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9th INTERNATIONAL CONGRESS ON BIOMATERIALS AND BIOSENSORS (BIOMATSEN 2024)

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Livia Alexandra Dinu	National Institute of Research and Development for Microtechnology, Romania
Mingjun Xie	Zhejiang Provincial People's Hospital, China
Marek Godlewski	Polish Academy of Sciences, Poland
Sanjairaj Vijayavenkataraman	New York University Abu Dhabi, UAE
Arcady Zhukov	University of Basque Country, Spain
Anil Koklu	ASELSAN, Turkiye
Olga Pechanova	Slovak Academy of Sciences, Slovakia
Taras Kavetskyy	Slovak Academy of Sciences, Slovakia
Kerry J Lee	Florida Gulf Coast University, USA
Owen J Guy	Swansea University, UK
Vasa Radonic	BioSense Institute, Serbia
Darya Alontseva	D. Serikbayev East Kazakhstan Technical University, Kazakhstan
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Kerry J. Lee	Florida Gulf Coast University, USA
Sivashankar Krishnamoorthy	Luxembourg Institute of Science and Technology (LIST), Luxembourg

9th International Congress on Biomaterials and Biosensors

PLENARY PRESENTATION

Id-493

Enzyme and Carbon Nanotube Devices Using Floatable Diatom Frustules as a Nanoporous Silica

K. UMEMURA

Department of Physics, Tokyo University of Science1-3 Kagurazaka, Shinjuku, Tokyo 1628601, Japan

Corresponding Author: meicun2006@163.com

Abstract: Diatom frustules are natural nanoporous biosilica. Specific gravity of living diatom cells is around 1.3 because of the nanoporous structures of frustules. Thus, frustules float in a solution long time although it will be settled if a frustule suspension is stored overnight without stirring.

In this work, we employed frustules as a support to attach enzymes and single-walled carbon nanotubes (SWNTs).[1-3] When papain enzyme molecules were attached onto frustule surfaces, the papain device could permanently float without stirring in a buffer solution during the enzyme reaction at 37 and 60 degrees. Other supports such as diatomite, mesoporous silica, and glass beads rapidly settled without stirring. The papain frustule device revealed better relative enzyme activities because of the low specific gravity and large surface area to attach papain molecules.

When SWNTs dispersed with DNA molecules were attached on frustule surfaces, the SWNT frustule device could be applied to biosensing. For example, near-infrared photoluminescence (PL) of SWNT on a frustule was drastically changed when small amounts of oxidants or reductants were injected to the suspension of SWNT frustule device. Furthermore, antioxidant abilities of several biomolecules such as papain and saponin could be well detected by using PL of the SWNT frustule device.

The frustule devices could be well recovered by simple centrifugation after the use. Re-use of the recovered frustule devices were available for five to seven times. The frustule device is flat structures although many of micron size supports for biomolecules are spheres. Thus, the frustule device could be easily observed by various microscopes such as atomic force microscopes and digital holographic microscopes.

In summary, our results indicated various advantages of diatom frustule. We hope our results provided helpful information to develop micron size biodevices.

Keywords: Frustule, Papain Single-Walled Carbon Nanotube.

PLENARY PRESENTATION

Id-497

A Real BandAId™: Incorporating Artificial Intelligence (AI) into Biomaterials, Nanotechnology, Sensors, and Medicine

T. J. WEBSTER

School of Health Sciences and Biomedical Engineering, Hebei University of Technology, Tianjin, China and Interstellar Therapeutics, Mansfield, MA USA

Corresponding Author: websterthomas02@gmail.com

Abstract: Artificial intelligence (AI) has already revolutionized numerous industries, yet, its use in nanotechnology and biomaterials is almost non-existent. This invited presentation will provide a summary of how AI can be used to design better biomaterials for various biomedical applications. In particular, AI is being used in implantable nano sensor design to prevent, diagnose, and treat various diseases from cancer to infection. Specifically, here, implantable sensors were designed, fabricated, and tested. Such sensors can detect the type of cell that attaches to an implant, communicate such information to a handheld device, and respond to ensure implant success. In particular, such sensors have been tested in animal studies in which sensors were inserted into the calvaria of rats, bacteria purposedly injected, and sensors used to detect bacteria presence as well as on-demand release antibiotics to eliminate infection. Further, AI has been used in such sensors to predict what types of drug delivery vehicles will be most effective for that particular patient based on prior patient health data and real time response to therapies. It is well known that due to variations in immune systems from patient to patient, patients will respond differently to the same biomaterial and drug treatment, thus, personalized or tailored treatments are necessary and can result from AI. In vitro, in vivo, and human clinical studies will be presented in which AI has already improved medicine. In this manner, this presentation presents a positive view on the implementation of AI into medicine via sensors showing how it can be used to improve disease prevention, diagnosis, and treatment.

Keywords: Green, Environmentally Friendly, Natural, Cell Produced**.**

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INVITED PRESENTATION

Id-485

ZnO-based Markers Activated with Rare Earth Ions for Theranostic Applications

M. GODLEWSKI[1,*], J. KASZEWSKI[1], J. ROSOWSKA[1], P. KIEŁBIK[2], M. M. GODLEWSKI[2]

[1]Institute of Physics, Polish Acad. of Sci., Al. Lotników 32/46, 02-668 Warsaw, Poland

[2]Department of Physiological Sciences, Faculty of Veterinary Medicine, Warsaw University of Life Sciences – SGGW, Nowoursynowska 159, 02-776 Warsaw, Poland

*Corresponding Author: godlew@ifpan.edu.pl

Abstract: Nanoparticles of wide band gap ZnO (and also of ZrO_2) after activation with rare earth (RE) ions were tested by us for application as fluorescence markers (FMs) allowing early detection of cancer. ZnO host (and also ZrO_2) were selected due to bio-safety of the material. It will be explained first why doping with selected RE ions results in an efficient and spectrally sharp photoluminescence (PL) in a visible light spectral region. In early studies we concentrated on the methods of introducing selected markers to organisms, and proved selectivity of our method. An effective trafficking of FMs to the areas of lung cancer was thus observed, whereas surrounding tissue was impermeable for nanoparticles. The data obtained confirm 100% selectivity of the method. In next step we demonstrated that markers developed by us can also be used as magnetic resonance imaging (MRI) contrast agents. The new are of the research focused on use of developed markers as transport agents, transporting a given medicine to area of tumor. A directed therapy turned out to be possible, proving theranostic properties of markers.

Keywords: Oxides, Nanoparticles, Fluorescence Labels, MRI, Cancer.

