements revealed random distribution of both elements. What is more, no other elements were observed in the spectrum, which confirms high purity of the product.

Such bimetallic nanomaterials can be tailored to specific applications, mainly for electronic nanodevices due to their unique electrical and mechanical properties. Multimetallic materials may possess wider tuning possibilities than monometallic counterparts. Almost endless configuration of metals and their concentration can be exploited to discover state-of-the-art materials. New source of building blocks for nanomaterial synthesis and promising results encourages further study this subject.

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OXIDATION OF SINGLE-WALLED CARBON NANOTUBES BY MODIFIED HUMMERS METHOD

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Hummers method was developed during the 60s of the XX century by William Hummers and Richard Ottoman[1] and nowadays it is the most popular way to synthesize graphene oxide (GO). Besides graphite, it is possible to use carbon nanotubes (CNTs) as a raw material for production of a type of GO,. During this process, CNTs are transformed to new 2D oxidized nanostructure called GO nanoribbons. Importantly, depending on the ratio of oxidation agent to CNTs or temperature, the reaction gives different products: intact CNTs (too small amount of oxidant), oxidized CNTs, nanoribbons (unzipped by oxidation if the amount of oxidation agent is sufficient), or CO_2 (excessive amount of oxidant).[3]
Our research was focused on analyzing the influence of the parameters of the Hummers method on the properties of the obtained products of oxidation of single-walled CNTs (SWCNTs). The impact of such conditions such as a ratio of $KMnO_4$/SWCNTs or reaction temperature/time on the microstructure and composition of the products of reaction was established. These were gauged by Raman spectroscopy, Scanning Electron Microscopy, and Transmission Electron Microscopy. Thin free-standing films from these materials were additionally manufactured to measure electrical conductivity of the material by the four-probe method. The main factor determining the final shape of the product was found to be the employed ratio of the oxidant to the raw material i.e. $KMnO_4$ to SWCNTs.

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HYBRID MATERIAL BASED ON POLYLACTIDE WITH LIQUID CRYSTAL 5CB AND SWCN

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In the latest technological solutions, more and more attention is paid to issues related to their impact on the environment [1-2]. When designing new hybrid materials, the entire life cycle of the material is taken into account, from its inception through its function to recycling. The group of materials that meet these assumptions are biodegradable polymers. By using appropriate admixtures, it is possible to obtain new materials with the desired properties, which can be easily recycled after fulfilled their purpose. Taking this into consideration, we decided to prepare a conductive, flexible and biodegradable material that could be used as an electrode. Hybrid layers based on PLA polymer (Polylactide) doped with SWCN and liquid crystal 5CB were prepared. PLA polymer has very good mechanical parameters and is very flexible, but it is a typical dielectric. On the other hand, conductive single-walled carbon nanotubes can form conductive layers, however very brittle. We have shown that it is possible to obtain a conductive and flexible material based on PLA with a small amount of carbon nanotubes (Fig. 1). Moreover, we have revealed that the usage of the 5CB liquid crystal admixture increase not only the flexibility of the created layer but also improve the conductivity.

a)  b)  c) 

Figure 1. Examples of created layers L,D-PLA:5CB:SWCN with different concentration of SWCN: 10:1:0.05 (a), 10:1:0.5 (b-c)

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ONE-POT EXFOLIATION AND DOPING OF GRAPHENE FLAKES USING THREE-ELECTRODE ELECTROCHEMICAL METHOD

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Graphene is an widely studied new-era material, possessing unique widely studied in recent year physical, chemical and transport properties. Practical application requires effective and scalable method of graphene synthesis. The most effective, in terms of yield and cost, is the electrochemical exfoliation of graphite from different forms of bulk graphite [1]–[4]. It uses the process of electrolysis of aqueous solutions of acids, bases and salts on carbon electrodes. By applying the appropriate voltage anions (usually sulphates) penetrate between the graphite anode layers, weakening the bonds between them and detaching individual graphene / multi-layer graphene flakes. There is also a modification of this method with two carbon electrodes and variable polarity voltage on them, which enables the alternate attraction and repulsion of ions, increasing the efficiency of the process. Decorating of carbon nanostructures with metal and metal oxide particles usually requires additional postprocessing, however several attempts for simultaneous exfoliation/doping process were made using the effect of decomposition of the dopant-containing salts during the electrolysis process [5], [6]. It requires specific chemicals and reaction conditions which make them difficult for wider application.

In this work a new modification of the electrochemical method allowing one-pot synthesis and doping of the graphene flakes with metals is proposed. The key element is be the three-electrode system. To the conventional two graphite electrodes, with the switching polarisation, a third, metal electrode connected permanently to the positive voltage will be added. It will be slowly electrochemically dissolved during the reaction providing source of dopant atoms, which are deposited on the currently negatively polarized electrode. What is important, it can be assumed that by setting the current flowing through the metal electrode the dopant amount can be precisely controlled, which will provide uniformity of obtained samples. Initial tests with the use of graphite tape and a nickel electrode showed that it is possible to obtain in this way graphene flakes, observable on a STEM microscope. EDX measurements showed the presence of nickel on the flakes visible under the microscope. Results of the analysis of the Raman spectra suggests strong oxidation and large amount of defects in the obtained flakes requiring more detailed study of the reaction conditions in future.

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DESIGNING MECHANICAL PROPERTIES AND CORROSION RESISTANCE OF MAGNESIUM ALLOYS FOR ORTHOPEDIC IMPLANTS

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The rapid development of implantology gives many people an opportunity to return to normal life. Implantology, that deals with the reconstruction and replacement of tissues of the human body, is constantly searching for better alloys characterized by high biocompatibility and osseointegration. Moreover, the environment of the human body does not favor the use of many metals and their alloys. Magnesium and its alloys are very interesting candidates for biodegradable implants [1]. They are characterized by high biocompatibility, good mechanical properties, but they have one disadvantage – low corrosion resistance in an environment with a high concentration of chlorides [2]. Too fast degradation process of Mg-based implants can lead to the lack of implant integrity with a tissue. Thus, it is necessary to modify the surface of these materials by applied oxide films, such as TiO_2 [3].
The article presents the results of structure, mechanical property investigations and corrosion behavior of MgCa2Zn1 and MgCa2Zn1Gd3 alloys and the alloys with TiO_2 films applied using magnetron sputtering technique.
The morphology observations of Mg-based alloys and the alloys with deposited TiO_2 films in scanning electron microscopy (SEM) and atomic force microscopy (AFM) were shown. The phase analysis was made with X-ray diffractometer. The tensile and compressive tests were carried out at room temperature with the static material testing machine. The results of corrosion resistance of substrate materials and the TiO_2 films using the potentiodynamic and immersion tests in Ringer's solution at 37 ºC were also presented.
The analysis of investigation results has shown that as cast Mg alloys show a dendritic microstructure with interdendritic solute rich regions. TiO_2 films deposited onto studied alloys had homogeneous structures without visible pores or cracks.
Improvement in mechanical properties was observed in MgCa2Zn1Gd3 alloy compared with the alloy without Gd addition. The results of the Tafel's analysis showed that the oxide films improved the corrosion resistance of the studied MgCa2Zn1 and MgCa2Zn1Gd3 alloys.

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USE OF HALLOYSITE FORSURFACE WATER TREATMENT

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The aim of our research is to determine the treatment efficiency of surface water by means of adsorption with halloysite Halloysite is a clay mineral belonging to the kaolinite group. In the world, halloysite is mined in opencast mines located in the USA, New Zealand and Europe, in Polish mine "Dunino" located in Legnica from which the raw material will be the subject of research. The mineral is characterized by mesoporosity, i.e. its pores are medium-sized (2-50nm) and have a specific surface area of 60 m^2/g [1]. The molecular structure of halloysite is characterized by the presence of two-layer packages. Their outer, tetrahedral surface is mostly composed of SiO_2 and the inner, octahedral surface of Al_2O_3, and hence those surfaces are oppositely charged. These properties determine the creation of interpack space, which can be filled by impurities dissolved in water and indicate halloysite ability for desquamation sorption, e.g. heavy metals, phosphates or nitrates, etc.[2]

Our research focuses on the production of the granular adsorbent based on halloysite and sewage sludge and on determining its effectiveness in the water purification process.

