Surface Engineering of Biomaterials, Devices and Regenerative Materials: Health, Food, and Agriculture Applications
Room Palm 1-2 - Session MD1-1-MoM

Coatings and Surfaces for Medical Devices: Mechanical, Corrosion, Tribocorrosion, and Surface Processing I

Moderators: Hamdy Ibrahim, University of Tennessee at Chattanooga, USA, **Sangeeta Kale**, Defence Institute of Advanced Technology (DIAT), India

10:00am **MD1-1-MoM-1 NaOh Etching and Oxygen Plasma Treatments on Surface Characteristics and Their Potential to Activate Micro-Arc Oxidized TiO_2 Biomedical Coatings.**, ***Paulo Noronha Lisboa-Filho [paulo.lisboa@unesp.br]***, UNESP, Brazil **INVITED**

Activation treatments such as NaOH etching or O_2 plasma can play an essential role in surface conjugation of titanium with biomolecules, providing a better interaction at the bone-implant interface. However, their application on complex titanium dioxide (TiO_2) surfaces is still not explored. In this contribution, bioactive and porous TiO_2 coatings produced by micro-arc oxidation (MAO) were treated with NaOH etching or O_2 plasma and then placed in contact with a reactive isocyanate test compound to evaluate the potential of molecule conjugation. Results suggested that O_2 plasma treatment has only changed the surface chemistry of the coating through carbon contaminants removal, plasma-driven oxidation and generation of functional OH species, including reactive carboxyl groups. This chemical modification by plasma has made the surface superhydrophilic. After NaOH etching, the coating became rougher and also superhydrophilic, containing titanate structures doped with sodium and calcium on its surface and inside the inner pores. Upon reaction with butyl isocyanate, the O_2 plasma-treated surfaces seem to better provide molecule conjugation, introducing characteristic conjugation bonds, and also making MAO coatings more hydrophobic due to the surface-terminated methyl chains from isocyanate. This proof-of-concept study has demonstrated the promising grafting potential given by O_2 plasma on complex TiO_2 surfaces.

10:40am **MD1-1-MoM-3 Sustainable Antifouling Coatings Based on Liquid-Like Solid Surfaces for Medical and Engineering Applications**, ***Jinju Chen [j.chen4@lboro.ac.uk]***, Loughborough University, UK; *Yufeng Zhu,* Shanghai Jiao Tong University, China; *Hernan Barrio-Zhang,* University of Edinburgh, UK; *Rui Han,* Loughborough University, UK; *Gary Wells,* University of Edinburgh, UK; *Rodrigo Ledesma-Aguilar,* University of Edindburgh, UK; *Waldemar Vollmer,* Queensland University of Technology and CSIRO, Australia; *Nicholas Jakubovics,* Newcastle University, UK; *Glen McHale,* University of Edinburgh, UK

Microbial biofilms present a pervasive challenge across healthcare, food production, water, and energy sectors, contributing to an estimated global economic burden exceeding $5 trillion annually. Overcoming this persistent problem demands durable, non-toxic, and scalable antifouling strategies that inhibit biofilm formation without relying on biocides.

In this study, we present a novel surface-engineering approach for long-term biofilm prevention using slippery, covalently attached liquid-like coatings—a new class of solid surfaces that combine the mechanical robustness of solids with the interfacial mobility of liquids. These permanently tethered liquid-like layers, independent of surface hydrophobicity, exhibit ultra-low interfacial friction and exceptional slipperiness (contact angle hysteresis <3°), effectively suppressing bacterial adhesion and subsequent biofilm growth.

When tested against two clinically relevant pathogens—Pseudomonas aeruginosa (PAO1) and Staphylococcus epidermidis (FH8)—the coatings achieved a 3–5 log reduction in biofilm biomass compared to polydimethylsiloxane (PDMS), a common catheter material, under both static and dynamic flow conditions over 14 days. Importantly, these liquid-like surfaces outperformed silver-based antimicrobial coatings, which rely on biocidal action but suffer from rapid fouling by dead bacteria and loss of efficacy over time. They also surpassed the emerging antibiofilm surfaces such as liquid-infused surfaces, whose performance under flow conditions is limited by oil depletion. In contrast, our covalently anchored liquid-like layers remain mechanically stable and maintain slippery, non-fouling properties even under dynamic shear.

Mechanistic analysis revealed that ultra-low liquid–solid friction, quantified by ultra-low contact angle hysteresis, is a strong predictor of long-term antibiofilm performance—defining a surface-physics design rule for future scalable coating development. Overall, this work provides a scientific and translational framework for designing durable, non-toxic coatings with long-term antibiofilm efficacy for medical devices and other biofouling-prone applications.

11:00am **MD1-1-MoM-4 Synergistic Fretting–Corrosion Mechanisms in DLC Coatings**, ***Tomasz Liskiewicz [T.Liskiewicz@mmu.ac.uk]***, Manchester Metropolitan University, UK; *Samuel McMaster,* Anglia Ruskin University, UK; *Michael Bryant,* University of Birmingham, UK; *Thawhid Khan,* University of Sheffield, UK; *Yu Yan,* University of Science and Technology Beijing, China; *Ben Beake,* Micro Materials Ltd, UK **INVITED**

This study investigates the synergistic interactions between fretting wear and electrochemical crevice corrosion in diamond-like carbon (DLC) coating systems on AISI 316L substrate under physiologically representative conditions. Particular emphasis is placed on understanding how albumin influences fretting–corrosion mechanisms, given their critical role in many engineering and biomedical environments. A combined experimental methodology is employed, integrating micro-mechanical characterisation (instrumented indentation and scratch testing) with fretting experiments employing in-situ electrochemical characterisation to assess coating durability, damage initiation, and interfacial degradation. Electrochemical techniques, including open-circuit potential monitoring, potentiodynamic polarisation, and electrochemical impedance spectroscopy, are applied in situ during fretting to capture the evolving interaction between mechanical and electrochemical degradation processes.

Fretting was replicated by applying micro-motion to the Al2O3 ball relative to the coated plate under a dead weight normal load. A maximum Hertzian contact pressure of 800 MPa was used for the tests, at a fretting displacement amplitude of 100 µm, giving a gross slip fretting regime. Each fretting test lasted 60 minutes resulting in 3600 cycles at a frequency of 1 Hz. Detailed surface and subsurface analyses using scanning electron microscopy, focused ion beam cross-sectioning, and energy-dispersive X-ray spectroscopy reveal progressive coating damage involving micro-cracking, interfacial delamination, and tribologically induced graphitisation of the DLC layer. Results demonstrate that fretting accelerates corrosion through mechanical disruption of the coating–substrate interface, while corrosion promotes further fretting damage via under-film attack and crack propagation, establishing a genuine fretting-corrosion synergy.

A mechanistic model is proposed in which mechanical defect initiation, electrochemical attack, and debris generation act in a feedback loop, driving progressive coating degradation. These insights highlight the importance of considering protein–surface interactions and combined degradation modes when designing DLC coatings for demanding fretting–corrosion service conditions in biomedical and engineering applications.

11:40am **MD1-1-MoM-6 Machine Learning Approach for Predicting the Corrosion Behavior of Coated Magnesium-Based Materials**, *Abdelrahman Amin,* University of Tennessee at Chattanooga, USA; *Ibrahim Awad,* Independent Researcher, USA; ***Hamdy Ibrahim [hamdy.m.elsayed@gmail.com]***, Kennesaw State University, USA

One effective approach to control the fast corrosion of magnesium alloys is coating them with a micro-arc oxidation (MAO) layer, which significantly slows down the degradation process. Although experiments have proven the efficacy of this method in studying corrosion, there remains a need to identify more time- and cost-effective solutions. Finite element analysis offers a potential solution, but the complexity of the factors involved in the MAO process makes machine learning methods a more efficient and time-saving alternative for predicting corrosion behavior. This study aims to expand existing machine learning models from predicting corrosion in uncoated magnesium to innovatively forecasting the degradation of MAO-coated samples, focusing on predicting corrosion current density and corrosion potential based on electrochemical corrosion test data.

The key factors involved in the MAO coating process were identified, and relevant data was collected from the literature, with more focus on electrochemical corrosion test results, particularly potentiodynamic polarization (PDP) corrosion test. The primary predictive variables were derived from the parameters of the MAO process, while the response variables were the PDP corrosion potential and corrosion current density. To determine the most accurate predictive model, we evaluated and compared several machine learning algorithms using Python with 80% training and 20% testing data. Once the most effective model was identified, we applied two different predictive approaches for comparison: (i) Exact value prediction, and (ii) Logarithmic value prediction. The Random Forest prediction method identifies the stone related to corrosion current prediction due to its wide range. However, the log prediction method addresses the weaknesses observed in the exact prediction method. Moreover, the Mean Absolute Error (MAE) confirms the model's accuracy. Corrosion Current Density and Corrosion Potential predicted from the log approach were more accurate compared to the obtained values from the exact approach.

12:00pm **MD1-1-MoM-7 Fabrication of Bio-Active Aptes-Gold-Coated Strips for Nerve Agent Detection Using Resonant Sensors***,*
Pranali Pandharpatte [pranali.pandharpatte@gmail.com]*, Piyush Shah,* Defence Institute of Advanced Technology (DIAT), India*; K.G. Girija, Chiranjib Mazumder,* Bhabha Atomic Research Centre (BARC), India*; Shaibal Banerjee, Sangeeta Kale,* Defence Institute of Advanced Technology (DIAT), India

Sarin (isopropyl methyl phosphono fluoridate) is an organophosphate ester with high potency as nerve agent, which is extremely dangerous and rapidly attacks the nervous system of human body and makes them incapable in merely few seconds. As direct experimentation with Sarin is highly restricted, dimethyl methylphosphonate (DMMP) serves as a widely accepted safe simulant to explore this biologically-hazardous molecule better.

Through this study, fabrication of active sensing surfaces on chromatography paper strips is discussed, which are coated with gold nanoparticles (AuNPs) and 3-aminopropyltriethoxysilane (APTES) via a dip-and-dry coating technique. These strips enable a rapid and selective chemical response towards DMMP, thereby changing their effective dielectric response.Such a strip is superimposed on a resonant sensor, which is a complementary split-ring resonator (CSRR) operating at 428 MHz. The compact and highly sensitive CSRR sensor is designed on an FR4 substrate with copper metallization, which are excited using RF signal to create electromagnetic field around. The coated strips superimposition on the sensor bed not only augments the electromagnetic near-field confinement of the sensor but also modifies the resonant frequency and signal power as the surface chemistry changes with DMMP interactions. Our studies show detection in the range of 100 to 500 ppm of DMMP, wherein the sensor demonstrates a frequency shift from 10 MHz to 18 MHz and a power variation of 1.98 dB to 4.7 dB. The CSRR–AuNPs–APTES hybrid system highlights the interdisciplinary relevance of surface-engineered coatings in biomedical and environmental sensing, offering potential solutions for nerve gas detections. A smart diagnostic platform with real-time monitoring for healthcare diagnostics is demonstrated.

Keywords- Organophosphorus compounds, Complementary split-ring resonator (CSRR), Surface engineering, Paper-based biosensor, RF sensor, Biocompatibility, Environmental monitoring, Real-time detection platform

Surface Engineering of Biomaterials, Devices and Regenerative Materials: Health, Food, and Agriculture Applications
Room Town & Country B - Session MD1-2-TuM

Coatings and Surfaces for Medical Devices: Mechanical, Corrosion, Tribocorrosion, and Surface Processing II

Moderators: Po-Chun Chen, National Taipei University of Technology, Taiwan , **Jean Geringer**, Ecole Nationale Superieure des Mines, France

8:00am **MD1-2-TuM-1 Metallic-Capped Nanoslit Structure Integrating with Microfluidic Devices for Biosensing Applications.**, ***Yu-Jui (Ray) Fan [rayfan@nycu.edu.tw]***, National Yang Ming Chiao Tung University (NYCU), Taiwan **INVITED**

A localized surface plasmon Resonance (LSPR) is the result of the confinement of a surface plasmon in a nanoparticle/nanostructure of size comparable to or smaller than the wavelength of light used to excite the plasmon. The plasmon resonant frequency is highly sensitive to the refractive index of the environment; a change in refractive index results in a shift in the resonant frequency. As the resonant frequency is easy to measure, it can be used as an immunosensor. We will introduce the metallic-capped nanostructures as LSPR biosensors integrating with microfluidic devices. In this talk, I will show two examples: (1) an LSPR sensor integrating with microfluidic-based polymerase chain reaction (PCR) for DNA detection, and (2) an LSPR sensor integrating with a microfluidic-based preconcentrator for antigen detection.