9th International Congress on Biomaterials and Biosensors

INVITED PRESENTATION

Id-486

Graphene and Silicon Chip Technologies for Biosensing Applications

O. J. GUY[1], D. W. GILLARD[1,*], M. ABDELKARIM[1]

[1]Swansea University, Centre for integrative semiconductor materials (CISM) and Dept. of Chemistry, Swansea University, United Kingdom

*Corresponding Author: 904871@swansea.ac.uk

Abstract: Semiconductor fabrication processes have been used to develop a number of biosensing technologies including Silicon Nanowire biosensors, Graphene-based biosensors, photonic biosensors, microneedle-based sensors and integrated microfluidics for lab-on-chip devices.

This invited talk will review the noteworthy contributions from Swansea University in the development and application of semiconductor-based biosensor technologies. The talk will explore the potential of nanowire and graphene platforms for the detection and monitoring of biomolecules with high sensitivity and specificity and highlight some of the challenges involved.

The utilization of graphene's unique electronic, mechanical, and biocompatible properties in particular, has led to the creation of a range of novel biosensing devices. The design, fabrication, and optimization of graphene-based sensors for the detection of various biomolecules, including proteins, DNA, and other bioanalytes will be presented. The work highlights the integration of graphene with diverse sensing modalities, such as electrochemical, field-effect transistor (FET), and waveguide techniques.

The talk will also discuss advancements in the functionalization of silicon and graphene surfaces to enhance biorecognition and the development of robust sensing platforms. Additionally, the abstract explores the application of these graphene biosensors in medical diagnostics, environmental monitoring, and food safety. Furthermore, the talk will address critical challenges in the field, such as scalability, reproducibility, long-term stability and multiplexed detection.

Keywords: Graphene, Silicon, Biosensors, Microneedles.

INVITED PRESENTATION

Id-488

Innovations in Gold Electrode Manufacturing for Cost-effective Biosensors

V. RADONIĆ[1,*], I. KUNDACINA[1], V. BENGIN[1]

[1]BioSense Institute, Serbia

*Corresponding Author: vasarad@biosense.rs

Abstract: Biosensors are advanced analytical tools that show potential for revolutionizing applications in fields ranging from healthcare to environmental monitoring in terms of rapid and specific detection of the target element in small amounts of liquid samples. In general, biosensors use immobilized biorecognition elements such as antibodies, aptamers, enzymes, flagella, etc. at the substrate surface for specific target detection (bacteria, biomolecule, etc.) through a chemical or physical transduction. Due to their high sensitivity and simplicity of usage, electrochemical biosensors show the biggest potential for commercial applications with still challenging tasks associated with massive electrode fabrication and bioconjugation procedures. Recent studies show that gold stands out as the most suitable substrate for electrochemical biosensors due to its chemical and mechanical stability, and affinity for binding molecules modified with thiol group.

In recent years, various fabrication technologies have been proposed for the massive production of gold electrodes. Conventional methods such as chemical vapor deposition, and physical vapor deposition combined with shadow mask or photolithography require a cleanroom facility, expensive equipment, and generate chemical waste which has to be additionally treated. This method produces thin film of the gold layer which is not easy to handle and can be damaged easily. Other methods such as inkjet printing and screen printing require sintering of the ink, which limits the substrate choice, and increases the price of the electrode together with the high price of the printer and ink. Screen printing is the most used technology for the massive production of gold electrodes. However, the reproducibility of the electrodes is still a challenging task due to the screen imperfections, while the organic components and impurities in the ink can interfere with biosensing layers.

This study presents novel biosensor cost-effective solutions based on an affordable method for the rapid fabrication of electrochemical biosensors using a combination of hot lamination of 24-karat gold leaves and low-cost polyvinyl chloride adhesive sheets and laser ablation to pattern gold leaf electrodes (GLEs). The proposed technology produces high conductivity and large surface area and explores various immobilization strategies for a range of biorecognition elements applicable to environmental monitoring, healthcare, and food safety. Surface properties of GLEs were examined utilizing scanning electron microscopy, optical profiler, and contact angle measurements while electrochemical properties of GLEs were evaluated through cyclic voltammetry and electrochemical impedance spectroscopy. The potential of proposed GLE is demonstrated in the development of different type of biosensors biofunctionalized with different types of biomolecules: aptamers, antibodies, and flagella. Number of applications will be presented which includes

aptamers-based biosensors for pathogens detection, antibodies-based sensors for animal hormone stress monitoring, flagellin-based sensor for heavy metal detection, aptamers-based sensors for tumor biomarkers detection.

Keywords: Gold Leaf, Fabrication, Biosensors, Pathogens, Hormone, Heavy Metal.

INVITED PRESENTATION

Id-490

Simvastatin- and Coenzyme-Q10-loaded Polymeric Nanoparticles Increased Nitric Oxide Synthase Activity via the Akt-eNOS Pathway in Obese Zucker Rats

O. PECHANOVA[1,*], E. SAMAN[1], A. BARTA[1], M. CEBOVA[1]

[1]Institute of Normal and Pathological Physiology, Centre of Experimental Medicine, Slovak Academy of Sciences, Sienkiewiczova 1, Bratislava, Slovakia

*Corresponding Author: Olga.Pechanova@savba.sk

Abstract: Metabolic syndrome is a serious medical condition that increases the risk of heart disease, diabetes, stroke, and atherosclerosis. Statins are among the drugs of the first choice used to treat the symptoms of metabolic syndrome. Besides the LDL-cholesterol-lowering effect, statins have pleiotropic beneficial effects on the cardiovascular system. However, long-term treatment with statins may be associated with serious side effects. With the aim to streamline the statin therapy, a copolymer of poly(ethylene glycol) methacrylate with N-vinyl-2-pyrrolidone and N-octadecyl methacrylamide was synthesized and loaded with simvastatin (SIMV) and coenzyme Q10 (CoQ10). We studied the effects of simvastatin- and coenzyme Q10-loaded polymeric nanoparticles on lipid profile and nitric oxide (NO)/reactive oxygen species (ROS) balance in the heart and aorta of adult male obese Zucker rats. The rats were divided into the untreated group, group treated with empty nanoparticles, and simvastatin-, or coenzyme Q10 (CoQ10)-, or a combination of simvastatin-loaded and CoQ10-loaded nanoparticles (SIMV+CoQ10). After 6 weeks, lipid profile was determined in the plasma and concentration of conjugated dienes in the liver. Akt, eNOS, phosphorylated eNOS (p-eNOS), NADPH oxidase, and NF-kappaB protein expressions were measured in the heart and aorta. All, simvastatin, CoQ10, and SIMV+CoQ10 treatments decreased plasma LDL levels, but only the combined SIMV+CoQ10 treatment increased the expression of Akt, eNOS, and p-eNOS in both heart and aorta. Interestingly, NADPH oxidase in the heart and NF-kappaB protein expression in the aorta were decreased by all treatments including nanoparticles alone. In conclusion, only combined therapy using simvastatin-loaded together with CoQ10-loaded nanoparticles ameliorated PI3K-Akt-eNOS pathway in obese Zucker rats. Moreover, enhancing the pleiotropic effects of simvastatin with the antioxidant properties of CoQ10 may increase the activating effect on PI3K-Akt-eNOS pathway and improve NO/ROS balance which may represent a promising tool for the treatment of cardiometabolic diseases.