Research which points to the possibility of using halloysite in the process of water purification effectively was done among others by A. Machnicka and E. Nowacka[3] according to their research effectiveness of wastewater pollution reduction in the form of phosphates totalled 89% and ammonium nitrogen- 81% in the halloysite bed under hydraulic loading of $0{,}04 m^3/m^2*h$. Moreover, it reduced the organic substrate by approximately 86%. According to the other research[4], modified halloysite (zeolite) showed the effectiveness of binding heavy metals into its structure- lead and zinc cations are bound in the zeolite structure 56.41 and 16.63%, respectively.

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PRELIMINARY MICROSTRUCTURAL AND MAGNETIC STUDIES OF SELECTED NZFO/F-MWCNTS NANOCOMPOSITES

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Nowadays, spinel ferrite nanoparticles (SF-NPs) are intensively studied due to their wide applications. Moreover, the combination of magnetic SF-NPs and carbon nanotubes (CNTs) into nanohybrids sensitive to the chosen synthesis method may expand their potential applications and make them highly attractive for new material development [1-2].

In present work we used the $Ni_{0.5}Zn_{0.5}Fe_2O_4$ ferrite nanoparticles (NFZO) synthesized via co-precipitation method [3]. The as-prepared NFZO and functionalized multi-walled carbon nanotubes (MWCNTs) were used to prepare NZFO/MWCNT nanocomposites with the 5 wt % of NFZO. First MWCNTs were dispersed in ethanol using ultrasonic waves. Next, the ethanol solution of NFZO was slowly dropped into MWCNTs solution under continuously magnetic stirring. After that, the whole system was heated up to 60 °C and maintained for 4 h. Finally, the material was filtered and dried. The calcination was carried out under argon protection at 300°C. The microstructure, composition and morphology of the nanocomposites were characterized by transmission electron microscopy (TEM/S-TEM). The magnetic properties were investigated with the use of the Physical Property Measurement System (PPMS, Quantum Design) with VSM and VSM Oven options.

The synthesis of the nanocomposites was proved. The TEM/S-TEM image before calcination process reveals the presence of agglomerated NPs with an non-homogenous distribution attached by electrostatic interaction to nanotubes. After calcination visible modification within morphology was noticed. The hysteresis loops of the NFZO/MWCNTs were investigated at 2K, 100K and 300K exhibit typical for SF-NPs thick S-shape. At low temperature small hysteresis with low coercivity (H_C) *is observed suggesting rather ferrimagnetic behaviour, whereas for* $T \geq 100K$ *the possible existence of superparamagnetic (SPM) state with almost zero* H_C *may occur. The observed modification of the saturation magnetization* (M_S) *over annealing can be caused by modification of magnetic interactions due to different morphology.*

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THE WATER-SOLUBLE AMINOFULLERENES. FROM PHOTODYNAMIC THERAPY TO siRNA TRANSFECTION

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Currently, carbon nanomaterials are being developed to treat cancer due to their attractive physicochemical and biological properties such as an enhanced permeability effect and their ability to produce reactive oxygen species. Here, we describe the synthesis of two water-soluble aminofullerenes (MonoaminoC_{60} and HexakisaminoC_{60}), which were evaluated as novel [60]fullerene based photosentizers exhibiting anticancer properties. Mechanistic studies of lipid peroxidation using cholesterol as a unique reporter molecule revealed that although all four fullerene nanomaterials primarily generated singlet oxygen, superoxide anion was also formed, which suggest a mixed mechanism of action (in which Type I and Type II photochemistry is involved). Remarkably, the generation of singlet oxygen and a superoxide radical by HexakisaminoC_{60} was found to be markedly elevated in the presence of bovine serum albumin and NADH, respectively.

Additionally, two water-soluble fullerene nanomaterials (HexakisaminoC_{60} and monoglucosamineC_{60} called here JK39) have been developed and synthesized as non-viral siRNA transfection nanosystems [2]. The ESI-MS and ^{13}C-NMR analysis of JK39 confirmed its high T_h *symmetry, while X-ray photoelectron spectroscopy showed the presence of nitrogen and oxygen-containing C–O or C– N bonds. Efficiency of both fullerene as siRNA vehicles was tested in vitro using prostate cancer cell line DU145 expressing GFP protein. The HexakisaminoC_{60} fullerene was an efficient siRNA transfection agent, decreasing the GFP fluorescence signal significantly in DU145 cells.*

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NANOPARTICLE SIZE EFFECT ON SONOCOATING PROCESS KINETICSAND THE LAYER PROPERTIES

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For more than a decade, ultrasonic technology has been applied with increasing frequency to the process of coating solid, fibrous, or complex material surfaces with nanoparticles (NPs), thereby imparting these surfaces with bactericidal, fungicidal, or bone-tissue-growth stimulation properties. This method, called ‘‘sonocoating”, occurs with objects immersed in a colloidal suspension of NPs subjected to high-power ultrasound. The physical phenomenon leading to coating is the implosion of cavitation bubbles created by ultrasound. Implosion results in high temperature and pressure spots as well as liquid microjets that drive NPs towards the material surface.

In this study, biodegradable polymer substrates were used for coating. Layers of nanoparticles (NPs) were produced from hydroxyapatite (GoHAP). GoHAP NPs were obtained using the hydrothermal microwave synthesis method described in detail by Kusnieruk et al. [1]. Two types of NPs, differing in particle size, were separately selected for coating: GoHAP with the particle size about 15 nm and GoHAP with the particle size about 45 nm. [2].

This work presents the mechanism of formation of the NPs layer deposited by sonocoating, as well as the relationship between the size of NPs used in the coating process and the properties of the deposited layer. The results obtained for 2 types of layers deposited by sonocoating on the surface of biodegradable polymer (PCL) are presented - the first type of layer was deposited with the use of GoHAP NPs with a size of 15 nm, and the second type with the use of GoHAP NPs with a size of 45 nm. The poster presents the kinetics of the NPs layer deposition process depending on the GoHAP NPs size as well as the properties of the obtained layers, such as morphology or contact angle.

In case of hydroxyapatite nanoparticles, the particle size affects the efficiency of the sonocating deposition process as well as the properties of the hydroxyapatite layers. The smaller the NPs size, the faster the NPs layer deposition. Moreover, the smaller the NPs used to produce the GoHAP layer, the smaller its contact angle and the higher the liquid absorption. For this reason, special attention should be paid to the nanoparticle size in the design of new materials for bone tissue regeneration.

Acknowledgments:

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CENTER FOR PRECLINICAL RESEARCH AND TECHNOLOGY - CEPT II

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In 2010 the Medical University of Warsaw (leader), the University of Warsaw and the Institute of High Pressure Physics PAN (Polish Academy of Sciences) institutions along with its seven partners gathered in the CePT Consortium and created a leading center for biomedical research in Europe, consisting of ten closely cooperating environmental research centers [1,2,3]. CePT's scientific activities were focused on the implementation of the research program in three research areas, focused on the issues of the most important civilization diseases. Currently, scientists at CePT are developing new research areas that correspond to the most important global trends in the areas of regenerative medicine, nanomedicine, and advanced diagnostic methods. They are on the list of Priority Research Directions within the Smart Specialization of the Mazowieckie Voivodeship. Therefore, in 2016, the CePT II initiative was created, which concerns the expansion of activities to new research areas, in particular regenerative medicine and nanomedicine [3].

The CEPT II consortium composed of leading Polish institutions supporting new technologies joined forces to increase research activities with the business sector through cooperation in areas such as nanomedicine, regenerative medicine, medical diagnostics and more. The Mazovia Voivodship granted CEPT II funding in the amount of PLN 26,334,894.34 and a total outlay earmarked in the amount of PLN 45,814 271.65 [3,4].

The main goal of the project is to increase the potential for the provision of services and research in the field of advanced technologies for enterprises, support for application research conducted in cooperation with enterprises and to strengthen cooperation between research units and industry.

Moreover, the outcome of the project will be increasing the potential of providing services and research in the field of advanced technologies to the industry sector. For that purpose new high-technology infrastructure was funded including cleanroom facilities for medical products manufacturing and packing processes [1].