8:40am **MD1-2-TuM-3 Plasma-Activated Chitosan-Hydrogel Coating Incorporating Natural Immunomodulatory Protein (GMI) for Enhanced Tissue Regeneration and Oral Cancer Inhibition**, *Yu-Rou Lin, Meng Yun Wu, Sheng-Yen Lin,* ***Ying-Sui Sun [yingsuisun@tmu.edu.tw]***, Taipei Medical University, Taiwan **INVITED**

Dental implant regeneration aims not only to restore alveolar bone integrity but also to re-establish the physiological functions of periodontal tissues and sensory feedback lost in conventional osseointegration. Conventional titanium implants, while mechanically stable, often lack the biological complexity of natural teeth. Therefore, regenerative implant strategies that promote bone formation, soft tissue integration, and nerve recovery are increasingly essential for long-term functional success. Meanwhile, oral cancer remains the sixth most prevalent malignancy globally, particularly in Southeast Asia. Betel nut chewing, smoking, and alcohol consumption are major etiological factors contributing to late-stage diagnosis, high recurrence, and impaired oral functions. Hence, developing biomaterials that simultaneously enhance tissue regeneration and suppress cancer progression represents a critical frontier in oral biomedical materials research. In this study, a plasma-activated chitosan-hydrogel coating incorporating a natural immunomodulatory protein, Ganoderma lucidum microspore immunomodulatory protein (GMI), was developed as a dual-functional platform for tissue regeneration and oral cancer inhibition. Plasma activation was employed to enhance the surface energy and introduce hydrophilic reactive groups (–OH, –COOH, $–NH_2$) on the chitosan hydrogel, improving protein immobilization efficiency and biointerface activity. GMI, known for modulating MAPK-related immune signaling, exhibits anti-inflammatory, antiviral, and anticancer properties while promoting tissue repair. The plasma-activated hydrogel surface was characterized using FESEM and immunofluorescence microscopy, confirming an extracellular matrix (ECM)-like morphology favorable for cell attachment. Biological performance was evaluated using dental pulp stem cells (DPSCs) and oral cancer cell lines. The AlamarBlue assay demonstrated that the plasma-activated GMI–hydrogel coating significantly enhanced DPSC viability and proliferation compared to untreated controls. Wound healing and migration assays revealed accelerated cell migration and coverage on the plasma-treated surfaces. Western blot analysis further confirmed the upregulation of MAPK-associated proteins involved in regenerative signaling. In parallel, the GMI-loaded coatings induced apoptosis in oral cancer cells, inhibiting their adhesion, spreading, and colony formation. These results collectively demonstrate that the synergistic combination of plasma surface engineering and GMI bioactivity enables precise modulation of cellular behavior toward regeneration while suppressing malignant cell functions.

9:20am **MD1-2-TuM-5 Low Temperature Plasma Assisted Strategies to Surface Engineering of Biomaterial**, *Claude Côté, Noureddine Oudini, Alexa Bagdasarian,* PLASMIONIQUE Inc., Canada*; Kambiz Chizari,* PLSMIONIQUE Inc, Canada*; Eduardo Loreto,* PLASMIONIQUE Inc, Canada*; Anita Sarkissian, Ryan Porter,* ***Andranik Sarkissian [sarkissian@plasmionique.com]***, PLASMIONIQUE Inc., Canada **INVITED**

The unique characteristics of materials at the nanoscale make them some of the most promising molecular building blocks in nanotechnology. Nanostructured materials have attracted significant attention across various industrial fields due to their exceptional mechanical, chemical, electrical, and optical properties, which enable a wide range of potential applications. However, each specific application demands precisely engineered structures tailored to its unique requirements. Consequently, the development of specialized strategies for selective processes - such as etching, deposition, functionalization, ion implantation, and synthesis - with excellent control is essential.

Biomaterials present additional challenges, as they must simultaneously satisfy multiple, and often competing, requirements, including biocompatibility, hemocompatibility, cytotoxicity, biodegradability, and mechanical and chemical stability.

Plasma- and vacuum-based technologies offer several distinctive advantages, particularly their ability to enable surface engineering with single-monolayer precision.

In this presentation, we will discuss a range of plasma-assisted surface modification strategies, illustrated with examples of their application to the surface engineering of biomaterials, including biodegradable materials.

10:00am **MD1-2-TuM-7 Superhydrophilic Metallic Coating: PVD Fabrication and Applications**, *Sea-Fue Wang,* National Taipei University of Technology, Taiwan*;* ***Jinn P. Chu [jpchu@mail.ntust.edu.tw]***, National Taiwan University of Science and Technology, Taiwan

Superhydrophilic coatings represent a powerful class of biomimetic technologies that address diverse real-world challenges—from maintaining building cleanliness and optical clarity to enhancing safety in medical settings and efficiency in industrial processes. In this presentation, I will report a novel superhydrophilic coating based on a sputter-deposited 316 stainless steel layer. The coated surface exhibits a water contact angle of approximately 10 degrees. Furthermore, this coating demonstrates notable antifouling and underwater superoleophobic properties, making it highly advantageous for application in separation membranes designed for oil/water emulsions. In addition to its antifouling and separation capabilities, this coating has proven highly effective at enhancing electrochemical responses, making it an excellent functional layer for sensor electrodes. This presentation will provide specific application case studies to demonstrate its practical utility in this domain.

10:20am **MD1-2-TuM-8 Ti-Nb-Mo Alloy Coatings Sputter-Deposited on 316L for Biomedical Applications**, *Katherine Martinez-Orozco, Bruno Aquino,* Federal University of Sao Carlos, Brazil*; Raira Apolinario, Haroldo Pinto,* University of Sao Paulo, Brazil*; Conrado Afonso,* ***Pedro Nascente [nascente@ufscar.br]***, Federal University of Sao Carlos, Brazil **INVITED**

Medical grade AISI 316L stainless steel (SS) has been widely used as prosthetic material due to its adequate biomechanical and biocompatibility properties, however, the cytotoxicity caused by the release of Cr and Ni ions can have toxic effects and cause allergies in human tissues. β phase (body-centered cubic) Ti-based alloys present lower elastic moduli, better biocompatibility, lower density, and better wear and corrosion resistance in biological environments than the 316L SS, however, they are much more costly. An economical option would be to coat a SS implant with a β-Ti alloy thin film with adequate composition to enhance the material biocompatibility. Nb and Mo are non-toxic and non-allergenic biocompatible metals, and their addition to Ti helps to stabilize the β phase. Ti-Nb-Mo alloy ternary alloys present a low elastic modulus that could prevent the stress shielding effect that can cause bone loss. We report on Ti-Nb-Mo alloy coatings deposited on 316L substrates by direct current magnetron sputtering. The following atomic compositions were produced: Ti74Nb21Mo5, Ti74Nb19Mo7, Ti72Nb19Mo9, and Ti67Nb22Mo11; a Ti80Nb20 coating was used as reference. Only the β phase was identified by grazing incidence X-ray diffraction. Scanning electron microscopy images revealed the presence of agglomerates and porous; the grain sizes decreased with the increasing in Mo content. The residual stresses presented a combination of compressive and tensile stresses. An inverse Hall-Petch effect was observed with the hardness reduction with the decreasing in grain size. X-ray photoelectron spectroscopy (XPS) analysis revealed that the Ti-Nb-Mo coatings presented oxidized surface layers, which can be beneficial for biomedical applications.

Surface Engineering of Biomaterials, Devices and Regenerative Materials: Health, Food, and Agriculture Applications
Room Town & Country B - Session MD2-1-TuA

Coatings and Sensors for Health, Food and Agriculture: Antibacterial, Bioactive, and Flexible Interfaces I

Moderators: Diego Mantovani, Université Laval, Canada, **Phaedra Silva-Bermudez**, Instituto Nacional de Rehabilitación Luis Guillermo Ibarra Ibarra, Mexico

1:40pm **MD2-1-TuA-1 Deposition and Surface Characterization of Low-Pressure Plasma Ultra-Thin Coatings Designed for Biomedical Applications***, **Laurent Houssiau [laurent.houssiau@unamur.be]**,* University of Namur, Belgium **INVITED**

Our research group combines expertise in surface characterization techniques, namely X-ray Photoelectron Spectroscopy (XPS) and Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS), with low-pressure plasma deposition of thin films and nanoparticles. This approach enables projects across diverse fields, including biomaterials, biosensing, tissue imaging, hybrid materials, adhesion, and cultural heritage. In this presentation, we will focus on the deposition and characterization of ultra-thin (<100 nm) films that impart new functionalities to substrate materials.

We will first present our work on gradient coatings for dental implants, designed to promote osseointegration while providing antibacterial properties. These coatings are deposited on Ti-6Al-4V (Ti64) alloys using Plasma-Enhanced Chemical Vapor Deposition (PECVD) from a titanium-containing organometallic precursor (titanium isopropoxide) injected in gas phase with argon and oxygen. By gradually decreasing the oxygen flow during the deposition, a compositional gradient is created, from an inorganic TiO_2-like layer at the implant interface to a more organic TiO_xC_y layer near the bone interface, ensuring a smooth transition between the metallic implant and bone tissue. A final magnetron sputtering step, within the same plasma chamber, introduces ZnO nanoparticles into the top TiO_xC_y layer, enhancing antibacterial activity. Depth profiling by XPS and ToF-SIMS confirms the compositional gradient and nanoparticle deposition.

We will then highlight our collaboration with Prof. Mantovani's group at Université Laval on plasma-deposited diamond-like carbon (DLC) and fluorocarbon coatings. Here, XPS and ToF-SIMS have been instrumental in elucidating coating quality, composition, and behavior under various conditions.

Finally, we will present recent research on graphene-based biosensors—an application that also integrates plasma modification and surface analysis for biomedical use. As a proof of concept, the biotin–streptavidin interaction was employed. Graphene layers were amine-functionalized by plasma polymerization, followed by biotin grafting, with XPS monitoring each surface modification step. Electrical I–V measurements revealed a Dirac point shift correlated with streptavidin concentration, demonstrating detection capabilities down to 0.1 nM.

2:20pm **MD2-1-TuA-3 Silver-Copper Nanocoating (Sakcu®) Deposited on Stainless Steel Brackets to Reduce Biofilm Formation of *Streptococcus Mutans* and Potentially Prevent Early Dental Caries***, **Alejandra Cervantes-Ramírez [aleebathory1@gmail.com]**, Lorena Reyes-Carmona, David Eduardo Martínez-Lara, Andrea Quiroz-Cervantes, Gina Prado-Prone, Sandra E. Rodil, Argelia Almaguer-Flores,* UNAM, Mexico

Introduction: Dental brackets facilitate the accumulation of bacteria during orthodontic treatments, favoring the biofilm formation of bacteria that produce organic acids, such as *Streptococcus mutans* (*S. mutans*). This bacterium can lead to enamel demineralization and cavity development. Therefore, creating antibiofilm devices can significantly contribute to preventing early-stage cavities during orthodontic treatments.