Acknowledgement: This work was supported by the national grant agency VEGA 2/0025/23.

Keywords: Polymeric Nanoparticles, Simvastatin, CoenzymeQ10, Heart, Aorta.

INVITED PRESENTATION

Id-491

Detection of Disease Biomarkers via Electrical and Fluorescence-based Biosensors

A. KOKLU[1,*]

[1]ASELSAN Inc., 06200 Yenimahalle, Ankara, Turkiye

*Corresponding Author: anil.koklu@kaust.edu.sa

Abstract: The COVID-19 pandemic has shown the urgency for innovative tools for disease diagnostics. The limited testing capacity along with long turnaround times of commonly used diagnostic tools, including the polymerase chain reaction (PCR), have hindered the efforts to return to normality. As an alternative approach, the rapid test kits such as lateral flow assays were used to curb the pandemic but the accuracy and detection sensitivity were always limited to be compared with PCR performance. User-friendly, cheap, rapid, accurate, sensitive, and portable sensors are vital for disease biomarker detection, especially in rural areas for point of care applications. In 2020, an electrochemical sensor was developed for the detection of the SARS-CoV-2 virus. The organic electrochemical transistor (OECT) was used as a biosensor and it translates the binding event into an electrical signal. In general, the OECT is composed of two main components: a channel made of a semiconducting polymer and a gate electrode that controls the channel's current and can also be considered as the real sensor component for a conventional electrochemical biosensor. The gold electrodes were fabricated on a disposable substrate, which is later on functionalized with a uniquely engineered protein construct that specifically binds to the target virus. Owing to the high density of recognition units immobilized on the gate electrode and more importantly to large signal amplification feature of the OECT, the sensor responds to very low concentrations of the protein. However, due to the diffusion-dominated transport, the sensor requires certain time to display a difference the output signal. This incubation step is mostly a main reason of long sample-to-result times and can cause difference among the same measurement, resulting in measurement errors. One of the most suitable way to reduce incubation time and later measurement error is to utilize from the convective forces to transport the target proteins towards to the sensor area. Alternating current electrothermal flow (ACET) was cooperated with an electrochemical biosensor to accelerate the device operation. Using the SARS-CoV-2 spike protein in human saliva as an example target, it is shown that ACET enables protein recognition within only a few minutes of sample exposure, supporting its use in clinical practice. Other alternative techniques, which can transport the target molecules towards to sensor surface, will be also assessed. Finally, other biosensing methods, including optical and lateral low assay, will be also discussed to present the versatility of particle transport techniques.

Keywords: SARS-CoV-2, Electrochemical Biosensor, Optical and Lateral Flow Assay based Biosensors.

9th International Congress on Biomaterials and Biosensors

INVITED PRESENTATION

Id-494

Development of Smart Composites with Ferromagnetic Microwires

V. ZHUKOVA[1,2], M. IPATOV[1,2], J. MALM[3], C. JOHANSSON[3], F.J. VALLEJO[4], P. OLASKOAGA[4], R. B. GARCIA-ETXABE[5], A. ZHUKOV[1,2,6,*]

[1]University of Basque Country, UPV/EHU, Dept. Polymers and Advanced Materials, and Dept. Appl. Phys. San Sebastian, Spain

[2]University of Basque Country, UPV/EHU, EHU Quantum Center, 20018 San Sebastian, Spain

[3]RISE Research Institutes of Sweden, Digital Systems, Göteborg, Sweden

[4]IDEKO Technology Center, Basque Research and Technology Alliance (BRTA), Elgoibar, Spain

[5]GAIKER Technology Centre, Basque Research and Technology Alliance (BRTA), Spain

[6]IKERBASQUE, Basque Foundation for Science, 48011 Bilbao, Spain

*Corresponding Author: arkadi.joukov@ehu.es

Abstract: One of the common problems in early damage detection in composite materials is wireless monitoring of stresses or temperature. Non-destructive techniques (NDT) are expensive and labor-intensive and employed sensors are not wireless or require for instance attached electrodes for supplying electrical field, occupying a significant space. One of the recently proposed solutions for composites monitoring is a new sensing method involving free space microwave spectroscopy using inclusions of ferromagnetic microwires presenting high frequency magnetoimpedance, MI, with high sensitivity to applied stress, temperature and magnetic field. Amorphous glass-coated microwires present superior mechanical and corrosive properties, together with excellent magnetic softness and high MI effect and, therefore, are suitable for the wireless monitoring of stresses and temperature of composites. The integration of such microwires into composite materials significantly modify the effective microwave response, making it possible to obtain a new tunable and self-sensing composite material. However, the conductive carbon fibers interfere with the microwave signal generated by the ferromagnetic microwires, making it difficult to be measured. We present new experimental results on wireless monitoring of composites containing both carbon fibers and glass-coated microwires. Using Taylor-Ulitovsky technique we prepared Co-rich microwires with nearly-zero magnetostriction coefficients, extremely low coercivity (of about 5 A/m) and MI ratio up to 570%. The composites with parallel oriented long microwire inclusions separated by 3 mm have been successfully prepared. The reflection (R) and transmission (T) coefficients were measured in free-space. The experimental set-up consists of a pair of broadband horn antennas (1-17 GHz) and a vector network analyzer. In spite of the influence of the conductive carbon fibers, application of an external low frequency modulated magnetic field allows to sensitive and stable extraction of the response signal (R and T coefficients) from the ferromagnetic microwires inclusions.

Keywords: Magnetic Microwires, Magnetic Softness, Sensing Composites, Stress and Temperature Monitoring, Carbon Fiber Composites.

9th International Congress on Biomaterials and Biosensors

INVITED PRESENTATION

Id-498

Advanced Synthetic Titanium Prosthesis for OOKP Surgery: Revolutionizing Osteo-Odonto-Keratoprosthesis (Tooth-in-Eye) Procedures

L. TAYEBI[1,*]

[1]Marquette University School of Dentistry, United States

*Corresponding Author: lobat.tayebi@marquette.edu

Abstract: In cases where conventional methods, such as penetrating keratoplasty (PK) and various keratoprostheses, prove inadequate for treating severely damaged corneas, osteo-odonto-keratoprosthesis (OOKP) surgery emerges as the exclusive recourse. This complicated, two-stage surgical intervention becomes imperative to restore vision in patients grappling with corneal injuries caused by thermal or chemical burns, physical trauma, end-stage Stevens–Johnson syndrome, multiple unsuccessful PK attempts, ocular cicatricial pemphigoid, or trachoma end-stage.