Acknowledgements:
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ENHANCED STRENGTH AND DUCTILITY OF ALMGSI10MG ALLOY FABRICATED VIA SLM AND PROCESSED BY ECAP

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Metal additive manufacturing (AM) is a very promising technology that allows the fabrication of complex metallic parts using powders as raw materials. The novelty of AM manifests as somewhat of a disadvantage relative to other manufacturing processes, such as casting; however, this also means that there are numerous interesting development opportunities. Such improvements can be implemented in any of the steps during the metal AM processing chain, i.e., new alloys and powder development, parameter optimization, or post-processing treatment. Currently, the development of new post-processing technologies (e.g., thermal, mechanical, and chemical treatments) [1] [2] [3] is particularly attractive because they may enhance the properties of the components fabricated via AM.

This study investigated the impact of the equal channel angular pressing (ECAP) combined with heat treatments on the microstructure and mechanical properties of AlSi10Mg alloys fabricated via selective laser melting (SLM) and gravity casting. Special attention was directed towards determining the effect of post-fabrication heat treatments on the microstructural evolution of AlSi10Mg alloy fabricated using two different routes. Three initial alloy conditions were considered prior to ECAP deformation: (1) as-cast in solution treated (T4) condition, (2) SLM in T4 condition, (3) SLM subjected to low-temperature annealing. Light microscopy, transmission electron microscopy, X-ray diffraction line broadening analysis, and electron backscattered diffraction analysis were used to characterize the microstructures before and after ECAP. The results indicated that SLM followed by low-temperature annealing led to superior mechanical properties, relative to the two other conditions. Microscopic analyses revealed that the partial-cellular structure contributed to strong work hardening. This behavior enhanced the material's strength because of the enhanced accumulation of geometrically necessary dislocations during ECAP deformation.

Abstracts must be submitted by April 1st 2021, through the official conference web page www.internanopoland.com.

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BIODEGRADABLE POLYMER MATERIALS

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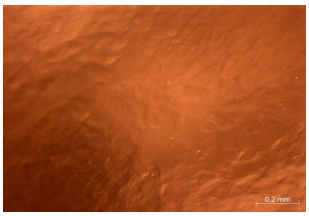
Growing consumption increases the use of polymer materials, e.g. in the form of beverage packaging, bags, plates, cutlery. These materials do not decompose and are deposited in landfills, which has an impact on natural environmental pollution. One of the current global problems is the presence of microplastics in the aquatic environment. The problem of storing plastic waste, have contributed to the search for an alternative to this type of material. For this reason, research has begun on the development of a technology for the production of biodegradable polymers that would replace traditional plastics, but would have similar properties. Since 1995, the production of packaging made of biodegradable polymers, i.e. polymers that decompose in a relatively short time, has started.

The scientific goal of this research was to develop and prepare biodegradable polymer materials, including those based on plant polysaccharides. Biodegradable polymer materials are increasingly used in various industries. As part of the work, the possibility of preparing biodegradable polymer materials from natural raw materials that could replace traditional, non-biodegradable materials was investigated. Uniform and continuous samples of polymeric material based on rice and potato starch were produced, which was confirmed using a stereoscopic microscope (Fig. 1a). Prepared samples of polymeric materials from various starches were tested using a Fourier transform infrared spectrometer equipped with an ATR attachment. The bands originating from vibrations of bonds belonging to the amylose and amylopectin molecules, of which starch is made, were recorded (Fig. 1b).

a) 

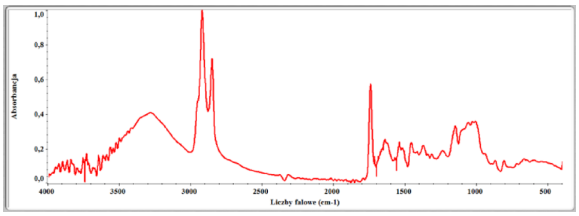
b) 

Fig. 1. Microscopic photo (a) and FTiR spectrum (b) of the prepared uniform layer

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THIN FILMS DEPOSITED BY ALD METHOD IN A MEDICAL INSTRUMENTS

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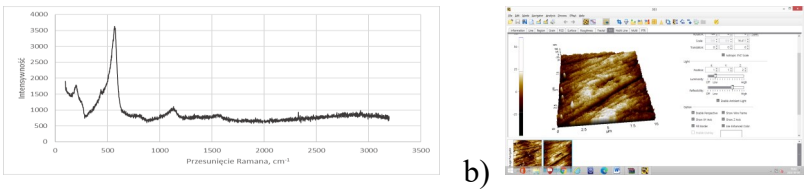
The development of materials science and medicine made it possible to start treatment or replace tissue and organs thanks to the use of biomaterials. For this type of treatment, it requires procedures or operations in which surgical instruments are needed. The design of the tool and the material from which it is made should meet the requirements of: safety, reliability, appropriate mechanical properties, as well as resistance to external factors such as temperature, humidity, impacts, corrosion in the environment of body fluids, disinfectants and drugs. Surgical instruments can be covered with coatings that protect them against corrosion, increase resistance to mechanical wear, reduce friction, reduce tissue damage, reduce the risk of infection and inflammation, allow electric tools to work without lubrication, e.g. toothed wheels in dental drills, and can also act as antireflection function. Coatings applied to surgical instruments play an important role in the health of the patient and in improving the working environment of the surgeon. In practice, tool coatings are primarily applied by chemical and physical vapor deposition methods. Unfortunately, this has its limitations. In the case of applying layers to the surface of porous biomaterials with complex shapes, it is important to carefully control the growth mechanisms, allowing the formation of a very thin layer. The possibility of such control and uniform coverage on all sides of geometrically complex surfaces is provided by the method of atomic layer deposition (ALD). The possibility of depositing thin films by the ALD method on surgical instruments was investigated (Fig. 1).



a) b)

Fig. 1. Raman spectra (a) and atomic force microscope image (b) thin film deposited by ALD

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INELASTIC SCATTERING OF PHOTONS IN THE STUDY OF MATERIALS

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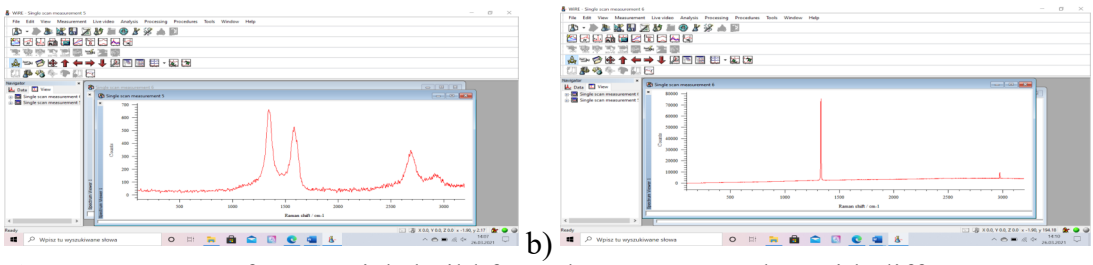
The discovery and description of inelastic scattering in 1928 was a breakthrough in the study of materials, for which C.V. Raman was awarded the Nobel Prize in 1930. This phenomenon is used in Raman spectrometers to conduct research in medicine, chemistry and biochemistry, as well as in forensic science. Thanks to research on the Raman spectrometer, it is possible to obtain information about the molecules that make up the sample, i.e. about the interconnection of atoms. If we have information about elements, which the sample is made of, the analysis of inelastic scattering can show us how these elements are connected with each other. Thanks to this device, it is possible to determine the allotropic variety of a substance composed of the same element or a polymorphic variety of a substance composed of a set of elements. The same atoms linked to each other in different ways have different properties. It is very well visible on the example of carbon atoms, which can be connected with each other in various ways, creating materials with different properties: graphene, graphite, carbon nanotubes (Fig. 1a), diamond (Fig. 1b); or on the example of titanium dioxide (TiO_2), which may have the structure of rutile, brookite, anatase.



a) b)

Fig. 1. Raman spectra for materials build from the same atoms but with different arranged: a) carbon nanotubes; b) diamond

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IMPROVEMENT OF THE PERFORMANCE CHARACTERISTICS OF INDUSTRIAL LUBRICANTS BY NANOADDITIVES –LUBRINAN

1.