Objective: To deposit the Ag-Cu nanocoating (SakCu®) on conventional metallic brackets and evaluate its capacity to reduce the biofilm formation of the cariogenic strain *S. mutans.*

Methods: The deposition of the Ag-Cu nanocoating on stainless steel brackets (American Orthodontics®) was carried out using the magnetron sputtering technique. The micro-morphology and chemical composition of the coated and uncoated bracket surfaces were evaluated using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS), respectively. The *in vitro* antibiofilm effect of surfaces was assessed by Alamar blue kit and the counting of colony-forming units (CFU) assay using *S. mutans* (ATCC 25175). The evaluation was conducted after 1, 3, and 7 days of incubation under anaerobic conditions. Qualitative observation of bacterial adhesion on the surfaces was performed using SEM.

Results: The stainless-steel surface of the orthodontic brackets was coated with a uniform nanolayer of silver and copper without significantly changing their surface morphology. The microbiological results showed that the Ag-Cu nanocoating reduced the biofilm formation of *S. mutans*, especially at the initial incubation times (55% on day 1 and 85% on day 3), compared to the biofilm formed on the surface of brackets without the nanocoating.

Conclusion: The SakCu® nanocoating on orthodontic brackets reduced biofilm formation of the cariogenic *S. mutans* strain, especially during early contact periods. This suggests that the Ag-Cu nanocoating can potentially prevent biofilm formation on orthodontic devices and the development of initial caries, thereby improving treatment and rehabilitation in the mid-term.

Acknowledgments: Financial support of UNAM-PAPIIT # IT207824, # TA10424and SECTEI #159, projects.

2:40pm **MD2-1-TuA-4 ZnO Nanowires: A Platform for Biosensing Applications***, Rafael Salinas, Shirlley Martínez, Guillermo Santana Rodriguez, Carlos Ramos, **Ateet Dutt [adutt@iim.unam.mx]**,* UNAM, Mexico **INVITED**

Our research focuses on the design and characterization of advanced nanomaterials, particularly hybrid gold–zinc oxide (Au–ZnO) nanowires, for chemical and biosensing applications. We investigate how variations in size, morphology, and composition influence their structural and functional performance. The synergistic combination of Au and ZnO imparts these nanowires with distinctive physicochemical properties, enabling the creation of highly sensitive and efficient sensing platforms.

In one study, we developed one-dimensional ZnO nanowire-based systems for the rapid detection of cancer biomarkers, demonstrating precise photoluminescent signal generation through the integration of nanoscale receptors. Furthermore, we achieved tunable photoluminescence responses across analyte concentrations ranging from 1×10^2 to 1×10^8 CFU mL^{-1}, allowing direct visualization of targeted bacterial cells on ZnO nanowire surfaces.

This contact-based nano-biosensing approach enables real-time detection while substantially reducing both processing and response times—an essential advantage for rapid pathogen identification in critical scenarios. By deepening our understanding and control of these hybrid nanostructures, we aim to advance their practical implementation in clinical diagnostics and broader biomedical technologies.

4:00pm **MD2-1-TuA-8 Photoresponsive Bilayer Coating Integrating Zinc and a Chitosan-Antibiotic Drug Delivery Film for on-Demand Antimicrobial Photodynamic Therapy in Biomedical Implants***, **Samuel Santana Malheiros [samuelsmalheiros@gmail.com]**[1], Maria Helena Rossy Borges,* University of Campinas (UNICAMP), Brazil*; João Gabriel Silva Souza,* UnG, Brazil*; Elidiane Cipriano Rangel,* UNESP, Brazil*; Carlos Fortulan,* University of São Paulo, Brazil*; Nilson Cristino da Cruz,* UNESP, Brazil*; Eduardo Buozi Moffa,* University of Saskatchewan, Canada*; Bruna Egumi Nagay, Valentim Adelino Ricardo Barão,* University of Campinas (UNICAMP), Brazil

Despite significant advances in surface treatments, failures of biomedical implants due to bacterial colonization, wear and insufficient bioactivity remain persistent clinical challenges. Here, we engineered a light-responsive antimicrobial bilayer coating for titanium implants consisting of: (i) an inner porous oxide layer doped with bioactive elements Ca, P, and Zn produced by plasma electrolytic oxidation (PEO) and covered by (ii) an outer biodegradable chitosan (CS) thin film for controlled delivery of the photosensitive antibiotic demeclocycline (DMC), enabling antimicrobial photodynamic therapy, a light-activated process where a photosensitizer produces reactive oxygen species (ROS) to eliminate microorganisms. After preparation, samples underwent morphological, physical, chemical, optical, crystallinity, and tribological characterization. Coating's photo-responsiveness was indirectly assessed via methylene-blue degradation under illuminated and dark conditions. Antimicrobial performance was tested under illuminated and dark conditions using a 96-hour polymicrobial biofilm model (human saliva as inoculum). Bioactivity was assessed by hydroxyapatite formation, proteomic analysis of the adsorbed proteins from human blood, and cytocompatibility with pre-osteoblastic cells.

[1] **Graduate Student Award Finalist**

Regarding results, PEO generated a moderately rough, porous oxide layer (Ra ≈ 1 µm) composed of calcium, phosphorus, and zinc oxide, partially covered by the CS film, which reduced roughness to Ra ≈ 0.6 µm while maintaining hydrophilic behavior (contact angle < 40°). CS and DMC incorporation was confirmed by EDS, FTIR, and XPS analyses and UV–Vis spectroscopy attested DMC's photoactive absorption within the visible light wavelength spectra (Soret band ~450 nm). XRD confirmed high crystallinity of the PEO inner oxide layer which imparted mechanical robustness under tribological loading, while the outer polymeric film provided a cushion effect evidenced by the lowest friction coefficient, minimal mass loss, and preservation of the inner layer morphology. Upon light irradiation, photoexcited DMC generated ROS, leading to > 3-$\log_{10}$ reductions in biofilm viability and > 50% decreases in metabolic activity, dry mass, and protein content, along with favorable shifts in microbial community composition. Beneficial protein adsorption profiles, enhanced hydroxyapatite formation, and cytocompatibility confirmed the coating's bioactive potential. Overall, the developed smart light-responsive coating unites ROS-mediated antimicrobial action on-demand, wear protection, and bioactivity in an industry-scalable platform, with potential to enhance biomedical implants longevity and reliability.

4:20pm **MD2-1-TuA-9 Electrospun Nanocomposite Membranes for the Development of Osteoinductive Microambients***, Phaedra Silva-Bermudez* ***[pssilva@inr.gob.mx]****, Julieta García-López,* Unidad de Ingeniería de Tejidos, Terapia Celular y Medicina Regenerativa; Instituto Nacional de Rehabilitación Luis Guillermo Ibarra Ibarra, Mexico*; Gina Prado-Prone,* Laboratorio de Biointerfases, DEPeI, Facultad de Odontología, Universidad Nacional Autónoma de México*; Monserrat Ramirez-Arellano, Gustavo E. Martínez-Murillo,* Unidad de Ingeniería de Tejidos, Terapia Celular y Medicina Regenerativa; Instituto Nacional de Rehabilitación Luis Guillermo Ibarra Ibarra, Mexico*; Lucia S. Flores-Hidalgo,* Posgrado en Ciencia e Ingeniería de Materiales, Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México*; Sandra E. Rodil,* Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México

Displaced, particularly open fractures, represent a significant clinical challenge due to their complexity, variability andhigh complication rate, predominantly due to infections and delayed bone healing rates. In Mexico, approximately 50,000 cases occur annually, with infection rates reaching up to 10%, which is notably higher than those reported in developed countries. Given this concern, there is a growing interest for developing biomedical materials capable of promoting bone regeneration while minimizing infection risk.

Electrospinning is a versatile technique that enables the fabrication of polymeric nanofibrous membranes with high porosity, conformability, and suitable for controlled drug release and degradation. Recently, nanomaterials have attracted significant interest to develop composite materials with specific biofunctionalities. In particular, magnesium oxide nanoparticles (MgONPs) have demonstrated osteogenic properties by promoting cellular proliferation and differentiation towards the osteoblastic phenotype.

Thus, the aim of the present project is to develop composite (polycaprolactone, type B gelatin and MgONPs) membranes capable of thriving an appropriate microambient at the site of the bone fracture, aiming to contribute to increase osteogenesis and decrease bacterial infection. Membranes were fabricated via electrospinning based on polycaprolactone (PCL) and gelatin (Gel), and incorporated with MgO NPs at different concentrations (2, 5, and 7 wt%). Their micro-morphology, chemical composition, wettability, and mechanical properties were examined using SEM, EDS, FTIR, WCA, TGA, DSC and tension tests. The biocompatibility and osteoinductive capability of the membranes was assessed using human bone marrow-derived mesenchymal stem cells (BM-MSCs). Cell viability was assessed after 24 h exposure to membrane lixiviates (MTT assay), and after 24 and 72 h of cells directly cultured on the membranes surfaces (calcein/ethidium homodimer assay). The osteoinductive potential of the membranes was evaluated by assessing the osteogenic differentiation of BM-MSC in contact with membranes lixiviates, by using Alizarin Red staining and immunofluorescence assays against collagen Type I, Osteocalcin and Osteopontin.

The nanocomposite membranes exhibited a microfibrillar-porous structure, and appropriate wettability and mechanical properties for clinical use. The cytocompatibility and osteoinductive effects were dependent on the MgO NPs concentration, with higher NPs concentration increasing cell differentiation towards the osteoblastic phenotype.

4:40pm **MD2-1-TuA-10 Cationic Coatings for Titanium Implants: Integration of Tribocorrosion Resistance and Bioactive Performance***, João Pedro dos Santos Silva* ***[jpedrooss85@gmail.com]****,* Ecole des Mines de St-Etienne - Université de Lyon, France*; Maria Helena Rossy Borges, Thais Terumi Sadamitsu Takeda, Catia Sufia Alves Freire de Andrade, Valentim Adelino Ricardo Barão,* Universidade Estadual de Campinas, Brazil*; Jean Geringer,* Ecole des Mines de St-Etienne - Université de Lyon, France

Failures in implant therapies remain common, mainly due to biofilm formation and the exacerbated inflammatory response caused by coating degradation and release of metallic particles, which inhibit tissue healing and bone regeneration. To address these challenges, we developed a cationic coating (CC) combining antimicrobial properties, tribocorrosion protection, and enhanced biological response through electrostatic interactions, while also improving surface bioactivity and osseointegration potential, all while being drug-free. Titanium discs were treated by plasma electrolytic oxidation (PEO) to form –OH groups and then silanized individually with 3-aminopropyltriethoxysilane (APTES), tetraethyl orthosilicate (TEOS), or 3-glycidyloxypropyltrimethoxysilane (GPTMS), resulting in the CC. Five groups (Ti, PEO, APTES, GPTMS, and TEOS) were evaluated for surface characterization, tribocorrosion performance, microbiological behavior, and cytocompatibility. Micrographs revealed distinct morphologies among the groups, and 3D confocal images confirmed rough topography and increased surface area. After silanization, an increase in positive surface charge confirmed by zeta potential and higher hydrophobicity indicated effective chemical modification. Electrochemical tests under open circuit potential, cathodic, and anodic polarization showed that CCs exhibited low current densities, fast repassivation, and high stability under friction, unlike Ti and standalone PEO. The coefficient of friction and mass loss were reduced by up to 75% compared to titanium, demonstrating superior tribocorrosion resistance. Electrochemical impedance spectroscopy confirmed film integrity after wear, indicating resilient behavior and the formation of an effective barrier. The microbiological response revealed the best anti-adhesion performance for the APTES group, with reductions of 45% (Escherichia coli) and 65% (Staphylococcus aureus). Other experimental groups also showed significant reductions ($p < 0.0001$). Regarding biofilm formation, clear differences were observed between control and experimental groups, confirming that CC effectively controls microbial growth. Finally, human mesenchymal stem cell (hMSC) assays showed higher metabolic activity and proliferation on APTES and TEOS surfaces, with increases above 150% compared to the control and greater viability on days 1, 3, and 8. Thus, CCs demonstrated high electrochemical stability, tribocorrosion resistance, anti-adhesion effects, and the ability to modulate biofilm growth, along with superior biocompatibility, establishing them as a promising solution for more durable, stable, and biologically integrated implants.