The OOKP procedure involves the creation of an autologous frame, termed osteo-odonto-lamina, using the patient's tooth and adjacent bone (Stage 1). This construct undergoes implantation into a submuscular pouch for vascularization over several months before being inserted into the eye (Stage 2).

Acknowledged for its high success rates, OOKP remains an exceptionally aggressive surgical approach, particularly in its necessitation of tooth extraction and surrounding tissue removal. Additionally, the technique encounters limitations due to the absence of suitable dentition and tooth-supporting tissues in many patients. Furthermore, OOKP cannot be employed in children lacking fully developed adult dentition.

To address these challenges and limitations associated with OOKP, we are developing a new synthetic titanium prosthesis to replace the osteo-odonto-lamina. This presentation is going to discuss the design nuances of our prosthesis, featuring a solid component supporting an optical cylinder and a porous section promoting the bio-integration of the implanted prosthesis. We will also present our ongoing progress focusing on material consideration and modification of the titanium alloy (Ti6Al4V), as well as optimizing the design configurations of the prosthesis, including the pore size and porosity of the components, as part of our efforts to enhance the efficacy of this titanium prosthesis.

Keywords: Titanium, Osteo-odonto-keratoprosthesis, OOKP, Osteo-odonto-lamina, Prosthesis, Tooth-in-Eye.

INVITED PRESENTATION

Id-501

Electrospray Preparation Method and Biomedical Application of Multifunctional Gelatin-based Microgel

M. XIE[1,*]

[1]Plastic and Reconstructive Surgery Center, Department of Plastic and Recon-structive Surgery, Zhejiang Provincial People's Hospital (Affiliated People's Hospital), Hangzhou Medical College, Hangzhou, Zhejiang, China

*Corresponding Author: xiemingjun@zju.edu.cn

Abstract: Compared with bulk hydrogels, microgels have special excellent properties, such as tiny size, rich hydrogel network and adjustable rheological properties, which can meet different needs in the biomedical field. This work intends to develop microgel mass manufacturing equipment to produce various multi-functional gelatin-based microgels and introduce them to new application scenarios. The work includes: (1) Successfully developed an automated microgel electrospray device suitable for gelatin-based microgel preparation; (2) The electrospray preparation process of one-component gelatin-based microgels was studied, and it was confirmed that the loading cells could survive normally inside and spread in 3D microenvironment; (3) An electrospray preparation method for heterogeneous gelatin-based microgels embed-ded with microfibers was proposed, and a vascularized tumor microunit with both fibrous vascular structure and spherical tumor structure was constructed to simulate the complex interaction between cells in tumor tissues. (4) The electrospray preparation process of arrayed gelatin-based microgels was studied, and a large-throughput antitumor drug screening system, sandwich three-dimensional microtumor array chip, was constructed; (5) A microgel-based bioink suitable for the bioprinting of large-scale vascularized tissues, namely "temperature-sensitive sacrifice" microgel-based bioink, was developed, and centimeter-level tumor tissues with complex 3D vascular networks were constructed. (6) A microgel-based bioink, namely "functionalized concrete" microgel-based bioink suitable for in-situ bioprinting of defective organs was developed, and it was used to realize in-situ repair of defective organs.

Keywords: Microgel, Electrohydrodynamics, 3D Bioprinting, Tissue Engineering.

9th International Congress on Biomaterials and Biosensors

INVITED PRESENTATION

Id-502

Metallic Nanoparticles-graphene Nanohybrids as Artificial Enzymes for Environmental and Biomedical Electrochemical Applications

L. A. DINU[1,*]

[1]National Institute for Research and Development in Microtechnologies (IMT-Bucharest), Bucharest, Romania

*Corresponding Author: livia.dinu@imt.ro

Abstract: In the last years, more and more nanomaterials have been studied as artificial enzyme, due to their high catalytic activity towards the determination of various organic compounds, and biomarkers. In the last years, electrochemical techniques have been developed for the detection of various compounds because they bring important advantages, such as high sensitivity, fast response time, low cost and the possibility for point-of-care (PoC) and on-site monitoring, through miniaturization. Electrochemical sensors with high sensitivity and selectivity are desired. Enzyme-based sensors represent one of the most selective electrochemical sensors, but they have several weaknesses, such as complex immobilization procedure that may cause loss of activity and signal reproducibility, special storage conditions (2-8 ºC), low sensitivity and less stability in time. Also, they are losing ground for the development of a stable, reliable, sensitive, and selective sensor for commercial use. Likewise, cost effectiveness is another concern that can decisively affect sensor application due to the huge implementation scale and volume in environmental monitoring. Low-cost materials, which also benefit from unique physico-chemical properties, are the nanosized materials. The findings from 2007 broke the conventional idea that inorganic materials are bio-inert, and inspired researchers to explore nanomaterials as catalyst or artificial enzymes (nanozymes) in electrochemical applications. The nanozymes' scientific field embodies an incipient research area, which has generated massive scientific enthusiasm due to their superior properties in terms of 'refined' response to external incentives, self-assembly ability, large surface area, size-dependent catalytic activities, and, most important the structural tunability. Nanozymes based on graphene functionalized with metallic nanoparticles, as sensitive material for the development of electrochemical sensors, were exploited in biomedical and environmental applications. Carbon paste and screen-printed electrodes have been chemically modified with several nanohybrid materials based on graphene or graphene quantum dots modified with gold and silver nanoparticles, for the non-enzymatic detection of i) bisphenol A and ii) quercetin and dopamine from biological samples, and iii) catechol and iv) glyphosate from water samples. These nanozyme-based sensors showed very low detection limits, high sensitivity and selectivity for the analysis of selected analytes. This research integrates the newest ideas and features of the next generation of artificial enzymes, with the miniaturized and portable screen-printed electrodes, by bringing aside biology, chemistry, electronics and materials science. This research has high impact in several scientific domains, such as electrochemical, environmental, agricultural and biomedical fields and opens new research pathways that make nanozyme-based electrochemical sensors to be used as reliable analytical tools.

Acknowledgment: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, core project number PN 2307/29.12.2022 “Advanced research in micro-nano electronic and photonic devices, sensors and microsystems for societal applications” within PNCDI IV (2022–2027).
Keywords: Nanozyme, Electrochemical Sensors, Graphene Nanohybrids, Environmental, Biomedical.