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The poster presents basic information about the realisation of the LUBRINAN project. The project focuses on the development of a line of lubricants, in which conventional additives will be replaced or supplemented with nanocomponents. This line will include 3 products commonly used in industry and automotive sector: greases and emulsifying and non-emulsifying machining oils.
The introduction of nanomaterials aims at improving the anti-wear and anti-seizure properties of lubricants at elevated temperature, higher pressure and long operating time of mechanical devices. The results of the research have shown, that it is possible to achieve better operating parameters with much smaller amount of a nanoadditive in comparison with a conventional substance. In machining systems, where the main working medium is water, it is planned to improve the protection against microbial contamination. Better operational parameters will be achieved as a consequence of an effective cooperation between the Consortium Partners: ŁUKASIEWICZ-ICSO and ORLEN OIL and the external experts.
The key issue is the modification of the nanoparticles and the development of an efficient methodology to enter the nanocomponents into the base. The first proposed method of modification considers the production of superconcentrates of the nanoaddtives in the base oil or oil-water base. The second is the physicochemical functionalization of nanoparticles. The lubricants comprising the nanoadditives will undergo detailed physicochemical analysis, with particular emphasis on stability during storage, assessed with spectroscopic methods. The developed lubricants will be subjected to a comprehensive application evaluation under real operating conditions.
The result of the project, the line of lubricants, will be characterized by improved functional parameters compared to those of lubricants currently offered by ORLEN OIL and competitors. As it is beneficial for environmental and economic reasons, it is planned to achieve those parameters while reducing the concentration of conventional substances.
This project is supported by the National Centre for Research and Development, POIR.04.01.04-00-0017/20-00.

TOPOLOGY OPTIMIZATION OF HINGE BRACKET USED IN AVIATION INDUSTRY MADE BY 3D PRINTING TECHNIQUE

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Topology optimization is innovative method which can guarantee massive improvements in part design. It consists in reducing volume of the material subjected to specified conditions. The main requirement is that material has to retain his mechanical properties. Huge advantage of using topology optimization is weight reduction which makes this application very important for aviation industry. Part subjected to topology optimization usually has complex geometry. This technology gives great results especially when is combined with additive manufacturing technology, where geometry does not comprise a problem.

Hinge bracket is a part used in planes. It unites spoilers to the top surface of wings. Hinge brackets allow the spoilers to move upward and downward. This part has to provide adequate strength, stiffness and weight. Properly made topology optimization is crucial for safety of passengers. In this work CAD software was used for topology optimization of hinge bracket. Nowadays programs like SolidWorks provide tools appropriate for this kind of tasks [1, 2].

The aim of the work was to design the hinge bracket in the SolidWorks program and then to optimize its topology. Then simulations were run in a similar way to real conditions. The next step of the work was printing the element using the SLA method from the Rigid 4000 resin and performing strength tests.

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NANOHYDROXYAPATITE FOR BIOMEDICAL APPLICATIONS

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Hydroxyapatite (HAp, $Ca_{10}(PO_4)_6(OH)_2$) is a material that is classified as bioactive, meaning that it will support bone ingrowth and osseointegration when used in orthopeadic or dental applications. It is also an inorganic component of hard tissues such as bones and teeth, which is responsible for strength and stiffness. Due to its good biocompatibility with the human body, it is widely used in biomedical applications. Hydroxyapatite may be employed in forms such as e.g. powders, pastes, porous blocks and component of composites for filling bone defects or voids.

Nano-sized hydroxyapatite is obtained by hydrothermal synthesis using microwave reactor in Clean Room classes ISO8 and ISO7. Microwave energy allows precise control of the reaction temperature and obtained grain size. Obtained nanoparticles have less than 45 nm grain size and big similarity to natural apatite in living organisms. Phase purity was measured using X-ray diffraction. Thanks to scanning electron microscopy (SEM) the morphology of produced nanohydroxyapatite was characterized. The density and specific surface area was determinated using helium pycnomerty and BET method.

The Laboratory of Nanostructures IHPP PAS is able to synthesize innovative hydroxyapatite nanoparticles: GoHAP™. The certification process and marketing of GoHAP™ in the medical market is currently underway.

ACKNOWLEDGEMENTS: The following research was funded by the Centre for Preclinical Research and Technology- CePT II from the Operational Program of the Masovian Voivodship (RPMA.01.01.00-14-8476/17-01).

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THE INFLUENCE OF ZNO OXIDE LAYER ON THE CORROSION BEHAVIOR OF TI6AL4V TITANIUM ALLOY

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Generally, titanium and its alloys haves been regarded as inert and biocompatible materials with good corrosion resistance as a result of the ability to form a TiO_2 oxide layer. However, based on literature data it can be concluded that titanium degradation products, in the form of titanium particles, metal-protein groups, oxides and ions, may cause allergic, inflammatory reactions and bone resorption. The corrosion process of Ti6Al4V in the human body environment may be intensified by a decreased pH and concentration of chloride compounds. Additionally, the chemical and physicochemical character of the surface are responsible for proper cooperation between the metal implant and tissue environmental of the human body. In order to minimalize the toxicity reaction, the surface modification could be performed. The use of inorganic oxide layers in biomedical application has attracted interest due to their high chemical stability, satisfactory biocompatibility and possible high antibacte-rial potential. The purpose of this research was to analyze the corrosion resistance of the uncoated Ti6Al4V alloy and alloy with zinc oxide ZnO layer, deposited by atomic layer deposition method (ALD) in a corrosion solution of neutral pH and in a solution simulating peri-implant inflammatory conditions. The microscopes observation using scanning electron microscope, and the phase constituents analysis using the X-ray diffraction method were performed. Additionally, as part of the assessment of the physicochemical properties of the uncoated samples and those with the ZnO layer, tests of wetting angle, pitting and impedance corrosion were carried out. The number of ions released after the potentiodynamic test were measured using the inductively coupled plasma atomic emission spectrometry (ICP–AES) method. Based on the obtained results it can be concluded that the surface conditions and the pH of Ringer's solution have a significant effect on the corrosion resistance of Ti6Al4V titanium alloy. The optimum physico- and electrochemical properties were recorded for the samples with ZnO layer. The contact angle measurements showed that, the surface modification by the ALD method effected in the increase in wetting angle. The hydrophobic character of the surface and high value of surface free energy are associated with better corrosion resistance and can lead to reduced bacterial adhesion thereby, in effect, reducing biocorrosion.

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SEPARATION, PURIFICATION AND ELECTRICAL CHARACTERIZATION OF LARGE-DIAMETER SINGLE-WALLED CARBON NANOTUBES

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Single-walled carbon nanotubes (SWCNTs) have been among the most intensively researched nanomaterials for the last third decades. While the word "tubes" describes these structures' appearance very well, it does not fully tend to reflect the complexity of these materials. The type of structure of an SWCNT can be quantified by the so-called chiral vector i.e. the conceptual way of wrapping the graphene sheet into such a cylindrical form. This property determines SWCNT properties such as electrical conductivity (metallicity or semi-conductivity) and optical properties. Unfortunately, the scientific community has not developed effective, reproducible, and inexpensive methods of producing monochiral products. Several separation methods, such as electrophoresis, column chromatography, selective polymers dispersion, have been used recently to separate materials with specific properties out of post-synthetic mixtures of carbon nanotubes [1]. However, the mentioned methods require specialized equipment, expensive and sophisticated reagents, making it impossible to implement on a larger scale.

In contrast to them is aqueous two-phase extraction (ATPE) [2]. This method's separation mechanism is based on preferential diffusion of the analyte into one of the two immiscible water phases. With the appropriate selection of the systems' qualitative and quantitative composition, it is possible to separate the SWCNT due to their electric conductivity, diameter size, or chirality type.

In this contribution, we present one-step ATPE extraction for the separation of large-diameters SWCNTs due to their electrical conductivity character [3]. Additionally, we developed a straightforward and effective way to purify the separated fractions from polymers and surfactants. We also measured the electrical properties of obtained pure semiconducting and metallic fractions.