5:00pm **MD2-1-TuA-11 PEO-Polymer-Bioglass Hybrid Coatings for Bioactivity and Tribocorrosion Improvement of Ti–6al–4v***, Paulo Soares* ***[pa.soares@pucpr.br]****,* Pontifícia Universidade Católica do Paraná, Brazil

Metallic implants play a crucial role in various medical applications. Achieving rapid bone regeneration, preventing corrosion and wear, controlling metal ion release, and preventing infections are key objectives in implant development. However, osseointegration and implant durability can be affected by several factors. This study focuses on the development of multifunctional coatings for metallic implants, particularly titanium alloys, to provide wear and corrosion protection, and bioactivity properties. Oxidation of titanium alloy (Ti6Al4V) was performed using the plasma electrolytic oxidation (PEO) technique. Subsequently, a bioabsorbable PCL polymer film containing bioglass particles (BGs) was deposited on the oxidized surfaces. The coatings were characterized using scanning electron microscopy, energy-dispersive spectroscopy, X-ray diffraction, and contact angle measurements. Tribocorrosion tests were conducted in artificial saliva, and in vitro assessments of bioactivity were made. The PEO technique successfully provided a suitable surface for subsequent polymer film adhesion. The presence of BG particles enhanced the bioactivity of the coatings. Tribocorrosion tests revealed improved wear and corrosion resistance and reduced friction coefficients for the hybrid coatings compared to uncoated surfaces. These findings pave the way for the development of implant coatings with improved clinical performance, addressing the challenges associated with metallic implants.

Surface Engineering of Biomaterials, Devices and Regenerative Materials: Health, Food, and Agriculture Applications
Room Town & Country B - Session MD2-2-ThM

Coatings and Sensors for Health, Food and Agriculture: Antibacterial, Bioactive, and Flexible Interfaces II

Moderators: Valentim A.R. Barão, University of Campinas (UNICAMP), Brazil, **Mathew T. Mathew**, University of Illinois College of Medicine at Rockford and Rush University Medical Center, USA

8:00am **MD2-2-ThM-1 Surface Modification of AZ31B by Oxygen-Plasma Immersion Ion Implantation to Promote Schwann Cell Interaction for Peripheral Nerve Regeneration***, Luciana Malvestiti [luciana.malvestiti.1@ulaval.ca], Carlo Paternoster, Francesco Copes,* LBB, CHU de Quebec research center, Laval University, Canada*; Paolo Mengucci, Giani Barucca,* Department SIMAU, Università Politecnica delle Marche, Ancona, Italy*; Silvia Ceré,* INTEMA-CONICET, Mar del Plata National University, Argentina*; Andranik Sarkissian,* Plasmionique Inc., Varennes, QC, Canada*; Diego Mantovani,* LBB, CHU de Quebec research center, Laval University, Canada

Their biocompatibility, electrical conductivity and biodegradability properties, make Mg-based alloys a potential biomaterial for peripheral neuropathy. Even if these alloys release Mg^{2+} cations, fundamental in neurological functions, their high corrosion rate triggers implant failure and tissue damage. To control the degradation pattern, and improve the biological response, a plasma-based technique (oxygen-plasma immersion ion implantation, O-PIII) was used on a Mg-based substrate (AZ31B) to generate a thin MgO layer. In addition, other modified surface properties such as roughness and surface energy, improved the general biological response of the material

O-PIII was performed in a PBII-300 system (Plasmionique) on the surface of chemically polished (CP) AZ31B (Al 3 wt.%, Zn 1 wt.%, Mg bal.) specimens. Pressure (5 to 10 mTorr), and pulse repetition rate (200 to 1000 Hz) were working parameters. The morphological, chemical and electrochemical characterization was performed with scanning electron microscopy (SEM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), static drop contact angle, and polarization curves in Hanks' solution. The cytotoxicity of the corrosion products toward Schwann cells (SC), and the interaction between the modified alloy and SC were studied through an indirect test and adhesion test, respectively.

Plasma treatment introduced different surface features depending on the used parameter values, which affected the morphology, roughness, chemical composition, and corrosion resistance. After O-PIII, XPS revealed an increase in MgO content, accounting for the ~70% total detected oxygen. The hydrophilicity of the treated surfaces decreased, from ~40° for CP to ~75°-100° after O-PIII, being within the range that promotes protein adsorption[2]. Applying O-PIII, the corrosion rate was reduced, improving also the corrosion pattern of the material. SC exposure to 10% and 1% extracts did not show a relevant cell viability reduction. After 6 h of incubation, SC were adhered on the modified surfaces exhibiting an elongated morphology, which could be compatible with a regenerative phenotype.

O-PIII modified the AZ31B surface topography, chemical composition (Mg oxide/hydroxide related species), and wettability, enhancing its corrosion resistance. Low concentration of corrosion products did not affect SC viability, moreover, the modified surface allowed SC attachment. These results support the use of O-PIII technique as a potential surface modification for AZ31B, constituting a valid approach for peripheral nerves regeneration.

8:20am **MD2-2-ThM-2 Multifunctional PEO–PPy/Zn Coatings Combined with Electrical Stimulation for Enhanced Antimicrobial and Osteogenic Titanium Surfaces***, Valentim A. R. Barão [vbarao@unicamp.br], Maria Helena R. Borges, Samuel Santana Malheiros, Julia M. Teodoro,* University of Campinas (UNICAMP), Brazil*; João Gabriel S. Souza,* Guarulhos University (UNG), Brazil*; Elidiane C. Rangel,* Sao Paulo State University (UNESP), Brazil*; Ana Paula Souza, Bruna Egumi Nagay,* University of Campinas (UNICAMP), Brazil

Dental implant failure often results from polymicrobial biofilm infections and poor osseointegration, underscoring the need for multifunctional surface modifications of titanium (Ti). Here, we developed a plasma electrolytic oxidation (PEO) coating followed by the electrodeposition of the conductive polymer polypyrrole (PPy) and the antimicrobial agent zinc (Zn), combined with osteogenic stimulation through electrical therapy (ES). We systematically investigated the surface, mechanical, physicochemical, tribological, electrochemical, antimicrobial (mono- and polymicrobial biofilms), and biological properties, as well as osteogenic activity using MC3T3-E1 cells. Ti discs were prepared as four groups: (1) machined, (2) PEO, (3) PEO+PPy, and (4) PEO+PPy/Zn, each evaluated with or without ES. The PEO+PPy and PEO+PPy/Zn surfaces exhibited enhanced mechanical strength, tribocorrosion resistance, reduced wear, and increased hardness ($p<0.05$). Zn incorporation imparted pronounced antimicrobial effects, significantly decreasing biofilm viability and metabolic activity ($p<0.05$), while promoting protein adsorption ($p<0.05$). Moreover, ES further improved cell proliferation, osteogenic differentiation, and mineralized nodule formation ($p<0.05$). Collectively, the multifunctional PEO+PPy/Zn coating, particularly when combined with ES, shows strong potential to enhance implant longevity by strengthening substrate resistance, preventing microbial colonization, and stimulating osteogenesis.

8:40am **MD2-2-ThM-3 Effect of Zirconium Addition on Zn- and Mg-Based Thin Film Properties Deposited by Magnetron Sputtering for Intravascular Biodegradable Materials***, Fatiha Challali [fatiha.challali@univ-paris13.fr], Cristiano Poltronieri,* Laboratoire des Sciences des Procédés et des Matériaux (LSPM) – CNRS, France*; Vinicius De Oliveira F. Sales, Carlos Henrique Michelin Beraldo, Carlo Paternoster,* Université Laval, Canada*; Frédéric Chaubet,* Université Sorbonne Paris Nord, France*; Philippe Djemia,* Laboratoire des Sciences des Procédés et des Matériaux (LSPM) – CNRS, France*; Diego Mantovani,* Université Laval, Canada

Intravascular medical devices allow the treatment of internal vessel-related diseases circumventing open-surgery, in daily-hospital treatment, and with great benefits for patients. The thickness of the devices is inversely proportional to how far in vascular bed diseased sites can accessed, especially for cerebrovascular applications. Unhappily, the fabrication of thin and ultrathin (hundreds to tens of microns) metallic implants remains a key challenge for these applications. Moreover, biodegradable metals are now a reality for adding the degradability components to these devices. For thin intravascular applications, zinc-based alloys are promising candidates due to their moderate degradation rates compared to magnesium-based materials, despite mechanical properties and corrosion rate still need to be investigated. The uniformity of the expected degradation also constitutes a main bottleneck, and metallic glasses, being exempted by surface defects like grain joints, provide a new insight, as recently shown on amorphous Zn–Mg–Ca. Thin film metallic glasses (TFMGs), characterized by a disordered atomic structure, exhibit exceptional mechanical properties, including a large elastic limit (>2%), high hardness, and yield strength (>2 GPa). Their homogeneous atomic arrangement promotes uniform corrosion with tunable rates depending on alloy composition.

This work aimed to enhance the glass-forming ability (GFA) and achieve tunable corrosion rates in Zn- and Mg-based thin films through the addition of Zr. Incorporating Zr as a glass-forming element is an effective strategy to extend the compositional ranges of amorphous or nanocrystalline alloys. The addition of Zr enables precise control over the microstructure and crystallinity, facilitating the design of biodegradable materials with improved performance. Thin films of Zn–Zr and Mg–Zr binary alloys were synthesized by magnetron co-sputtering onto silicon substrates using pure metallic targets, with thicknesses ranging from 300 to 900 nm, covering a wide composition range. The film microstructure and chemical composition were analyzed by XRD and SEM/EDS, respectively. Corrosion behavior was evaluated through electrochemical measurements performed at room temperature, while biodegradability was assessed by immersion tests in simulated body fluid at 37 °C for up to eight weeks. XRD results showed that Mg–Zr films exhibited a nanocrystalline structure, while amorphous Zn–Zr films were obtained for Zn contents between 26 and 88 at.%. Immersion tests revealed premature cracking and delamination in Zn- and Mg-rich films after one week, whereas Zr-rich films remained adherent even after eight weeks of immersion.

9:00am **MD2-2-ThM-4 Influence of Microstructure and Processing Voltage on the Formation and Properties of Coatings Obtained by Micro-Arc Oxidation (MAO) in Ti-25Ta-xNb Alloys**, ***Fernanda de Freitas Quadros [ff.quadros@unesp.br]***, Sao Paulo State University (UNESP), Brazil; *Katia Barbaro,* Istituto Zooprofilattico Sperimentale del Lazio e della Toscana, Italy; *Diego Rafael Nespeque Corrêa,* Sao Paulo State University (UNESP), Brazil; *Julietta V. Rau,* Istituto di Struttura della Materia, Consiglio Nazionale delle Ricerche, Italy; *Carlos Roberto Grandini,* Sao Paulo State University (UNESP), Brazil

The Micro-Arc Oxidation (MAO) technique has emerged as one of the most effective methods for improving the surface properties of metallic materials, particularly in titanium (Ti) alloys used for biomedical applications[1]. Although Ti exhibits good mechanical performance, high corrosion resistance, and excellent biocompatibility, issues such as corrosion, infection, and implant rejection may still occur[2]. Ti is an allotropic element, displaying a hexagonal close-packed (α) structure below 882 °C and a body-centered cubic (β) structure above this temperature[2]. The addition of β-stabilizing elements, such as tantalum (Ta) and niobium (Nb), lowers the β-transus temperature and can enhance the material's corrosion resistance and biocompatibility due to the intrinsic properties of Ta and Nb [3]. This study aimed to investigate the influence of microstructure, particularly through variations in Nb content, on coatings obtained by MAO in Ti-25Ta-xNb alloys (x = 10, 20, and 30 wt.% Nb) under different applied voltages (200, 250, and 300 V). X-ray diffraction (XRD) analyses revealed the predominance of Ti oxides in the anatase and rutile phases, with rutile being more pronounced in samples processed at higher voltages [3]. Scanning electron micrographs showed that both the alloy microstructure and the applied voltage significantly influenced coating formation and morphology, with variations in pore size, shape, and interconnectivity [3]. Rockwell C microhardness tests demonstrated good film adhesion to the substrate under all conditions analyzed [3]. In biological assays, Ti-25Ta-xNb substrates (200–300 V) exhibited non-cytotoxic behavior toward stem cells and effective antibacterial activity against Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, and Enterococcus faecalis, with the Ti-25Ta-30Nb alloy treated at 300 V showing the most promising performance. These findings indicate that surface modification via MAO, combined with controlled Nb addition, produces coatings with excellent adhesion, biocompatibility, and antimicrobial properties. The authors acknowledge the financial support from the funding agencies FAPESP, CAPES, and CNPq.