9th International Congress on Biomaterials and Biosensors

INVITED PRESENTATION

Id-509

Design of Biosensor Assays for Study of Single Live Bacteria and Cancer Cells using Single Silver (Ag) Ultrasmall Nanoparticle Optical Probes

K. J. LEE[1,*]

[1]Florida Gulf Coast University, United States

*Corresponding Author: kerlee@fgcu.edu

Abstract: The increased knowledge and advancement of nanoparticle (NP) science and technology offers innovative opportunities for more sophisticated diagnostic and therapeutic tools at the nanoscale size, which can enter the cells to target, visualize, and manipulate processes at the cellular level. Noble metal NPs (e.g., Ag), have special ability as effective optical nano-biosensing probes for detecting and following the transport, accumulation, and efflux kinetics of single living cells, bacteria, and cancer cells using their visual size-dependent LSPR. Ag ultrasmall (U)NPs (<5nm) are a great tool to use because they function on the cellular scale, which is nano-sized, to translate the language of the cell and learn about its behavior to be able to have a better understanding of how to effectively treat it. Bacteria and cancer cells have increasing multi-drug resistance (MDR), exhibiting resistant to antibiotics and chemotherapy respectively, requiring increased doses and use of several different types causing an increase in the side effects to the patients. It is important to investigate the nanoscale exchanges of Ag UNPs as bio-nanoprobes with bacteria and human cancer cells to offer new fundamental knowledge about the biosensing capabilities for positive detection and possibilities for clinical diagnosis and new drug delivery.

Keywords: Biosensor, Live Bacteria Cells, Live Cancer Cells, Silver Ultrasmall Nanoparticles, Optical Probes.

INVITED PRESENTATION

Id-511

Enhancing the Biocompatibility and Bacteria Resistance of 3D Printed Ti6Al4V Alloy Endoprosthetic Implants by Applying Ta and Ta-Cu Coatings

D. L. ALONTSEVA[1,*], B. N. AZAMATOV[1], Y. I. SAFAROVA (YANTSEN)[2], R. YAMANOGLU[3], C. J. NWACHUKWU[4]

[1]D. Serikbayev East Kazakhstan Technical University, School of Digital Technologies and Artificial Intelligence, Ust-Kamenogorsk, Kazakhstan

[2]Nazarbayev University, National Laboratory Astana, Astana, Kazakhstan

[3]Kocaeli University, Department of Metallurgical and Materials Engineering, Kocaeli, Turkey

[4]Nazarbayev University, School of Engineering and Digital Sciences, Astana, Kazakhstan

*Corresponding Author: dalontseva@ektu.kz

Abstract: Currently, the issue of manufacturing patient-specific medical implants-endoprostheses (orthopedic, dental) with increased biocompatibility and resistance to bacterial infections is the focus of attention of scientists, surgeons, and medical production specialists. Such implants could significantly reduce the risks of implant rejection and periprosthetic infections, as well as the patient's recovery time after surgery. The combination of advanced technologies for 3D printing of porous implant scaffolds, microplasma spraying (MPS), and magnetron sputtering (MS) of coatings provides a unique opportunity to produce customized implants with the desired combination of mechanical, bioactive, and antibacterial properties.

This study aimed to optimize the additive manufacturing (AM) process for titanium implant components, focusing on achieving specific porosity levels while enhancing surface biocompatibility and bacterial resistance through MPS of tantalum (Ta) coatings and MS of tantalum-copper (Ta-Cu) coatings. Furthermore, it sought to elucidate how variations in scaffold porosity, alongside MPS and MS process parameters, affect these critical properties. The ultimate goal was to establish guidelines for selecting process parameters that yield the optimal composition, thickness, and microstructure.

Scaffolds with three different porosity groups were obtained according to their stereolithographic models by selective laser melting (SLM) of certified Ti6Al4V alloy (powder) using an AM Mlab cusing R (Concept Laser, Lichtenfels, Germany) system for metal products. MPS of pure Ta wire onto substrates was carried out by microplasmatron MPS-004 (E.O. Paton Electric Welding Institute, Ukraine) to improve the biocompatibility and corrosion resistance of Ti6Al4V alloy. Our previous studies have confirmed the increased biocompatibility and corrosion resistance of microplasma-sprayed Ta-coatings compared to commercially pure Ti-coatings. To increase antibacterial resistance, the scaffolds were coated with varying thicknesses of a 25%Cu-75%Ta-coating using dual DC MS by EPOS-PVD-440 installation (Beams&Plasmas, Novosibirsk, Russia). In vitro biocompatibility testing of MPS coatings was performed using rat mesenchymal stem cells (MSCs), while corrosion resistance was assessed using polarization curves in a simulated saline solution. The resistance of MS coatings to Staphylococcus aureus bacteria was studied in vitro using the disc diffusion method. The microstructure and surface morphology of the specimens were

analyzed using a scanning electron microscope (JSM-6390LV JEOL, Tokyo, Japan) and a non-contact optical profilometer (Huvitz HDS-2520, Gyeonggi, Republic of Korea). The concentration of Cu ions released from MS Ta-Cu coatings was measured using an ICP-MS Agilent 7500cx inductively coupled plasma mass spectrometer (Agilent Technologies, Wilmington, DE, USA).

Key findings demonstrate the influence of scaffold porosity and MS coating thickness on bacterial inhibition, the ability of MPS Ta-coatings to enhance biocompatibility, and the reduction of surface roughness and increase in corrosion resistance due to Ta-coatings. Significantly, the study proves the feasibility of integrating SLM, MS, and MPS in implant manufacturing, offering tailored parameters to optimize implant properties. This pivotal research marks significant progress in endoprosthetic implant technology and provides a robust framework for future explorations, potentially leading to more durable, compatible, and infection-resistant implants.

Acknowledgment: This research was funded by Ministry of Science and Higher Education of the Republic of Kazakhstan, grant number AP13268737.

Keywords: Additive Manufacturing, Microplasma Spraying, Magnetron Sputtering, In-vitro Test.

9th International Congress on Biomaterials and Biosensors

INVITED PRESENTATION

Id-513

3D Bioprinting: Challenges in Commercialization and Clinical Translation

S. VIJAYAVENKATARAMAN[1,2,*]

[1]The Vijay Lab, Division of Engineering, New York University Abu Dhabi, UAE

[2]Department of Mechanical and Aerospace Engineering, Tandon School of Engineering, New York University, Brooklyn, NY11201, USA

*Corresponding Author: vs89@nyu.edu

Abstract: 3D Bioprinting has become a revolutionary tool in the field of tissue engineering and regenerative medicine. Bioprinting industry has seen a tremendous growth in the past decade, with a number of bioink companies and bioprinter companies on the rise. While the growth of bioprinting has been tremendous in terms of research and reach, permeating into life sciences research where two-dimensional cell culture has been the norm, we are yet to witness a commercial success in terms of clinical translation. This talk will highlight some of the recent works from The Vijay Lab at New York University Abu Dhabi and highlight some of the lesser-discussed challenges in the field that are to be overcome to fully translate the use of bioprinting into the clinics and make it a standard of testing in the pharmaceuticals industry.