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THE METALLIZATION OF POLYMERS MATERIALS FOR THEIR LIFE EXTENSION

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Classic injection molding of parts made of polymeric materials is very popular because of the ease and low cost of manufacture. As part of the project, it is planned to manufacture its own metalized injection molds using the incremental method dedicated to the micro-injection molding machine. Polymers such as PLA or ABS are susceptible to 3D printing due to their parameters and low manufacturing cost, but they also have many disadvantages such as low heat resistance and low mechanical properties. To overcome difficulties the team has decided on surface metallization developed forms [1-3].

The goal of the project is to develop the process of metallization of injection molds made by the incremental method from a copolymer of acrylonitrile, butadiene, and styrene. It is assumed to use the method of electroless deposition of metallic coatings, it will be necessary to modify it to eliminate environmentally and harmful substances such as chromium from the process, optimize the parameters of individual baths, and develop preparatory procedures of the surface of the forms to get a high-quality form-coating combination. The main goal is to manufacture parts that are resistant to predicted operating conditions.

The team is in the process of developing the optimal parameters printing method that gives the best ratings for durability, production time, and material consumption. The next task will depend on suitable surface preparation. The most important aspect of the obtained coating is its strong adhesion, the appropriate surface roughness will determine it. The development of surfaces with appropriate parameters is another task to be solved.

In the near future, there are plans to purchase other materials that will allow for a better effect of processing, and manufacturing developed forms. There is a chance to produce injection molding forms not only from pure polymers but also from polymers with additions of metallic powders such as copper. Which provides an easier way to find the optimal thermal parameters, because heat dissipation from the injection mold is also a very important aspect.

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METAL OXIDE NANOSTRUCTURES FOR DYE-SENSITIZED SOLAR CELLS

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In a conventional dye-sensitized solar cell DSSC, the photoanode consists of dye molecules anchored to a wide band gap semiconductor deposited on glass coated with transparent conductive oxide (indium or fluorine doped thin oxide; ITO or FTO respectively). The photoanode serves dual functions as the support for sensitizer loading and transporter of photo-excited electrons from sensitizer to external circuit. The mesoporous photoanode film is conventionally composed of TiO_2 nanoparticles (NPs) with a high specific surface area, which is responsible for dye-loading and photoelectron transfer. The photoanode is one of the main components in DSSCs which determines its performance. In this study, different TiO_2 nanostructures, such as NPs and NPs with nanowires (NWs) were used to fabricate dye-sensitized solar cells. Scanning electron microscopy SEM was used to characterize the morphology of the prepared photoanodes. The photovoltaic performance of the fabricated solar cells was further evaluated by measuring the current–voltage characteristic.

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ONE-DIMENSIONAL NANOMATERIALS - POSSIBILITIES OF ELECTROSPINNING METHOD

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The rapid progress that has been made in the field of nanotechnology, particularly in the last sixteen years, has made it possible to develop new technologies for preparing nanoscale objects, including composite and polymeric fibres with small diameters of just several nanometers. Materials in the form of nanofibres are characterised by a considerable length and a small cross-section whose diameter may be approximately 100 times smaller than their length. Due to the large ratio of surface area to mass, nanofibres are also characterised by high specific surface, which in turn provides far better physical properties of such materials in relation to the properties of conventional fibrous materials on the macro scale. The most important methods of polymer nanofibre production include, drawing, template synthesis, phase separation, molecular self-assembly, electrospinning, producing fibres in the electrostatic field.

The most effective technology of all the above-mentioned methods is producing fibres in the electrostatic field, which does not require complicated procedures and expensive equipment. This type of process allows to produce polymer and composite nanostructures on an industrial scale relatively easily and quickly. Unlike other techniques of nanofibre production, the greatest advantage of electrospinning is that, in most cases, the process is carried out at room temperature and in atmospheric pressure, while in order to produce nanofibres, only a properly prepared spinning solution is required, which is usually prepared using a solvent appropriate for a given polymer and a simple magnetic mixer. Thus, it is possible to quickly and cheaply receive fibrous nanostructures with well-defined, controlled morphology as well as a desired chemical composition and structure. Another advantage of this technology is the fact that it is possible to use the majority of the previously known polymers in the world in the process of electrospinning, which perfectly illustrates the application possibilities of the solution electrospinning technology.

The method of nanofibre electrospinning shares most features in common with classical technologies for producing synthetic fibres, which allow the formation and the production of a stream of previously dissolved or melted polymer and its co-axial extension, connected with the transition of the polymer from the liquid to the solid state. Therefore, the technique itself is not a new method, yet it constantly enjoys a remarkable interest due to high application possibilities.

NANOMETRIC ZINC OXIDE THIN FILMS DEPOSITED BY VACUUM METHODS

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Transparent conductive oxides (TCOs) are an important materials category applicable in different kinds of electronic devices, like e.g. flat-screen displays, photovoltaic cells, light-emitting diodes or electrochromic devices. TCOs are characterized by both optical transparency and electrical conductivity [1].

One of the promising material belonging to the TCOs group is zinc oxide. It is a semiconductor from the II -VI groups. Its energy gap is approximately 3.37 eV. This material also demonstrates a high level of transparency for electromagnetic waves with wavelengths above approx. 400 nm [2].

A significant impact on the properties of the deposited layer has the method of its production. In the case of ZnO films, the rise of those layers can be conducted using many different techniques based mostly on physical and chemical processes. The most common are: Sol-Gel, chemical vapour deposition (CVD) and physical vapour deposition (PVD) [3]. The most promising growth methods of ZnO films are: magnetron sputtering and atomic layer deposition, ALD.

This research work aims to analyse how the chosen thin film depositing method and the process temperature impact on the properties of thin zinc oxide films. The ZnO thin films optical and electrical properties, structure, topography and chemical composition have been examined. Analysed ZnO thin film has been deposited using magnetron sputtering and atomic layer deposition techniques.

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A HIGH-PERFORMANCE WOOD

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Construction sector, which is based on traditional materials, generates large quantities of carbon dioxide and impurities, while consuming large amounts of energy. Wood, which was the basic building material for many centuries, nowadays has been almost completely replaced by the steel and concrete due to their better strength properties. The research team under the direction of J. Song conducted, however, some research which demonstrated that the chemical and thermal (physical) modification of wood results in a strength equal to or even exceeding the steel parameters.

Pinewood with a large number of natural defects was selected for the tests to see how these modifications will improve its original parameters. The samples were leached using different aqueous solutions - the best results corresponded to a mixture of 3.75M NaOH and 0.5M Na_2SO_3. During the wood leaching, lignocellulose is partly extracted (leached) which causes formation of the cavity system within the wood, confirmed by SEM tests. With the such established cavity system, the efficiency of hot pressing is higher. The samples that were leached longer demonstrated thus better mechanical properties. The maximum leaching time was 6 weeks.

As a result of the research, wood constructional material samples with increased tensile strength of 122 MPa was obtained. Such strength makes the construction of many engineering objects, e.g., bridge structures, such as footbridges, possible.

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NANOMATERIALS FOR STATE SECURITY AND DEFENSE

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One of the basic human needs is a sense of safety. This applies to different areas of life, but we expect health care and protection of personal safety in the first place. These two socially important aspects of life inspire the research work of the Laboratory of Nanostructures of the Institute of High Pressure Physics, PAS. One of our priorities is manufacturing materials for the police to fight crime and terrorism. In 2018, the Laboratory began to work on dactyloscopic materials as part of the project with the acronym Nanodak. The project is implemented in cooperation with the Central Forensic Laboratory of the Police and the Tomsad Company. The reason for taking up the topic was to increase the level of internal security by developing new methods of visualization of fingerprints, based on the use of nanoparticles. In addition, the improvement of the work comfort of forensic experts and technicians thanks to the use of non-toxic nanopowders. For example, the commonly used aluminium powder (argentorate) can cause neurological and lung diseases. Aerosol formulations with organic particles often contain hazardous volatile substances. Therefore, the project partners set themselves the goal of producing materials for the visualization of fingerprints that will be at least as effective as currently used, and at the same time harmless to the health of users. Two variants of the nanodetector formula have been developed: powder and suspension. Both are based on non-toxic nanoparticles and water is the diluent in the suspension. The concentration of nanoparticles in the air during the application of the preparations is low and short-time lasting. And the respiration fraction level is not risky for the operator. In terms of visualization of traces, the results are very promising, even for the so-called difficult surfaces (furniture board, plastic, etc.). As part of the project, two prototype apparatus stations were created: one for the synthesis of nanoparticles and another for the semi-automatic preparation of nanodetectors. These solutions minimize the impact of the human factor on the course of processes, and in the near future they will enable a quick transition of production from the experimental to the commercial stage. The results of the project confirmed the remarkable utility potential of nanomaterials, and also proved that the most effective method of quick materialization of new ideas is the cooperation of experts from various fields, from research and industrial environments.