1. *Review of micro-arc oxidation of titanium alloys: Mechanism, properties and applications.* Journal of Alloys and Compounds, 2023. **948**: p. 169773.
2. *A review—metastable β titanium alloy for biomedical applications.* Journal of Engineering and Applied Science, 2023. **70**(1): p. 1-36.
3. *Surface Characteristics of TiO2 Coatings Formed by Micro-Arc Oxidation in Ti-25Ta-x Nb Alloys: The Influence of Microstructure and Applied Voltage.* Coatings, 2025. **15**(6): p. 730.

9:20am **MD2-2-ThM-5 Pulsed Laser Deposited Electron-Rich Max Phases as Antibacterial, Anticorrosive Agents and Toxic Gas Detectors**, ***Sangeeta Kale [sangeetakale2004@gmail.com]***, *Revathi B.S., Piyush Shah,* Defence Institute of Advanced Technology (DIAT), India **INVITED**

MAX phases are layered ternary carbides and nitrides which exhibit both metallic and ceramic properties, demonstrating their promise for biomedical applications. Salient properties include high electrical conductivity, mechanically rigid, thermal and chemical stability, corrosion resistive, drug delivery agents and antibacterial nature. MAX, along with its derivative MXenes, show a plethora of applications which are under rapid investigations.

Considering the complex structure, achieving high-quality thin films of MAX phases is quite challenging. Of many techniques used, pulsed laser deposition (PLD) technique is one of the best routes for generating stoichiometric thin films, provided the substrates are carefully chosen. Through this work, we explore PLD of Titanium Aluminium Carbide (Ti_3AlC_2) MAX phase thin films on Silicon (100) substrate, focusing on film properties and possible applications. A KrF Excimer Laser (248 nm, 20 ns) was used to grow the film from MAX target. At 700°C, energy density ~2.5 J/cm^2, pulse repetition rate of 5 Hz, at chamber pressure of 1×Torr, 2000 Å films were grown.Uniform, pin-hole-free smooth films showed no indications of fragmented growth. Microscopic morphological studies hinted presence of free electrons on the film surface, which confirmed the metallic behaviour of the film on a semiconductor substrate. These stoichiometry-maintained micro-crystallites show large number of free electrons with intrinsic strain which could be explored for non-conventional device applications.

Through this talk, these films as anti-corrosive and anti-bacterial agents would be explored. Simple Salt-spray technique and both gram-positive and gram-negative bacterial agents would be used for these confirmations. Toxic chemical, Hydrazine, is evaluated against this MAX phase for its detection using simple potentiometric approach. These results would be elaborated using structure-property relationships.

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10:20am **MD2-2-ThM-8 Dislocation-Mediated Plasticity and Strain Localization in Transition Metal Nitrides: Insights from Micropillar Compression**, ***Rainer Hahn [rainer.hahn@tuwien.ac.at]***, CDL-SEC, TU Wien, Austria; *Peter Polcik, Szilard Kolozsvari,* Plansee Composite Materials GmbH, Germany; *Klaus Boebel,* Oerlikon Surface Solutions AG, Liechtenstein; *Helmut Riedl,* CDL-SEC, TU Wien, Austria **INVITED**

Transition metal nitrides are key materials in advanced protective and functional coatings, yet their mechanical response is often constrained by intrinsic brittleness. Recent studies show that defect engineering and electronic structure control can fundamentally alter this behavior, enabling metallic-like plasticity in selected compounds. In this work, we employ in-situ micropillar compression to investigate the deformation mechanisms of epitaxial TiN, CrN, and WN thin films. Despite their structural similarity, these nitrides exhibit strikingly different responses under load. TiN and CrN deform through slip-band formation and early strain localization, indicating limited dislocation mobility and a strong tendency toward brittle failure. In contrast, WN displays pronounced metal-like plasticity, sustaining large plastic strains through dislocation glide and interaction processes more typical of metallic systems. These findings demonstrate how compositional tuning and bonding character influence the transition from brittle to ductile behavior in refractory nitrides. The results establish in-situ micropillar compression as a powerful tool to uncover intrinsic deformation pathways and identify WN as a key model system bridging metallic and ceramic mechanical responses.

11:00am **MD2-2-ThM-10 Biofunctional Zinc Phosphate-Loaded Membranes as a Potential Anti-Biofilm and Remineralizing Approach for Caries Management**, ***Gina Prado-Prone [gpradoprone@comunidad.unam.mx]***, *Lorena Reyes-Carmona, Lizeth A. González-Vargas,* Laboratorio de Biointerfases, DEPeI, Facultad de Odontología, Universidad Nacional Autónoma de México; *Phaedra S. Silva-Bermudez,* Unidad de Ingeniería de Tejidos, Terapia Celular y Medicina Regenerativa; Instituto Nacional de Rehabilitación Luis Guillermo Ibarra Ibarra, Mexico; *Sandra E. Rodil,* Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México; *Nicola Cioffi,* Dipartimento di Chimica, Università degli Studi di Bari Aldo Moro, Italy; *Camila A. Zamperini Zamperini,* Department of Restorative Dentistry, College of Dentistry, University of Illinois Chicago, USA; *Argelia Almaguer-Flores,* Laboratorio de Biointerfases, DEPeI, Facultad de Odontología, Universidad Nacional Autónoma de México

Introduction: Dental caries is the most common oral disease, mainly caused by persistent cariogenic biofilm on dental surfaces. The acidic environment created by acid-producing and acid-tolerant bacteria leads to dental demineralization and, ultimately, caries formation. The most important strategies in cariology currently focus on preventing caries and treating early-stage lesions by inhibiting biofilm formation and optimizing tooth health remineralization. Therefore, developing novel antibiofilm and remineralizing anti-caries biomaterials has great potential to enhance caries prevention and treatment.

Objectives: To develop zinc phosphate (ZnP)-loaded membranes and evaluate their capacity to prevent dental caries-related biofilms and promote dental remineralization.

Methods: ZnP microparticles were synthesized via chemical precipitation. Membranes were synthesized via electrospinning a polycaprolactone-gelatin blend (1:1) incorporating ZnP microparticles at 1%, 2%, and 5% (w/w) concentrations. The micro-morphology, chemical composition, wettability, and thermal properties were analyzed using SEM, EDS, FTIR, WCA, TGA, and DSC. The *in vitro* anti-biofilm effect was evaluated by turbidity and Alamar Blue assays using four bacteria associated with caries: *Streptococcus mutans* (25175™ATCC®), *Streptococcus sanguinis* (110556™ATCC®), *Lactobacillus acidophilus* (4356™ATCC®), and *Veillonella parvula* (17745™ATCC®). To assess the remineralization potential of the experimental membranes in *in vitro* root caries lesions, human root dentin specimens were slightly demineralized and exposed to the membranes under remineralization cycling. The mineral density, depth, and porosity of the final root caries lesions were assessed by computer microtomography and confocal scanning laser microscopy after rhodamine infiltration.

Results: Membranes exhibited a microfibrillar structure with interconnected porosity and desirable physico-chemical properties for clinical applications. Antibacterial testing showed 44-80% inhibition of biofilm formation of the four bacterial strains on the ZnP-membrane surfaces; the antibiofilm effect appears to depend on the ZnP concentration. The 5% ZnP-loaded membranes exhibited a more favorable pattern of remineralization for *in vitro* root caries treatment, but there were no statistically significant differences in caries depth and porosity among groups ($p \geq 0.05$).

Conclusions: ZnP-loaded membranes can potentially be used as an anti-biofilm and remineralizing approach for dental caries management.

Acknowledgements: This work was funded by the UI System/UNAM Joint Research Partnership Program, and the UNAM-PAPIIT #TA100424 and #IN207824 projects.

11:20am **MD2-2-ThM-11 Growth Mechanism and Cellular Response to Film Thickness Variations of Nanoporous Alkaline Titanate-Converted, Magnetron Sputtered Ti Thin Films***,* ***Matthew Wadge [m.wadge@mmu.ac.uk]****,* Manchester Metropolitan University, UK*; Kozim Midkhatov,* University of Manchester, UK*; Jonathan Wilson, Louise Briggs, Timothy Cooper, Zakhar Kudrynskyi,* University of Nottingham, UK*; Reda Felfel,* University of Strathclyde, UK*; Ifty Ahmed, Colin Scotchford, David Grant,* University of Nottingham, UK*; Justyna Kulczyk-Malecka,* Manchester Metropolitan University, UK*; Mahetab Amer,* University of Manchester, UK*; Peter Kelly,* Manchester Metropolitan University, UK

The standard process for improving bioactivity of implant surfaces for natural fixation is reliant on high temperature (>1500 K) plasma spraying of hydroxyapatite (HA) [1]. However, these surfaces have been shown to spall due to their brittle nature, high internal stresses, and weak mechanical adhesion [1]. Bioactive titanate surfaces have been developed as a low-temperature, more simplistic alternative, however, their applicability is limited to titanium (Ti) and its alloys only via chemical conversion routes [1]. The present authors previously demonstrated the applicability of titanate surfaces generated from PVD Ti coatings [2], however, assessment of thickness variation on cellular performance is still required, due to potential unwanted effects such as poor cellular proliferation. This paper highlights for the first time the cellular performance of titanate films generated on various thicknesses of Ti coating. By varying the thickness of the PVD deposited Ti coating, one can influence the formation mechanism of the wet-chemically derived titanate surface produced, since the mechanism is diffusion dependant and material limited.

Magnetron sputtering was employed to generate the Ti coatings (ca. 50, 100, 200, 500 nm) owing to its excellent step coverage, relatively quick deposition rate, ability to coat onto, and from, a wide variety of materials. In the conversion process, Ti coatings are treated in NaOH (5 M; 60 °C; 24 h) to generate sodium titanate structures [1]. The resultant materials were characterised using SEM, EDX, XPS, XRD, as well as cellular assessments, in order to understand the formation mechanism, the resultant morphological (Fig.1&2), structural (Fig.3) and chemical (Fig.4) properties, as well as influence on cellular response. It was clear that the Ti coatings exhibited good step coverage. Following titanate formation, only the 200 and 500 nm coatings produced the characteristic nanoporous 'webbed' titanate structures, due to the lack of free Ti in the coating, as opposed to the conventional diffusion limitation (Na and O) of the titanate mechanism. Both XPS and XRD analyses confirmed the formation of titanate on all of the coatings tested, despite the morphological differences and irrespective of thickness. Through utilising sputtering, the applicability of these titanate materials in a biomedical context can be significantly improved due to its ability to coat most materials and matching the subsequent wet-chemical temperature conditions.