Keywords: Bioprinting, Translation, Challenges, Commercialization, Clinical.

INVITED PRESENTATION

Id-516

Network Properties of Polymer Matrixes for Controlling a Functionality of Amperometric Biosensors: Recent Advances and Perspectives

T. KAVETSKYY[1,2,*], M. GOŹDZIUK[3], I. DONCHEV[4], N. HOIVANOVYCH[2], O. NYKOLAISHYN[2], L. PANKIV[2], Y. KUKHAZH[2], O. MUSHYNSKA[2], O. ZUBRYTSKA[2], J. OSTRAUSKAITE[5], B. ZGARDZIŃSKA[3], O. ŠAUŠA[1,6], H. ŠVAJDLENKOVÁ[7], A. KIV[4,8]

[1]Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovakia

[2]Drohobych Ivan Franko State Pedagogical University, Drohobych, Ukraine

[3]Institute of Physics, Maria Curie-Sklodowska University, Lublin, Poland

[4]South Ukrainian National Pedagogical University named after K.D. Ushynsky, Odesa, Ukraine

[5]Kaunas University of Technology, Kaunas, Lithuania

[6]Comenius University in Bratislava, Department of Nuclear Chemistry, Bratislava, Slovakia

[7]Polymer Institute, Slovak Academy of Sciences, Bratislava, Slovakia

[8]Ben-Gurion University of the Negev, Beer-Sheva, Israel

*Corresponding Author: kavetskyy@yahoo.com

Abstract: Application of polymer materials as holding matrixes of immobilized enzyme is an innovative approach in a construction of the amperometric biosensors. The constructed laccase biosensor based on the ureasil/As_2S_3 composite was characterized by a very high sensitivity, but a weak point of the biosensor was very strong unexpected electrochemical noise at chronoamperometric measurement. At the same time, new perspectives of the ureasil-based polymers for construction of amperometric enzyme biosensors were further found. In particular, a correlation between the network properties of the biosensor sensing layers (e.g., free-volume V_h at glass transition temperature T_g and coefficients for the thermal expansion of free-volume voids α_{F1}, α_{F2} as well as their difference ($\alpha_{F2} - \alpha_{F1}$), and swellability or crosslinked density) based on the pure ureasil and ureasil/As_2S_3 composites of different history (fresh and aged samples) and biosensor characteristics (e.g., a maximal current at substrate saturation Imax, apparent Michaelis-Menten constant K_M^{app} to ABTS chosen as a substrate, the slope of the calibration curve B, and the sensitivity of bioelectrodes obtained by means of cycle voltammetry and chronoamperometric analysis) was established. On the other hand, vegetable oil-based photopolymers were used as a holding matrix in biosensors. Recently, amperometric laccase biosensors for analysis of phenol derivates were constructed using graphite rods (type RW001) as working electrodes and the photocross-linked polymers as a matrix. Such matrix consisted of epoxidized linseed oil (ELO), bisphenol A diglycidyl ether (RD) as reactive diluent and 50% mixture of triarylsulfonium hexafluorophosphate in propylene carbonate as photoinitiator (PI). The synthesis was made by the reaction of ELO and 10 mol.% or 30 mol.% of RD, using 3 mol.% of PI (ELO/10RD and ELO/30RD, respectively). The holding matrixes were used for an immobilization of commercial laccase from the fungus Trametes versicolor. The network properties of the polymer matrixes, holding biosensing element, were studied by means of positron annihilation lifetime spectroscopy (PALS) and swelling measurements. The

amperometric enzyme biosensor parameters were evaluated using cyclic voltamperometry and chronoamperometric analysis. The next phase of research was nanostructure investigation of soybean oil-based samples. Two groups of the investigated samples contain epoxidized soybean oil (AESO), vanillin dimethacrylate (VDM) and/or vanillin diacrylate (VDA) and 2,2-dimethoxy-2-phenylacetophenone (DMPA) as PI. The samples contained different molar ratios of the tested substances. PALS and swelling parameters were examined. The samples were tested in the temperature range of 120-320 K. The aim of the research is to find correlation between nanostructure and detection properties of the polymer matrixes. It is necessary to find the best material to construct highly sensitive biosensors in order to detect xenobiotics pollution in wastewater. Finally, some recent advances and perspectives in this research are highlighted.

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Keywords: Polymers, Positron Annihilation, Free Volume, Crosslinking, Biosensors.

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ORAL PRESENTATION

Id-487

Molecular Vapor Deposition (MVD) – For Biosensing Applications

D.W. GILLARD*, J. MITCHELL, M. GRIMES, H. ASHRAF, O.J.GUY, M.M.ALI, M. ABDELKARIM, S.MCINTYRE, S. SHARMA, O.J.GUY

Swansea University, Centre for integrative semiconductor materials (CISM), Swansea, United Kingdom

Corresponding author*: 904871@swansea.ac.uk

Abstract: Molecular vapor deposition (MVD) is an advanced deposition technique that can be used for depositing metal/non-metal and organic thin films. The process has similarities to Atomic Layer Deposition (ALD) but offers several advantages in that MVD does not require the use of a continuous flow of gas (usually nitrogen) through the chamber to carry the precursor vapor. By removing the carrier gas, the precursor gas diffusion onto the surface of the desired substrate is not kinetically limited which allows for very conformal coatings of high aspect ration features, as well as deposition at low temperatures of 150^{o}C or less [1]. The low temperature deposition of materials and high aspect ratio coatings is very important for biosensor applications where the underlying substrates can be sensitive to temperature and are geometrically inconsistent. Current work in this field includes the application of aluminium oxide on graphene in the fabrication of passivated graphene devices. The passivation layer is critical in protecting the metal interconects from corroding during subsequent biofunctionalisation and biosensing processes [2]. This paper reports the development of MVD processes for passivation layers and the use of such passivation layers in biosensing devices. In addition, MVD can be used for deposition of Platinum (Pt) metal . Pt is widely used as an electrode in electrochemical sensing. This paper will present fabrication processes for MVD platinum films formed on non-planar substrates, such as microneedles. The Pt-coated microneedles can bes used in electochemical sensing of analytes present within interstitial fluid and this this Pt-coated microneedle technology provides a route toward transdermal sensing applications.

Keywords: MVD; Biosensors; Microneedles; Platinum; Electrochemistry.