Work on nanomaterials for dactyloscopy is funded by Polish National Centre for Research and Development, grant number: DOB-BIO9/08/01/2018, project: "Disclosure of traces of fingerprint with the use of nanoparticles produced using high pressure technologies", as a part of the competition no. 9/2018 for execution of project related to scientific research and development works for the national security and defense.

NANOMATERIALS FOR STATE SECURITY AND DEFENSE

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One of the basic human needs is a sense of safety. This applies to different areas of life, but we expect health care and protection of personal safety in the first place. These two socially important aspects of life inspire the research work of the Laboratory of Nanostructures of the Institute of High Pressure Physics, PAS. One of our priorities is manufacturing materials for the police to fight crime and terrorism. In 2018, the Laboratory began to work on dactyloscopic materials as part of the project with the acronym Nanodak. The project is implemented in cooperation with the Central Forensic Laboratory of the Police and the Tomsad Company. The reason for taking up the topic was to increase the level of internal security by developing new methods of visualization of fingerprints, based on the use of nanoparticles. In addition, the improvement of the work comfort of forensic experts and technicians thanks to the use of non-toxic nanopowders. For example, the commonly used aluminium powder (argentorate) can cause neurological and lung diseases. Aerosol formulations with organic particles often contain hazardous volatile substances. Therefore, the project partners set themselves the goal of producing materials for the visualization of fingerprints that will be at least as effective as currently used, and at the same time harmless to the health of users. Two variants of the nanodetector formula have been developed: powder and suspension. Both are based on non-toxic nanoparticles and water is the diluent in the suspension. The concentration of nanoparticles in the air during the application of the preparations is low and short-time lasting. And the respiration fraction level is not risky for the operator. In terms of visualization of traces, the results are very promising, even for the so-called difficult surfaces (furniture board, plastic, etc.). As part of the project, two prototype apparatus stations were created: one for the synthesis of nanoparticles and another for the semi-automatic preparation of nanodetectors. These solutions minimize the impact of the human factor on the course of processes, and in the near future they will enable a quick transition of production from the experimental to the commercial stage. The results of the project confirmed the remarkable utility potential of nanomaterials, and also proved that the most effective method of quick materialization of new ideas is the cooperation of experts from various fields, from research and industrial environments.

Work on nanomaterials for dactyloscopy is funded by Polish National Centre for Research and Development, project no. DOB-BIO9/08/01/2018, project title: "The detection of latent fingerprints with the use of nanoparticles produced using high pressure technologies", (acronym NANODAK), competition no. 9/2018 for execution of project for purpose of national security and defense.

THE CONCEPT OF A CLAMP REUSABLE THAT SEALS THE MASK AND PREVENTS THE GLASSES FROM FOGGING

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The current world situation forces us to use protective masks every day. Unfortunately, most of them do not provide sufficient protection, especially in the nasal area, where the mask does not adapt to the shape of the nose. This creates two problems: the first one is the lack of tightness and thus a higher probability of spreading microorganisms, the second problem is faced by people using glasses because the airflow causes them to fog, which in some cases may create dangerous situations, e.g. while driving, operating machinery, etc. [1, 2]

The aim of our project was to create a clip, mounted to the mask, that would be safe for every skin type - also for allergic skin - and would ensure sufficient adhesion of the mask to the face. When choosing the most optimal solution, we focused primarily on the comfort and safety of the user, but we also tried to make the material as ecological as possible. Secondly, we focused on the availability of the finished product and its affordability, i.e. it was made of inexpensive materials.

The prototype of the clip was prepared in the AutoDesk Inventor environment, where its physical properties and durability were tested. Combining the low price of the material with its high strength was particularly difficult - the introduction of reinforcement in the form of fibers proved to be helpful. Another obstacle was working out the appropriate geometry of the product. We paid great attention to make the clamp comfortable for the user. Designing a proper geometry, which fulfills all of the criteria, required various tests and eliminations of design flaws.

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ZINC OXIDE NANOSTRUCTURES DOPED EUROPIUM AND YTTRIUM IONS FABRICATED VIA ELECTROSPINNING

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One-dimensional nanomaterials currently play a key role among all functional nanomaterials due to their properties, including high surface area-to-volume ratio and low-cost manufacturing methods. One of the most efficient methods of producing one-dimensional nanostructures is electrospinning, which allows for the production of nanofibers with diameters in nanometer ranges, high quality and desired properties. Electrospun nanofibers are currently used in photocatalysis, solar cells, water purification processes, or as drug delivery systems in the human body [1].

The purpose of this work was manufacturing process of one-dimensional nanostructures via hybrid method combining sol-gel technique of preparing spinning solutions, electrospinning process of producing organic-inorganic nanofibers and high-temperature treatment in order to remove all organic compounds from nanofibers. The spinning solution was prepared based on ceramic precursors in form of zinc acetate, europium chloride and ytterbium chloride, and polymer used to give viscous properties of solution was polyvinylpyrrolidone. The calcination process was carried out in a high-temperature furnace at 600°C in the air atmosphere.

In order to investigate the obtained ZnO - doped europium and yttrium ions nanostructures, morphology and structure of produced 1D nanomaterials were examined using scanning and transmission electron microscopy. Fourier transform infrared spectroscopy was used to study chemical and structural characterization of nanomaterials.

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SYNTHESIS AND ANALYSIS OF MORPHOLOGY, STRUCTURE AND OPTICAL PROPERTIES OF BISHMUTH (III) OXIDE NANOWIRES

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The purpose of this article was to produce two types of thin films via the spin-coating and electrospinning process from a polyartylonitryle (PAN)/bismuth acetate dihydrate Bi(NO3)3/and dimethylformamide (DMF). The obtained nanomaterials in the form of thin films and fibrous mats which contain composite nanofibers were calcined at temperatures ranging from 400 to 600°C to remove the organic phase. The two -dimensional bismuth oxide nanostructures were studied using a scanning electron microscope (SEM) and a transmission electron microscope (TEM) to analyse the influence of the used temperature on the morphology and structures of the obtained ceramic nanomaterials. In order to examine the chemical structure of produced two types of thin films, the energy dispersive spectrometry (EDX) was used. Besides, a thermogravimetric analysis (TGA) was performed to show the polymer concentration loss in a function of temperature in order to obtain pure bismuth oxide nanomaterials. The optical property analysis was performed on the basis of UV-Vis spectra of absorbance as a function of the wavelength. Using the modified Swanepoel method, which the authors proposed, and the recorded absorbance spectra determined the banded refractive index n, real n' and imaginary k part of the refractive index as a function of the wavelength, complex dielectric permeability ε, real and imaginary part ε_r and ε_i of the dielectric permeability as a function of the radiation energy of the produced Bi_2O_3 thin films.

The PAN/Bi_2O_3 composite nanofibers were produced by electrospinning. The average fiber diameter was about 117 nm. The material has a porous structure, very branched, in some places a material allowance is visible due to too low viscosity of the solution.

Calcination of fibers at 400 ° C and 600 ° C resulted in the production of Bi_2O_3 ceramic nanowires. Nanowires have a smaller diameter than the composite nanofibers because the polymer has been degraded. Based on the results, it can be concluded that the calcination temperature affects the morphology of the materials.

The carried-out analysis of the optical properties of thin layers of the manufactured nanowires showed a high degree of absorption of electromagnetic radiation of the UV range. In addition, designated energy gap values of the tested Bi_2O_3 nanostructures, in the order of 2.47 eV and 2.19 eV, suggested that such materials can find a wide range of applications, with particular emphasis put on electronic industries, substrates of computer chips and solar cells.