References

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11:40am **MD2-2-ThM-12 Antibacterial Performance of Electrodeposited Copper Coatings on Titanium Alloy Surfaces for Biomedical Applications***,* ***Bryan Angel Zárate Verduzco [1629251c@umich.mx]****,* Universidad Michoacana de San Nicolás de Hidalgo, Mexico*; Victor Manuel Solorio García, Miguel Ivan Dávila Perez,* Tecnologico Nacional de México/ Instituto Tecnológico de Morelia, Mexico*; Roberto Guerra González, Sandra Edith Lopez Castañeda, Alfonso Lemus Solorio, Maria Guadalupe Carreon Garcidueñas,* Universidad Michoacana de San Nicolás de Hidalgo, Mexico

The increasing incidence of implant-associated infections underscores the urgent need for effective antibacterial surface modifications that prevent biofilm formation without compromising the mechanical integrity of metallic implants. In this study, copper (Cu) coatings were electrodeposited onto Ti6Al4V alloys fabricated by powder metallurgy to impart bacteriostatic functionality and inhibit microbial colonization. Controlled deposition was performed at varying durations (1 min, 5 min, 15 min, 1 h, and two h). Surface morphology and composition were characterized by scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS), revealing dense, adherent Cu layers whose thickness increased proportionally with deposition time. Microbiological assays against Staphylococcus aureus (MRSA) and Escherichia coli demonstrated over 99% reductions in bacterial viability after 24 h, along with marked suppression of biofilm development and maturation on the coated surfaces. The antibacterial mechanism was attributed to the controlled release of Cu^{2+} ions, which induces an oligodynamic effect on bacterial membranes and interferes with early-stage adhesion and extracellular matrix formation. These results confirm that electrodeposited Cu films on Ti6Al4V represent a cost-effective, scalable, and environmentally responsible route toward infection-resistant implants. This approach provides a promising alternative to conventional antibiotic prophylaxis, supporting the development of next-generation biomaterials designed to reduce post-surgical infections and improve the long-term safety and performance of metallic implants.

12:00pm **MD2-2-ThM-13 Low-Pressure Plasma Processes for the Deposition of Adherent Diamond-Like Carbon Coatings on Titanium Alloys for Biomedical Applications***,* *Chloé Audet,* ***Pascale Chevallier [pascale.chevallier@crchudequebec.ulaval.ca]****,* Laboratory for Biomaterials and Bioengineering, (CRC-Tier I), Dept Min-Met-Materials Eng., & Regenerative Medicine, CHU de Quebec, Laval University, Canada*; Sandra Rubio,* Laboratoire Interdisciplinaire de Spectroscopie Electronique, Namur Institute of Structured Matter, University of Namur, Belgium*; Andranik Sarkissian,* Plasmionique Inc, Canada*; Laurent Houssiau,* Laboratoire Interdisciplinaire de Spectroscopie Electronique, Namur Institute of Structured Matter, University of Namur, Belgium*; Diego Mantovani,* Laboratory for Biomaterials and Bioengineering, (CRC-Tier I), Dept Min-Met-Materials Eng., & Regenerative Medicine, CHU de Quebec, Laval University, Canada

Titanium and its alloys are widely recognized as the gold standard for bone contact implants due to their suitable mechanical properties and biological performances. However, their long-term clinical performance remains impaired, mainly due to insufficient integration with surrounding tissues and the risk of infection. In order to enhance their performance, surface modification through coatings are explored. Among these coatings, diamond-like carbon (DLC) has emerged as a promising material due to its superior mechanical properties, chemical inertness, and stability, as well as its ability to integrate antibacterial agents such as Ag, ZnO, etc., resulting in a multifunctional coating. However, due to the high intrinsic stresses of DLC compared to the native oxide layer, the adhesion of DLC to metallic surfaces remains rather low. Therefore, this work focuses on improving DLC adhesion to the Ti alloy surface using plasma-assisted chemical vapor deposition (PECVD), by optimizing different surface pretreatments prior to coating. The results showed that the nature and duration of the pretreatment significantly influenced the chemical composition and topography of the substrate prior to deposition, which in turn had an impact on the thickness, structure and morphology of the DLC. Short methane carburizing, particularly for 10 min, appeared to be the most effective pretreatment, as it removed the native oxide layer, enhanced carbon implantation, led to thick, adherent DLC coatings with a diamond-like structure, and stable even after 7 days of aging in pseudo-physiological conditions. In contrast, argon etching alone was ineffective, and combining both treatments yielded thinner films.

Controlled plasma carburization prior to DLC deposition significantly improves coating adhesion and stability on Ti alloys, paving the way for improved implant performance. The addition of antibacterial agents within the DLC matrix could further improve clinical outcomes of implants and reduce implant-associated infections.

Keywords: Surface modification, plasma-enhanced chemical vapor deposition, diamond-like carbon, Ti-alloy medical implant.

Surface Engineering of Biomaterials, Devices and Regenerative Materials: Health, Food, and Agriculture Applications
Room Golden State Ballroom - Session MD-ThP

Surface Engineering of Biomaterials, Devices and Regenerative Materials: Health Food, and Agriculture Applications Poster Session

MD-ThP-1 Eco-Friendly Synthesis of Graphene Intercalation Material for Highly Sensitive Maldi-Ms Bioanalysis, *Yao-Tsung Hsu,* Graduate Institute of Medical Sciences, College of Medicine, Taipei Medical University, Taiwan*; Shih-Min Wang,* National Atomic Research Institute, Taiwan*; **Fu-Der Mai [fordmai@tmu.edu.tw]**,* Department of Biochemistry and Molecular Cell Biology, School of Medicine, College of Medicine, Taipei Medical University, Taiwan

Introduction: Developing highly sensitive and environmentally benign materials for biomolecular analysis remains a critical challenge. Matrix-Assisted Laser Desorption/Ionization-Mass Spectrometry (MALDI-MS) is a powerful tool in proteomics, but its sensitivity is often limited by the co-crystallization matrix. We propose a novel, eco-friendly synthesized intercalation material designed to function as an "amphiphile attractor" to significantly boost analytical performance.Methods: Our methodology begins with the sonication-induced scission of few-layer precursory graphene, leading to the asymmetric cleavage and production of nanoscale Asymmetrically Cleaved Graphene (ACG), with an average dimension of 41.58 nm. The ACG exhibits high surface energy, making it intrinsically "amphiphile-attractive." Subsequently, ACG is self-assembled and wrapped by amphiphiles into a hemimicelle structure, allowing it to intercalate into bulk graphite to form the final Asymmetrically Cleaved Graphene Intercalated Material (ACGIM).Results and Discussion: The unique structure of ACGIM is highly promising for bioanalysis. The attracted amphiphiles within the ACGIM effectively stabilize biomolecules, which is crucial for signal integrity. To validate its analytical potential, we conducted a signal enhancement experiment using ACGIM as a novel matrix substitute for peptide detection via MALDI-MS. The results demonstrated a remarkable 22-fold enhancement in the detection signal for the target peptide compared to conventional methods.Conclusion: The ACGIM represents a new class of amphiphile-attractive intercalation materials synthesized under green conditions. Its superior ability to stabilize biomolecules and significantly enhance signal intensity in MALDI-MS offers a robust platform for highly sensitive bioanalysis, particularly in peptide and protein research. Further exploration into its application for diverse biomolecule types is warranted.

MD-ThP-2 Study of the Antimicrobial and Osteoinductive Properties of Polymeric Nanocomposite Membranes, ***Lucia Sofia Flores-Hidalgo [floreshidalgol@pceim.unam.mx]**,* Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México*; Phaedra S. Silva-Bermúdez,* Unidad de Ingeniería de Tejidos, Terapia Celular y Medicina Regenerativa; Instituto Nacional de Rehabilitación Luis Guillermo Ibarra Ibarra, Mexico*; Gina Prado-Prone,* Laboratorio de Biointerfases, DEPeI, Facultad de Odontología, Universidad Nacional Autonoma de Mexico, Mexico*; Monserrat Ramirez-Arellano,* Facultad de Medicina, Universidad Nacional Autonoma de Mexico, Mexico*; Sandra. E Rodil,* Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México

Nanofibers have garnered considerable attention in recent years due to their wide-ranging applicability in various fields, including tissue engineering, biotechnology, medicine, sensing, and bioremediation. Among the different fabrication methods for composite membranes, electrospinning stands out for its ability to utilize a wide range of polymers and copolymers. Several configurations of the electrospinning process exist; among them, co-electrospinning is noteworthy, as it allows the simultaneous spinning of two independent polymer solutions while preserving their individual properties.

Polycaprolactone (PCL) and gelatin are two polymers widely studied for biomedical applications due to their good biocompatibility and biodegradability. In parallel, nanoparticles of various metal oxides, such as zinc oxide (ZnO) and magnesium oxide (MgO), have been investigated for their antibacterial and osteoinductive properties, respectively.

For this reason, the present work reports the porous microfibrous structure of PCL/gelatin nanocomposite membranes obtained via electrospinning by combining fibers containing ZnO nanoparticles and fibers containing MgO nanoparticles. These membranes were characterized morphologically and compositionally using SEM, FTIR, TGA, EDS, DSC, and ICP analyses. Finally, biological assays were performed to evaluate their antibacterial efficacy and their potential to promote an osteoinductive environment, assessing their possible use as an adjuvant in the treatment of open fractures.

MD-ThP-3 Understanding the Influence of Sn and Nb on Morphology, Sustainable Synthesis of Calcium Phosphate 1d Nanostructures via Electrospinning for Advanced Functional Applications, *Yao Mawuena Tsekpo, Weronika Smok,* Faculty of Mechanical Engineering, Silesian University of Technology, Poland*; Adrian Adrian Radon,* Łukasiewicz Research Network – Institute of Non-Ferrous Metals, Poland*; Pawel Jarka, **Tomasz Tanski [tomasz.tanski@polsl.pl]**,* Faculty of Mechanical Engineering, Silesian University of Technology, Poland

Calcium phosphate compounds are a sustainable material with applications in biomedicine and environmental remediation. The influence of dopants on the morphology of one-dimensional (1D) structures prepared by the electrospinning technique with biogenic calcium as a starting material remains understudied. This work presents a novel method for synthesising calcium phosphate nanowires doped with Sn and Nb using Galatea paradoxa clamshells as a calcium source. The process integrates electrospinning and sol-gel techniques to achieve 1D nano calcium pyrophosphate and aims to elucidate the influence of temperature on the process. Thermogravimetric analysis (TGA), Scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), and Fourier transform infrared spectroscopy (FTIR) were employed to characterise the nanostructures. Calcination at 600 ºC and 700 ºC reveals the formation of wire-like structures at the nanoscale with diameters ranging from 68 – 403 nm. The Sn-doped wires were observed to be more thermally stable at higher temperatures (700 ºC) whilst having narrower wire diameters as compared to the Nb-doped wires. XRD analysis confirmed the presence of Sn and Nb, corroborating the presence of their oxide and aligning with the Fast Fourier Transform (FFT) diffraction patterns obtained in TEM. These findings indicate the successful formation of 1D nanostructures of calcium phosphate nanowire doped with Sn and Nb. The observed structure and morphology of the prepared nanostructure exhibit properties suitable for application in bone regeneration and biomedicine, adsorption of harmful heavy metals, and as a sustainable photocatalyst.

MD-ThP-4 Advancing Surface Engineering of Additively Manufactured Dental Implants by HiPIMS β-Ti Coatings, ***Juan Carlos Sanchez-Lopez [jcslopez@icmse.csic.es]**,* Instituto de Ciencia de Materiales de Sevilla (CSIC-US), Spain*; Amanda Robau-Porrua,* Universidad de Concepción-Chile*; Marleny Rodríguez-Albelo,* Universidad de Sevilla, Spain*; Celia Garcia-Hernandez, Cristina Garcia-Cabezon,* Universidad de Valladolid, Spain*; Jesús Eduardo Gonzalez-Ruiz,* Universidad de la Habana, Cuba*; Yadir Torres,* Universidad de Sevilla, Spain

Improving the mechanical compatibility and corrosion resistance of metallic implants is essential for long-term clinical success. Titanium and its alloys are widely used for dental and orthopedic devices, yet surface reactivity and elastic modulus mismatch with bone can limit their performance. Surface modification by magnetron sputtering offers an effective strategy to tailor surface properties at the nanoscale while preserving bulk integrity.The β-phase Ti alloys show a significant reduction of the elastic modulus compared with bulk titanium, improving biomechanical compatibility and mitigating stress-shielding effects.