ORAL PRESENTATION

Id-489

Synthesis of Carbon Nanodots as Fluorescent and Radiological Contrast Agents

T. S. ATABAEV*, Z. BARANCHIYEVA, Y. ZHUMADILOVA

Nazarbayev University, Department of Chemistry, Astana, Kazakhstan

* Corresponding author: timur.atabaev@nu.edu.kz

Abstract. Recently, there has been a growing interest in carbon nanodots (CDs) because of their excellent fluorescent properties, low price, simplicity of preparation, and biocompatibility [1]. In this talk, we will discuss recent advances in the synthesis and testing of CDs at Nazarbayev University, as well as the global advancements in the fabrication of multifunctional CDs. The main focus of this talk will be on metal- and nonmetal-doped CDs suitable for use as radiocontrast agents in MRI and CT. In particular, we will discuss the synthesis of I- and Mn-codoped CDs, the importance of biocompatibility, process scalability, and production cost minimization.

Acknowledgment: This research was funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant no. AP19578878).

Keywords: Carbon nanodots; Radiological contrast agents; fluorescence; CT; MRI.

ORAL PRESENTATION

Id-506

Application of Nanozymes in Lateral Flow Test Systems For Food Control

O. D. HENDRICKSON*, N. A. BYZOVA, E. A. ZVEREVA, A. V. ZHERDEV, B. B. DZANTIEV

Bach Institute of Biochemistry, Research Center of Biotechnology of the Russian Academy of Sciences,

Leninsky prospect 33, 119071, Moscow, Russia,

Corresponding Author*: odhendrick@gmail.com

Abstract: Nanozymes are nanoparticles that contain metal(s) and possess enzyme-like catalytic activities. Nanozymes have unique features due to their large surface area. Unlike enzymes, catalytic reactions occur on the surface of nanozymes. Thanks to this, chemical modification can be used to change the catalytic activity, ensure affinity interactions, direct transport *in vivo*, etc. Compared to their natural analogs, nanozymes are characterized by high stability and easy and low-cost preparation and may demonstrate even higher catalytic activity. One of the promising nanozyme applications is using them as labels in immunoassays, including lateral flow test systems (LFTs).

In this study, highly sensitive LFTs using nanozyme labels were developed for the detection of bacteria *Salmonella typhimurium* and *Listeria monocytogenes*. Bacterial cells are relevant pathogen contaminants of food products and drinking water. They can cause foodborne illnesses – infectious diseases or intoxications resulting in fever, abdominal disorders, and other symptoms. Bacteria can pass through the entire food chain – from animal feed and primary production to the home or food service establishments – and persist in food and the environment for a long time. These serious consequences make it necessary to develop methods for rapid point-of-care control of food contamination at all stages of food production. LFTs based on the immunochromatographic principle can ensure mass monitoring of foodstuffs for the presence of contaminants. The advantages of LFTs are simplicity, rapidity, sensitivity, and low cost. All reagents are preliminarily applied to the test strip and the analysis is carried out by the incubation of the strip with the tested sample followed by a visual assessment of the colored bands.

We used several types of nanozymes as labels in the LFTs, namely, bi- and trimetallic core@shell nanoparticles (Au@Pt, Au@Ag-Pt) and Prussian blue nanoparticles (PBNPs). Bi- and trimetallic nanoparticles were synthesized using gold nanoparticles (AuNPs) as a core. Pt or Ag-Pt shells were formed by the reduction of the corresponding salts on the gold surface. Prussian blue was obtained by the reaction of ferric salts with potassium hexacyanoferrate (II). All nanozymes were characterized by composition, size, and shape. The LFTs were performed in the sandwich format. Specific antibodies were labeled with AuNPs as a traditional immunochromatographic label and nanozymes. All the used nanozymes had peroxidase-mimic catalytic properties. The substrate was added to test strips after the lateral flow process followed by the formation of nanoparticle-labeled immune complexes. This initiated the oxidizing of the substrate to an insoluble product, whose dark color contributed to the overall coloration intensity. In this way the catalytic enhancement provided increased sensitivities of the LFTs. The comparison with AuNPs-based LFTs

demonstrated that the application of nanozyme labels allowed for a 100-1000-fold decrease in the detection limits. It was shown that the developed LFTs were effective for the detection of bacterial cells in food products (milk, meat extracts) as well as in drinking water. The developed approaches were successfully used to develop LFTs of other contaminants (other pathogens, antibiotics, phycotoxins, protein biomarkers).

Acknowledgement: This investigation was financially supported by the Russian Scientific Foundation (project No 23-46-10011).

Keywords: Nanozymes, Enzyme Mimics, Bacterial Pathogens, Lateral Flow Test Systems, Catalytic Enhancement, Food and Water Safety.

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POSTER PRESENTATION

Id-495

Preparation, Structural and Magnetic Properties of Mnfepsi-Based Glass-Coated Microwires

M. SALAHELDEEN[A,B,C*], V. ZHUKOVA[A,B*], J. ROSERO[D], M. IPATOV[A,B], AND A. ZHUKOV[A,B,E]

[a]University of Basque Country, UPV/EHU, Dept. Polymers and Advanced Materials, and Dept. Appl. Phys. San Sebastian, Spain

[b] University of Basque Country, UPV/EHU,EHU Quantum Center, 20018 San Sebastian, Spain

[c] Physics Department, Faculty of Science, Sohag University, Sohag 82524, Egypt

[d] BCMaterials, Basque Center for Materials, Applications and Nanostructures, Leioa 48940, Spain

[e] IKERBASQUE, Basque Foundation for Science, 48011 Bilbao, Spain

[*] Corresponding author: valentina.zhukova@ehu.es

Abstract. Compared to the conventional vapour-compression refrigeration, magnetic refrigeration technology promises a 25% higher energy efficiency and does not use dangerous and environmentally unfriendly refrigerants such as ozone depleting chemicals (e.g., chlorofluorocarbons), hazardous chemicals (e.g., ammonia) or greenhouse gases (e.g., hydrofluorocarbons and hydrochlorofluorocarbons). This makes magnetic refrigeration one of the most promising technologies to replace vapour-compression refrigeration in the near future. There are several materials with a large magnetocaloric effect, MCE, near room temperature. Among all candidates for solid-state refrigerants, the $(Mn,Fe)_2(P,Si)$-based materials are among the most promising because they provide optimal conditions for practical applications (large MCE, low cost starting materials, and environmental benefits). The miniaturization of MCE devices based on small-size MCE particles, wires, ribbons, films, bi- and multilayers, pillars is quite important for future technological applications. Therefore, fabrication of the $Mn,Fe)_2(P,Si)$-based thin glass-coated microwires from brittle MnFePSi alloy might be interesting from the point of view of application of MCE. We prepared a $Mn_{48}Fe_{22}P_{15}Si_{15}$ microwires with metallic nucleus diameter, d = 11.2 μm and total diameter, D = 28.3 μm coated by thin flexible and biocompatible glass-coating for the first time by using the Taylor–Ulitovsky Technique. This low-cost, single-step fabrication approach enabled the preparation of kilometers-long microwires from a few grams of low-cost components (Mn, Fe, P, and Si) for a variety of applications. The analysis of the magnetic measurements revealed a well-defined magnetic anisotropy in the whole temperature range. Moreover, relatively hard magnetic properties were observed for the temperature range of 5–400 K, where the average of coercivity, $H_c \approx 465$ Oe. Moreover, the elevated Curie temperature (> 400 K) observed in the investigated sample, makes this material as an appealing choice for several industrial applications.