THE MODERN ENGINEERING MATERIALS USED IN ELECTROCHEMICAL ENERGY STORAGE DEVICES AND RECYCLING ANALYSIS

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Energy storage devices are a very important element of the modern world. They are used to collect electricity obtained in power plants using renewable energy sources, electric vehicles, and portable electronic devices. The first part of the poster deals with the use of innovative materials in electrochemical energy storage devices. The use of modern engineering materials in the construction of such devices improves their parameters. After applying material modifications, the cell capacity, efficiency, and production costs increase.

In Lithium-Ion batteries, anodes made of carbon material (graphite) are replaced by anodes made of a modern porous silicon material. The cells containing silicon anodes have a capacity 70% greater than a traditional Li-Ion battery with a carbon electrode. Modern Li-Ion cell cathodes have lithium iron phosphate instead of lithium cobalt oxide (LixCoO2). The use of a lithium-phosphorus compound ensures a reduction of production costs and safe use of the batteries. The poster also describes the modification of the supercapacitor's active materials. Also, modern materials are environmentally friendly. The second part of the poster contains information on the collection of waste batteries and accumulators in EU countries and a comparison of recycling processes. Two technologies, hydrometallurgical and pyrometallurgical, are an important part of the recycling of electrochemical cells. Both technologies are used worldwide to recycle Li-Ion cells. The pyrometallurgical technology is used by Umicore, and the hydrometallurgical technology by AEA Technology, Recupyl, and Retriev [1-3].

Recycling batteries is a very important issue because of the potential contamination of the environment by the toxic and harmful materials they contain. Batteries containing innovative active materials have better parameters than cells with older solutions. The poster presents modern material solutions and the processes of recovery of valuable raw materials contained in accumulators and batteries.

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THE CONCEPT OF A ANTIVIRUS HANDLE REUSABLE USE TO COUNTER THE SPREAD OF COVID-19

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Nowadays, when most people's lives were affected by the pandemic of COVID-19, more and more effort is put into reducing microorganisms spread. A big part of society is worried about using public surfaces (e.g. handles, elevator buttons, railings) in case of some potential virus vectors who had contact with them. Great popularity gained disinfectant liquids, one-time gloves, various tissues, and wipes but experience has shown us that it isn't a long-time solution. That's how we started a project aimed at raising personal protection against microorganisms as an alternative to mentioned methods [1].

The main antivirus handle's task is to allow safe contact with public surfaces in a fast and effective way. From the beginning, the project assumed being portable, easy to use, and reusable for increasing its ecological values. The primary part of the handle is a piece of ecological and non-absorbing moisture material, we name it holder, that protects our skin from the surface which is being touched. The holder includes special tabs for fingers to improve convenience and stability in use. The second part of the handle is a casing for the holder which contains a cartridge sprayed with a nanosilver layer. Cartridge's objective is to eliminate microbes seated on the holder. Both holder and the cartridge are exchangeable in case of wear or breakage. Materials selected for producing the handle must meet the ecological criterion. Another important criterion is to make the handle enough portable to carry it in a pocket or use it as a keychain.

The antivirus handle provides high self-protection and good utility values. It perfectly fills the gap in popular precautionary measures and has a chance for helping people in mass use.

The next step in our research is to improve the system of hiding the holder in the casing. We discovered few problems with a winding mechanism that collides with a cartridge. The handle is still in a prototype phase and for sure new shortcomings will appear.

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The project carried out as part of the Student Scientific Circle of Plastics and Composites Processing "HEAD TO HEAD"

NATURAL FILLER-REINFORCED BIODEGRADABLE COMPOSITES USED IN THE FOOD PACKAGING INDUSTRY

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Wood-polymer composites (WPCs) are a group of composites with a thermoplastic or thermosetting matrix and a wood filler used as reinforcement. They are mainly formed by injection moulding or extrusion technology. The advantages of WPCs are good mechanical properties, including high stiffness, as well as low weight and cost. Wood-polymer composites are used in the automotive industry, as extruded profiles for windows, doors, railings, platforms, floor panels, and stairs, as well as for everyday items such as flower pots, toys, or packaging [1, 2].

The aim of the research work was to create an eco-friendly, fully biodegradable material that can be used in food packaging. The composite was formed by combining a thermoplastic polymer BIOPLAST GS 2189 and wood particles used as filler. Matrix polymer produced by BIOTEC GmbH & Co. is a completely biodegradable material in an industrial composting environment. Moreover, it contains 75% of renewable raw material. As the reinforcing phase, the sawdust from deciduous trees (oak, ash) with a size of 160-500 mm was used. This study considered samples made of raw polymer and different percentage content of wood filler i.e. 5%, 10%, 15%, 20%.

The effects of reinforcement volume fraction on mechanical properties and water absorption of the composite were investigated. Microscopic observations of material structure, as well as the interface between the matrix and reinforcing phase, were carried out. It was found that with the increasing amount of wood particles the hardness, Young's modulus, and the water absorption increased. On the contrary, the impact strength and the bending strength decreased. Microscopic observations showed an even distribution of the filler and good adhesion between the polymer matrix and reinforcement particles.

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THE APPLICATIONS OF $A^{15}B^{16}C^{17}$ NANOWIRES AND THEIR NANOCOMPOSITES FOR SENSORS AND ENERGY HARVESTING

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The continuous development of the economy, related to urbanization and the growth of the population, entails an increasing energy demand. Renewable energy sources have become more and more popular due to the pollution of the environment caused by fossil fuels (coal, oil, gas, etc.). They allow not only to obtain green energy but also to become independent from imported fuels and energy. Among the widely available and underrated energy sources are the human body motions, vibrations, pressure changes, acoustic waves, and other mechanical energy forms.

Among the most interesting materials having a wide range of interesting properties are $A^{15}B^{16}C^{17}$ compounds. Their main representative and at the same time the best known, examined, and characterized is antimony sulfoiodide (SbSI). The greatest interest in this compound is due to its piezoelectric properties discovered by Berlincourt in 1964 [1]. The presented values of the electromechanical coefficient (k_{33} = 0.8) and the maximum value of the piezoelectric modulus ($d_{33}=2\cdot10^{-9}$ C/N) for the SbSI single crystal put it at the forefront of known piezoelectric materials. For this reason, this compound is an excellent material for piezoelectric sensors and energy harvesters.

In this presentation, the application of SbSI and SbSeI nanowires, as well as their composites with different matrix materials: epoxy resin [2], cellulose [3], PAN [4], PVP, and PVDF [5] in sensors and for energy harvesting will be discussed.

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SURFACE TREATMENT OF Al-Si-Cu ALLOYS BY DEPOSITED HYBRID PVD+ALD COATINGS

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The need to maintain a high pace of research on light metal alloys, and in particular aluminum alloys, is dictated by the high popularity of these materials in the industry. The main consumer of aluminum alloys is the automotive and aviation industries, where an important role is played by reducing the weight of vehicle components while ensuring their high mechanical and physicochemical properties. Surface treatment allows giving materials high surface properties while maintaining relatively low properties of the substrate because often the exploitative properties of the entire element are determined not so much by the possibility of transferring loads through the entire active cross-section of the material, but by their mechanical and physicochemical properties of the surface [1,2].

The main objective of the research is to investigate the effect of the conditions for the production of WC-C/TiO_2 and CrN/TiO_2 coatings obtained in a hybrid process combining PVD and ALD technologies. The eutectic Al-Si-Cu alloy was the substrate for the coatings under test. The TiO_2 layer was made by the ALD method with a variable number of cycles, i.e. 200, 500, and 1000 cycles. Besides, the uncoated substrate and coated with PVD coatings of WC-C and CrN type. Structural studies were performed using SEM, TEM, and AFM microscopy. The analysis of the chemical composition in the micro-areas was performed using the EDS spectroscopic method. The tribological properties of the Ball-on-plate method and electrochemical properties of the potentiodynamic method and EIS spectroscopy were investigated.