Building upon our previous studies on flat titanium substrates, the present work represents a significant step forward by applying high-power impulse magnetron sputtering (HiPIMS) coatings to real 3D titanium implant geometries. This transition allows us to assess the feasibility of conformal deposition on complex surfaces while maintaining the advantageous features of HiPIMS. Ti-35Nb-7Zr-5Ta (wt. %) β-type coatings were deposited onto dental implants fabricated by Laser Bed Fusion (LBF), producing dense, adherent layers with controlled nanoroughness and uniform coverage, even within threaded regions.

Microstructural and chemical analyses (SEM, XRD, XPS) confirmed homogeneous β-phase formation and the presence of a protective TiO_2 surface layer. Nanoindentation revealed a reduction in elastic modulus of up to 30% compared with uncoated titanium, mitigating stress-shielding effects. Electrochemical tests in simulated physiological media demonstrated enhanced corrosion resistance and surface stability.

These results highlight the versatility of HiPIMS as a scalable tool for the conformal coating of complex 3D implants, enabling the development of next-generation dental and orthopedic biomaterials with optimized mechanical and corrosion performance.

MD-ThP-5 Electrochemical Characterization of Copper-Coated Commercial Ti6Al4V Alloy for Advanced Biomedical Applications*,*

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Electrodeposited copper (Cu) coatings on titanium alloys are promising candidates for multifunctional biomaterials combining antibacterial and conductive properties. This study evaluates the electrochemical performance and corrosion resistance of Cu coatings applied to commercial Ti6Al4V. Open-circuit potential (OCP), linear polarization resistance (Rp), electrochemical impedance spectroscopy (EIS), and potentiodynamic polarization tests were performed in Hank's solution at 37 °C, with pH measurements during the tests. Results showed that Cu deposition modifies the passive behavior of Ti6Al4V, shifting the corrosion potential toward more active values while maintaining acceptable polarization resistance. Among the tested conditions, deposition exhibited the lowest corrosion rate compared to the base material. Equivalent circuit modeling of EIS data revealed two time constants associated with the outer Cu layer and the Ti oxide interface, evidencing a dual protective mechanism. The combined analysis indicates that optimized deposition time can balance ion-release kinetics and surface passivation, contributing to long-term functional stability. These insights lay the groundwork for predictive corrosion models and the rational design of antibacterial, corrosion-resistant coatings for next-generation biomedical implants.

MD-ThP-6 TiO_x Nanocoating as Antimicrobial for Personal Protective Equipment*,*

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Introduction: Pathogenic bacteria and viruses could be transmitted by aerosols formed from saliva droplets. These bioaerosols are becoming the main airborne transmission source for respiratory microorganisms. It has been reported that health professionals are highly exposed to bioaerosols generated during medical or dental procedures since rotary instruments are used, which produce pathogenic bioaerosols. The development of nanomaterials with antimicrobial activity to cover personal protective equipment (PPE), such as facemasks, could be an option to avoid the transmission of these pathogens.

Objective: The aim of this study was to evaluate the antibacterial and antiviral capacities of titanium oxide nanocoating (TiO_x) deposited on polypropylene (PP) fabrics used to produce medical and dental protective equipment.

M**ethods:** TiOx nanocoating was deposited on PP fabric by magnetron sputtering. They were characterized using optical microscopy, XPS, WCA, optical profilometry, and ICP-MS. For antimicrobial evaluation, pathogenic bacteria and surrogates virus (RNA and DNA bacteriophages) were used. Two methodologies were used: short (2 min) and long (24 h) term interaction of nanocoatings with bacterial and viral aerosols.

Results: ZnO nanocoating was homogeneously deposited on the PP. The antimicrobial results showed a reduction of the bacteria between 18-95 %, depending of the bacterial strain tested. With respect to viral assays with RNA bacteriophages, a total reduction of the viral replication was achieved after 24 h. However, the DNA phage was not completely inactivated.

Conclusions: TiO_x nanocoating showed antimicrobial potential against bacteria and surrogate viruses. This nanocoating has the potential to be used to cover medical PPE, to reduce and prevent the transmission of pathogens in medical and dental environments.

Keywords: Nanocoating, titanium oxide, antibacterial.

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MD-ThP-7 "Adsorption of Heavy Metals in Aqueous Solutions by Polymeric Nanofibers"*,*

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Heavy metal contamination of water resources constitutes a significant and persistent threat to human health and ecosystem integrity on a global scale. In Mexico, the synergy between geogenic sources and intensified anthropogenic activity (mining, industrial, and agricultural) has led to the contamination of strategically important water bodies, adversely affecting the quality of life in various regions, with the state of Michoacán being a particularly relevant case study. Conventional wastewater treatment technologies, such as chemical precipitation or reverse osmosis, often exhibit critical limitations in terms of efficiency at low concentrations, high operating costs, and the generation of toxic byproducts. Given this situation, nanotechnology is emerging with disruptive solutions. Specifically, nanomaterials, and particularly polymeric nanofibers obtained through the versatile electrospinning technique, have been postulated as a high-potential alternative. Their distinctive attributes, including exceptional specific surface area, high interconnected porosity, and remarkable ease of surface chemical functionalization, position them as high-capacity adsorbents.This research comprehensively explores the potential of nanofibers, with a particular focus on those formulated from biopolymers such as chitosan and biodegradable polyesters such as polycaprolactone (PCL), for the adsorption of heavy metal cations (e.g., lead, cadmium) in aqueous systems. An in-depth review of the principles governing water pollution, heavy metal speciation and toxicity, and existing treatment technologies is provided, with a critical analysis of their foundations and limitations. Subsequently, the fundamentals of nanomaterials and nanofibers are addressed, detailing their unique properties. The electrospinning process is extensively explored, analyzing the effect of solution, process, and environmental parameters on the morphology and properties of the resulting fibers. Finally, the adsorption mechanisms are analyzed, and the state of the art regarding the use of electrospun nanofibers for heavy metal removal is reviewed, along with the materials and functionalizations employed, and the key factors governing their efficiency and regenerative capacity.

MD-ThP-8 Comparative Analyses of Conventional Electrical Discharge Machining (EDM) and Multiple Powder-Mixed EDM of Biomaterials*,*

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Powder-mixed EDM is widely implemented to improve the material removal rate and surface quality of metallic substrates by the addition of selective powders like graphene and HAP owing to their better electrical conductivity and biocompatibility nature respectively. This study highlights powder-mixed electrical discharge machining (PMEDM) of biomaterials such as commercially pure titanium and Nitinol using graphene and hydroxyapatite (HAP) powders which is used as additives in the EDM oil (dielectric medium) i n conventional EDM process. Taguchi L9 experiments were conducted for conventional EDM and Gr/HAP powder-mixed EDM processes with input parameters like pulse on (microsecs), pulse off, peak current (amp) and powder concentration (g/L).Comparative analyses were performed to evaluate the effects of powder addition on the microstructure, adhesion, and performance of the modified surfaces. The results showed that powder-mixed EDM significantly improved MRR and surface quality of coated samples compared to conventional EDM. Multi-objective optimization of MRR, SR and TWR for both the biomaterials were done using Grey Relational Analysis (GRA) method. Additionally, corrosion tests were performed to evaluate protection efficiency of coated samples by using Electrochemical impedance spectroscopy (EIS) and potentiodynamic polarization techniques. The results depicted higher corrosion resistance property of combined graphene and HAP powders conducted under simulated body fluid conditions. These findings suggest that integrating powder-mixed EDM with biocompatible nanomaterials presents a promising approach for biomedical applications.

Keywords: Powder-mixed EDM, Graphene and HAP powder, corrosion-resistance, Taguchi L9 approach, ANOVA, GRA

MD-ThP-9 Investigating the Corrosion Behavior of Sol Gel and PEO Coatings on Magnesium for Biomedical Applications*, Vinod Prabhakar* ***[vinodp2@uic.edu]****, Avirup Sinha, Sujoy Ghosh,* University of Illinois at Chicago, USA*; Hamdy Ibrahim,* Kennesaw State University, USA*; Mathew T. Mathew,* University of Illinois College of Medicine at Rockford and Rush University Medical Center, USA

Magnesium (Mg) alloys have been applied to orthopedics as its elastic modulus resembles bone, and its stress-strain behavior resembles ductile metals. Mg alloys exhibit high corrosion rates including high degradation and H_2 release. Existing coatings, such as titanium, sol-gel, and plasma electrolytic oxidation (PEO) have improved corrosion properties of Mg alloys. This study evaluates corrosion in bovine calf serum (BCS), a fluid that simulates lubricating human synovial joints. The goal of this study was to test the corrosion behavior of magnesium alloys with sol-gel and PEO coatings in BCS, and the hypothesis was that under BCS, the different coatings will increase the corrosion resistance of the Mg alloy. The experiments were conducted under a three-electrode setup, with the SCE reference electrode, graphite counter electrode, and Mg working electrode. Microstructures were analyzed through scanning electron microscopy (SEM) and profilometry to confirm corrosion sites, oxide damage, wear, and surface roughness. Corrosion current decreased, corrosion potential increased and the system's resistance and capacitance increased and decreased as the coating increased. These trends were expected as the coated alloys corrode slower and have less tendency for corrosion. Overall, this study effectively simulated Mg alloy corrosion in BCS.

MD-ThP-10 Mechanisms of Fretting Corrosion in Titanium-based Biomedical Modular Implant Interfaces*, Avirup Sinha [asinha38@uic.edu],* University of Illinois - Chicago, USA

Fretting corrosion is observed at modular junctions under load, where micro-motions lead to material loss and release of metallic ions or debris. Depending on applied load and displacement amplitude, fretting progresses through partial slip, mixed, and gross slip regime. In this study, fretting corrosion behavior was investigated under two contact configurations: metal on metal (Ti-6Al-4V on Ti-6Al-4V) and metal on ceramic (Ti-6Al-4V on ZrO2) in Bovin Calf Serum (BCS). BCS used in the experiment reflect two conditions: normal and infectious. Experiments were performed using 83 N normal load with a displacement amplitude of 5 µm at 1 Hz. Electrochemical protocols include sequential measurements of open circuit potential (OCP), potentiostatic (PS), and electrochemical impedance spectroscopy (EIS) which are synchronized with fretting motion. The test condition includes 10.9 mm diameter mirror polished disk and a 3 mm diameter pin with 20 ml of electrolyte used for each trial.This approach allows systematic evaluation of how contact pair and electrolyte chemistry influences the synergistic effects of wear and corrosion. The results are expected to advance the understanding of fretting corrosion in modular implants and support the design of materials and interfaces with improved in-vivo durability.

MD-ThP-11 Antimicrobial Potential of Silver-Copper Nanocoatings Deposited on Medical and Dental Polymeric Materials*, Argelia Almaguer-Flores [aalmaguer@comunidad.unam.mx], Lorena Reyes-Carmona, David E. Martínez-Lara, Gina Prado-Prone, Sandra E. Rodil,* UNAM, Mexico

Introduction: During medical and dental procedures, infection prevention is vital because patients are often more vulnerable, and an infection could be life-threatening. Additionally, maintaining a microbial-free clinical environment—including instruments and surfaces—is essential to prevent contamination by microorganisms such as bacteria, fungi, and viruses that could be transmitted to patients.

Objective: To evaluate the antibacterial potential of a silver-copper nanocoating (SakCu®) deposited on medical-grade polyurethane (flat substrates and medical hoses) to reduce the adhesion of opportunistic pathogens associated with medical and dental devices.