Keywords: Magnetic Microwires; Biocompatible Glass-Coating; Magnetic Refrigeration; Magnetic Anisotropy; Curie Temperature.

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POSTER PRESENTATION

Id-503

Preparation, Characterization and Wound Healing Effects Of New Collagen – Arginine Dressing

O. BRÎNCOVEANU [A,B,*], I.C. MARINAŞ [B,C], D. M. GABOREANU[B]

[a] National Institute for R&D in Microtechnology - IMT Bucharest, Romania

[b] Research Institute of the University of Bucharest – ICUB Bucharest, Romania

[c] Research & Development for Advanced Biotechnologies and Medical Devices, SC Sanimed International Impex SRL, Călugăreni, Romania

Corresponding Author*: oana.brincoveanu@imt.ro

Abstract. In recent years, there has been considerable interest in collagen-arginine dressing as potential materials for wound healing. These composites, featuring unique properties and high biocompatibility, offer several advantages for managing chronic wounds. The combination of collagen and arginine in dressings imparts beneficial characteristics such as high porosity, facilitating adequate oxygenation and moisture control critical factors for effective wound healing. Chronic wounds present a significant healthcare challenge, often resulting in prolonged healing durations and heightened patient morbidity. Given these challenges, the development of innovative wound dressings capable of promoting efficient wound closure is paramount. The objective of this study was to assess the structural and morphological properties of collagen-arginine dressing. Various characterization techniques, including scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), energy-dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD), contact angle measurements, antimicrobial and anti-oxidant activity were employed to evaluate the physical, chemical, and morphological features of these composites. Additionally, the release kinetics of nitric oxide (NO) and antioxidant activity were measured through chemical methods. Hemocompatibility studies demonstrated compliance with the requirements outlined in the ISO 10993 family of standards for medical devices.

Keywords: Collagen, Arginine, Dressing, Nitric Oxide, Wound Healing.

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POSTER PRESENTATION

Id-515

A Study on the Properties of Rigid Polyurethane Foam Using Modified Cellulose Nanofiber

J. OH, S. KIM*

Kyonggi University, Republic Of Korea

Corresponding Author*: ksb@kyonggi.ac.kr

Abstract: Cellulose nanofiber(CNF) is attracting attention as a reinforcement of polymer composite materials because of its high mechanical strength and biodegradability, but when applied to hydrophobic polyurethane(PU), CNF is self-aggregated and the physical properties of PU are deteriorated.

This study attempted to improve the properties of polyurethane foam(PUF) by improving the compatibility of PUF and CNF by modifying the surface of CNF to hydrophobicity using silanes with different functional groups.

In the case of PUF to which the modified CNF was added, the pore size of the foam was reduced, thereby improving mechanical strength and thermal insulation performance. In particular, in the case of PUF containing 0.5 wt% of CNF modified with aminosilane, the insulation performance and compressive strength were improved by 7% and 24%, respectively, compared to the neat PUF.

Keywords: Cellulose Nanofiber, Polyurethena Foam, Silane, Coupling Agent

All Submissions & Topics

Topic	Submission
1 - Biomaterials	483 - Transparent Tumor Imaging-Based Drug Penetration Monitoring
	503 - Preparation, Characterization And Wound Healing Effects Of New Collagen – Arginine Dressing
2 - Advanced Functional	494 - Development Of Smart Composites With Ferromagnetic Microwires
	495 - Preparation, Structural And Magnetic Properties Of Mnfepsi-Based Glass-Coated Microwires
	502 - Metallic Nanoparticles-Graphene Nanohybrids As Artificial Enzymes For Environmental And Biomedical Electrochemical Applications
	515 - A Study On The Properties Of Rigid Polyurethane Foam Using Modified Cellulose Nanofiber
3 - Artificial Organs An	513 - 3D Bioprinting: Challenges In Commercialization And Clinical Translation
5 - Bio-Nanomaterials A	490 - Simvastatin- And Coenzyme-Q10-Loaded Polymeric Nanoparticles Increased Nitric Oxide Synthase Activity Via The Akt-Enos Pathway In Obese Zucker Rats.
24 - Nano Biomaterials	485 - Zno-Based Markers Activated With Rare Earth Ions For Theranostic ApplicationS
	489 - Preparation Of Carbon Nanodots As Fluorescent And Radiological Contrast Agents
	493 - Enzyme And Carbon Nanotube Devices Using Floatable Diatom Frustules As A Nanoporous Silica
27 - Materials For Biomed	498 - Advanced Synthetic Titanium Prosthesis For OOKP Surgery: Revolutionizing Osteo-Odonto-Keratoprosthesis (Tooth-In-Eye) Procedures
	511 - Enhancing The Biocompatibility And Bacteria Resistance Of 3D Printed Ti6Al4V Alloy Endoprosthetic Implants By Applying Ta And Ta-Cu Coatings

28 - Novel Applications O	497 - A Real BandAIdTM: Incorporating Artificial Intelligence (AI) into Biomaterials, Nanotechnology, Sensors, and Medicine
	501 - Electrospray Preparation Method And Biomedical Application Of Multifunctional Gelatin-Based Microgel
34 - Biosensors	486 - Graphene And Silicon Chip Technologies For Biosensing Applications
	487 - Molecular Vapor Deposition (MVD) – For Biosensing Applications
	488 - Innovations In Gold Electrode Manufacturing For Cost-Effective Biosensors
	491 - Detection Of Disease Biomarkers Via Electrical And Fluorescence-Based Biosensors
37 - Antibodies	506 - Application Of Nanozymes In Lateral Flow Test Systems For Food Control
39 - Whole Cells	509 - Design Of Biosensor Assays For Study Of Single Live Bacteria And Cancer Cells Using Single Silver (Ag) Ultrasmall Nanoparticle Optical Probes
53 - Nanobiosensors And N	516 - Network Properties Of Polymer Matrixes For Controlling A Functionality Of Amperometric Biosensors: Recent Advances And Perspectives