As a result of tribological tests, an adverse effect of TiO_2 layers obtained by the ALD method on the modified PVD coatings was found. Particularly in the case of WC-C coatings modified with a TiO_2 coating, the reduction in wear resistance drops significantly. The cross surface area of the WC-C coating without the layer is 413 μm^2, and with the TiO_2 layer, it is in the range from 37309 μm^2 to 43280 μm^2. As a result of electrochemical tests, it was found that hybrid layers show much better anti-corrosion properties than PVD coatings and uncoated substrates. The polarization resistance for the WC-C/TiO_2(500) hybrid coating is 76250 $\Omega \times cm^2$, and the WC-C coating without the ALD layer is 2300 $\Omega \times cm^2$. Moreover, the SEM observations of the samples after tribological and electrochemical tests made it possible to identify the mechanisms of damage caused during the tests.

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EFFECT OF NANOFUNGICIDES ON NON-TARGET SOIL MICROORGANISMS

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Intensive studies focus on the synthesis and characterisation of nanomaterials that should be used in agricultural management. In theory, they are considered safer than conventional pesticides due to nanoformulation processes which results in a slower release of an active substance and/or the solubility increase in water poor soluble compounds. As a result, the efficiency of nanopesticide should increase and the concentration of effective dose – decrease [1]. Unfortunately, based on the current studies, the fate of nanopesticides applied in the environment and their unintended toxicological effect on non-target organisms is not possible to evaluate [2].

Therefore, the aim of this study was to assess the toxicity of newly synthesised captan fungicides bound with $ZnO_{35\text{-}45nm}$ and $SiO_{2\ 20\text{-}30nm}$ nanocarriers to non-target soil microorganisms during a 42-day mesocosm study. The physicochemical properties of nanofungicies were determined by the microscopy techniques (SEM, EDX, EDS). The total number of bacteria, was enumerated using the qPCR approach based on the 16S rRNA gene copy number. The changes in functional and structural biodiversity of the bacterial community were established by the Biolog (community level physiological profiles) and Phosholipid Fatty Acids (PLFA) methods, respectively.

All tested materials – captan, SiO_2 and ZnO nanocarriers, and captan/SiO2 and captan/ZnO nanopesticides significantly reduced the total number of soil bacteria 42 days after application. Nevertheless, analysis of the structural and functional diversity of microbial communities was not so distinct and revealed higher variation between soil samples than changes exerted by tested nanomaterials. The only active substance, fungicide captan, significantly changed the microbial structure after 42 days of the experiment. Obtained data shows that the application of nanomaterials may exert a toxic effect on some non-target microbial groups, and additional methods should be implemented to evaluate the effect of nanofungides on non-target soil microorganisms.

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TEST METHODS FOR DETERMINATION OF NANO-OBJECTS RELEASED FROM COMMERCIALLY AVAILABLE MATERIALS

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Nanomaterials are used to obtain specific product functionality. For example, nanosilver is mainly used due to its antibacterial properties and titanium dioxide has photocatalytic properties, which is used e.g. in self-cleaning coatings and air treatment.

Nanomaterials, in addition to their benefits, can pose a potential human health risk. The effects depend on a number of factors, such as: the size and shape of the particles, their surface area, solubility, degree of agglomeration, etc. The human respiratory system is the main way of occupational exposure to nanomaterials [1]. Therefore, nano-object release from nanomaterials and products containing them is a concern during their whole life cycle, i.e. from the production stage, through the use by the end user and, finally, degradation or utilization [2].

Knowledge about nano-object release from products might be useful, for example, for product developers or risk manager. It is therefore crucial to test the release of nanomaterials from various products in a controlled environment. Many methods of testing the release of nano-objects from nanomaterial-based products are described in the literature and available international standards. These methods depend mainly on the form of the product (e.g. powder, solid product, pure nanomaterial, composite), the process to be simulated during the test and the environment to which the nano-objects are released (air, water, soil) [3].

The Central Institute of Labour Protection - National Research Institute carries out research in the field of nanomaterials, particularly for the protection of employees and end users who might be exposed. In the Laboratory of Nanoaerosols, which is a part of the Aerosols, Filtration and Ventilation Laboratory, a test stand is currently being developed to determine the emission of nano-objects from functional materials coated with functional layers and from composites containing nanomaterials. The stand will allow to test the release of nano-objects while simulating various activities, e.g. abrasion, friction, impact of samples. Tension will also be simulated for textile samples. The study of the release of nano-objects will be carried out in a sealed test chamber with the use of SMPS, DiscMini and other counters. One of the parameters studied in the Laboratory is also the dustiness of nanomaterials.

This paper has been based on the results of a research task carried out within the scope of the fifth stage of the National Programme “Improvement of safety and working conditions” partly supported in 2021–2022 — within the scope of state services — by the Ministry of Economic Development, Labour and Technology. The Central Institute for Labour Protection – National Research Institute is the Programme’s main co-ordinator.

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TRANSPORT AND SEPARATION PROPERTIES OF MMM DOUBLE-POLYMER (PCL/PLA)MEMBRANES WITH DISPERSED HALLOYSITE PHASE

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Transport and separation properties of mixed matrix membranes with the dispersed halloysite nano-filler (in respect to humic acids from their aqueous solutions) were determined experimentally. Effects of chemical composition of the continuous (two-polymer) phase and selected decisive parameters of the potential technological process of membranes production were identified.

The optimal parameters for the selected manufacturing methods (sol-gel method, wet phase inversion method), as well as chemical composition of the two-polymer and halloysite suspension were determined. The following parameters were investigated: type of organic solvent used (DMF, THF), the proportions of both polymers in the membrane-forming solution - polycaprolactone (PCL) and polylactide (PLA), total concentration of both polymers in the solution (continuous membrane phase) and the concentration of halloysite nano-filler (membrane dispersed phase) in the suspension. Also analysis of the selected properties of various potential fillers (e.g. preprocessed halloysite), determination of the transport and separation capacity of various membrane structures (single and two-polymer, with and without the halloysite dispersed phase) in respect to the aqueous solutions of humic acids, as well as SEM / EDS analysis and strength tests of the structures of membrane samples produced in various process conditions were done.

The best mixed matrix membrane demonstrated the following characteristics – composition 20% (10% PLA +10% PCL), halloysite concentration 5 %. For this membrane feed flux was 2,6 cm^3/min, whereas separation efficiency in respect to humic acids was 95.88%.

The membranes test results, chemical and morphological composition, as well as their structure and mechanical resistance to stresses allowed one to determine the structural differences between the manufactured membranes depending on the selected production method and its dedicated parameters, composition of membrane-forming solutions / suspensions and the conditions under which the tests were carried out.

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THE ELECTROSPUN 2D NANOMATERIALS AND THEIR APPLICATION POSSIBILITIES

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Over the last fifteen years, one-dimensional structures have been particularly popular in the field of both scientific research and expected wide application possibilities. Unlike other zero-dimensional, two-dimensional, or three-dimensional nanostructures, nanowires have two limited quantum directions resulting from their nanometer diameter due to which electrons can easily move in a precisely defined direction, which is determined by the length of a single nanowire. This allows for the use of this structure in elements in which the main challenge is to conduct electricity excluding the tunneling transition. In addition, due to very high energy densities occurring in single-dimensional oxide nanomaterials resulting from the nanometric diameters of individual nanowires, these materials exhibit extremely different and better optical, magnetic, and electrical properties in abducting their counterparts in the micrometer scale.
Nanomaterials in the form of nanofibers, nanowires or nanorods are characterised by a considerable length and a small cross-section whose diameter may be approximately 100 times smaller than their length. The most effective technology of production of 2D nanomaterials is producing fibres in the electrostatic field, which does not require complicated procedures and expensive equipment. This type of process allows to produce polymer and composite nanostructures on an industrial scale relatively easily and quickly. The electrospun 2D nanostructures were studied using scanning electron microscope (SEM) and transmission electron microscope (TEM) to analyse the influence of used temperature on the morphology and structures obtained ceramic nanomaterials. In order to examine the chemical structure of obtained electrospun 2D thin films, the energy dispersive spectrometry (EDS) was used. Optical property analysis was performed on the basis of UV-Vis spectra of absorbance as a function of wavelength. Using the modified Swanepoel method which the authors proposed and the recorded absorbance spectra determined banded refractive index n, real n' and imaginary k part of refractive index as a function of wavelength, complex dielectric permeability ε, real and imaginary part εr and εi of the dielectric permeability as a function of the radiation energy of the produced electrospun 2D thin films.