Methods: The silver-copper nanocoating was deposited by magnetron sputtering in an inert argon (Ar) atmosphere, using a DC power source at 200 W. The characterization included scanning electron microscopy (SEM), Transmission electron microscopy (TEM), X-ray energy dispersive spectroscopy (EDS). The antibacterial assays included analysis of the effect of the SakCu® nanocoating on Gram-positive and Gram-negative bacterial strains, including *Escherichia coli* (ATCC 33780), *Pseudomonas aeruginosa* (ATCC 43536),*Staphylococcus aureus* (ATCC 25923), and *Staphylococcus epidermidis* (ATCC 14990).

Results: The nanocoating thicknesses obtained were 15, 30, and 50 nm. Surface morphology, analyzed by scanning electron microscopy (SEM), revealed a homogeneous coating in all cases. Transmission electron microscopy (TEM), elemental mapping, and electron diffraction (EDS) analyses confirmed an average composition of 42% Ag and 58% Cu, uniformly distributed, indicating the formation of an alloy. The antibacterial results showed a reduction in bacterial viability of more than 90% across all species tested.

Conclusions: The results showed the antibacterial potential of the silver-copper nanocoating (SakCu®) to prevent the adhesion of important opportunistic pathogens to medical-grade polyurethane surfaces on devices such as dialysis fluid bags and medical and dental hoses.

MD-ThP-12 Effects of the Temperature and Target Power on Microstructure and Electrochemical Properties of Fe-Mn-C-Zn Coatings via Magnetron Sputtering Co-Deposition*, Xinna Zhu [289549@studenti.unimore.it],* Department of Engineering "Enzo Ferrari" University of Modena and Reggio Emilia, Modena, Italy*; Carlo Paternoster,* Laboratory for Biomaterials and Bioengineering, (CRC-Tier I), Dept Min-Met-Materials Eng., & Regenerative Medicine, CHU de Quebec, Laval University, Québec, QC, Canada*; Andrea Gatto,* Department of Engineering "Enzo Ferrari" University of Modena and Reggio Emilia, Modena, Italy*; Carlos Henrique Michelin Beraldo,* Laboratory for Biomaterials and Bioengineering, (CRC-Tier I), Dept Min-Met-Materials Eng., & Regenerative Medicine, CHU de Quebec, Laval University, Québec, QC, Canada*; Silvio Defanti,* Department of Engineering "Enzo Ferrari" University of Modena and Reggio Emilia, Modena, Italy*; Paolo Mengucci, Gianni Barucca,* Department SIMAU, Università Politecnica delle Marche, Ancona, Italy*; Helton José Wigger,* Laboratory for Biomaterials and Bioengineering (LBB-BPK), Associação de Ensino, Pesquisa e Extensão BIOPARK, Toledo, Brazil*; Andranik Sarkissian,* Plasmionique Inc., Varennes, QC, Canada*; Diego Mantovani,* Laboratory for Biomaterials and Bioengineering, (CRC-Tier I), Dept Min-Met-Materials Eng., & Regenerative Medicine, CHU de Quebec, Laval University, Québec, QC, Canada

Iron–manganese (Fe–Mn) alloys recently gained attention as promising materials for biodegradable metallic implants due to their excellent mechanical properties, comparable to stainless steel. However, their clinical translation is limited by two key issues: a high risk of post-surgical bacterial infections and a slow degradation rate. *Staphylococcus* species are among the main causes of implant-associated infections, forming resilient biofilms highly resistant to antibiotics and disinfectants. To overcome these limitations, this study develops Fe–Mn–Zn composite coatings with improved antibacterial and corrosion properties. Zinc was selected for its antibacterial and electrochemical properties: the higher electronegativity compared to iron (–1.2 vs –0.89 V) and lower solubility in a Fe-Mn-C matrix is expected to promote galvanic effects and controlled ion release.

Coatings were produced by dual magnetron sputtering using commercial zinc and Hadfield steel targets. The Fe–Mn target was kept at 300W, while the zinc target varied between 0–150 W to modulate composition. Depositions were carried out on silicon wafers at room temperature and 150 °C. The coatings were characterized by scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), atomic force microscopy (AFM), X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), transmission electron microscopy (TEM), contact angle measurements, potentiodynamic polarization (PDP), electrochemical impedance spectroscopy (EIS), scratch testing, and nanoindentation.

Zinc incorporation produced coatings with low surface roughness (1–10 nm) and no visible defects, maintaining a homogeneous surface at all deposition powers, with a columnar structure and intercolumnar spaces observed. Coating thickness ranged from ~500 to 700 nm. EDS showed zinc content increasing with Zn target power, reaching about 35 wt%, while iron and manganese decreased proportionally. XPS revealed strong zinc enrichment at the surface compared to bulk concentration. Mechanical testing indicated a slight reduction in hardness with increasing zinc, though values remained comparable to stainless steel and titanium alloys made by similar techniques.

Overall, dual magnetron sputtering enabled fabrication of high-purity Fe–Mn–Zn coatings with uniform morphology and modulable composition. Temperature was identified as a key factor influencing microstructure and elemental distribution. Further studies are needed to validate antibacterial properties and elucidate their effect on different classes of bacteria, responsible for infections and pathologies in biomedical applications of degradable materials.

MD-ThP-13 Effect of Fabrication Route on Adhesion and Stability of Copper Electrodeposits on Ti6Al4V Substrates,
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The interfacial stability of metallic coatings strongly influences the functional lifetime of biomedical implants. This work investigates the effect of fabrication route on the adhesion and mechanical stability of electrodeposited copper (Cu) coatings on Ti6Al4V substrates produced by machining and powder metallurgy. Coatings were deposited under identical current and electrolyte conditions, and microhardness testing, DRX, and SEM/EDS microstructural analysis were performed. The Cu films on sintered Ti6Al4V exhibited significantly higher adhesion than those on machined samples, which correlated with increased roughness and open porosity inherent to the powder-metallurgy surface. Elemental mapping revealed partial diffusion of Cu into the Ti matrix, enhancing metallurgical bonding at the interface. These findings demonstrate that microstructural tailoring via the fabrication route can improve coating–substrate integrity and long-term performance in physiological conditions. The results provide a framework for integrating electrodeposition with energy-efficient manufacturing routes for functional coatings, bridging laboratory research with industrial implementation in biomedical device production.

MD-ThP-14 Improvement of Corrosion-Resistance Behavior of Electrophoretic Deposited Graphene-Hap Composite Coatings on Textured Biomedical Implant Surfaces.,
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Nickel-titanium alloys and commerciallly pure titanium are widely used as metallic bioimplants owing its unique combination of properties despite its inherent issue of poor corrosion resistance property. This study focusses on improving the corrosion resistance behavior of biomaterials (Nitinol and commerciallly pure titanium) by employing a 2-step processes including Femtosecond laser surface texturing (LST) and Electrophoretic deposition method (EPD). LST promotes refinement of surface grain size by the formation of TiO_2 phase within the EPD coated samples which renders mechanical interlocking points for better coating adhesion. To further enhance the corrosion resistance and biocompatibility nature of biomaterials, graphene and HAP composite coatings were prepared by EPD method onto the biomaterials. The metallic substrates were modified using the femtosecond laser texturing in order to generate micro-textures in the form of grid-like and circular patterns, followed by EPD coating on both bare and textured surfaces. The surface morphologies, microstructure and phase purity analyses were carried out using SEM, EDS, Raman spectroscopy and XRD techniques to confirm the actual composition and quality of the obtained coatings. Scratch test analyses were performed to determine the adhesion strength of the EPD-coated Gr/HAP coatings on laser-textured and bare substrate samples. The corrosion tests were conducted in simulated body fluid solution (SBF) to determine the protection efficiency of the coated samples using EIS and potentiodynamic polarization studies. The result of corrosion tests highlighted superior corrosion resistance property of laser textured coated samples as compared to bare and EPD coated samples due to the excellent corrosion resistance property of graphene nanosheets and higher adhesion property of Gr/HAP coating on the metallic substrates. This synergistic effect of both laser texturing and Gr/HAP composite EPD coatings could be a potential candidate for biomedical applications.

MD-ThP-17 On the Adhesion of a-C:H Coatings Deposited by PECVD on PDMS for Biomedical Applications,
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Polydimethylsiloxane (PDMS) is widely used in biomedical devices. Despite its favorable properties, such as hemocompatibility, elasticity, and stability, it remains prone to bacterial colonization, which can lead to severe infections and device failure. Hydrogenated amorphous carbon (a-C:H) coatings have emerged as a versatile route to enhance biomaterial surfaces, and can serve as platforms for the controlled release of antibacterial agents. However, adhesion of a-C:H coatings to soft polymers such as PDMS remains a critical bottleneck for clinical success. This study investigates how substrate bias and hydrogen incorporation during plasma-enhanced chemical vapor deposition (PECVD) affect adhesion, morphology, and interface integrity of a-C:H coatings on PDMS. Coatings deposited without bias were termed polymer-like carbon (PLC), and those deposited at −300 V as diamond-like carbon (DLC). The incorporation of hydrogen during deposition produced the hydrogenated counterparts, PLCH and DLCH. Time-of-flight secondary ion mass spectrometry (ToF-SIMS) depth profiling revealed greater coating thickness and sharper interfaces for non-biased coatings. In contrast, biased coatings showed thinner films with evidence of intermixing with substrate components. Regarding hydrogen incorporation, a decrease in coating thickness and surface roughness was observed, as well as a reduction in crack density after tensile deformation. Furthermore, immersion tests under pseudo-physiological conditions demonstrated that the PLCH remained stable for 21 days, with only localized cracks and no significant delamination under static and dynamic conditions. These results suggest that this coating can withstand physiological stresses while maintaining mechanical integrity. Therefore, among the variants studied, PLCH (non-biased + H_2) emerges as the most promising coating for flexible PDMS biomedical devices, offering an optimal balance of thickness, adhesion, flexibility, and chemical durability.

Keywords: Polydimethylsiloxane, Hydrogenated amorphous carbon, coatings, diamond-like carbon, polymer-like carbon, plasma-enhanced chemical vapor deposition, adhesion.

MD-ThP-18 An Asymmetric Capillary-Driven Microtiter Platform Enabling Centrifuge-Free Point-of-Care Diagnostics,
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We present an innovative microtiter platform that leverages asymmetric capillary action to enable rapid plasma separation and colorimetric analysis from ultra-low volumes of whole blood. In contrast to conventional workflows that rely on large sample volumes (>10 mL) and centrifugation, our simplified approach requires <10 µL of whole blood and no instrumentation. The platform is polymer-based and features spray-coated superhydrophilic nanoporous surfaces combined with hydrophobic screw-shaped sidewalls. Plasma separation is initiated through simple manual shaking using two fingers, which provides sufficient centrifugal force to displace blood cells toward the hydrophobic sidewalls, while asymmetric capillary-driven lateral flow retains the plasma in the bottom nanoporous zone. This streamlined process substantially reduces sample volume, cost, and processing time, offering a portable and user-friendly solution for point-of-care (PoC) diagnostics.

MD-ThP-19 Influence of Microstructures on the Corrosion Behavior of Cobalt-Chromium Alloys Under Different Ortho Joint Conditions,
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Cobalt-Chromium-Molybdenum (CoCrMo) alloys have been used in various biomedical applications, including hip and knee implants, making them highly essential in orthopedics. A major concern regarding these implants is their long-term corrosion resistance, as corrosion can have a negative impact on patient health. Corrosion resistance is impacted by a variety of factors, such as the alloy's microstructure and the environmental conditions that can affect the release of metal ions. In this study, two different microstructures of CoCrMo were tested including homogeneous and banded samples. Each microstructure was tested under three different conditions: normal, inflammatory, and infectious. To stimulate these environments, 30 g/L protein was used for normal conditions, 0.5 mM hydrogen peroxide for inflammation, and 15 µg/L LPS for infectious conditions. To test the long term effects of these conditions, 24 hour corrosion experiments were performed using a three-electrode electrochemical set up. The electrochemical testing protocol included the sequence of open circuit potential, potentiostatic run, electrochemical impedance spectroscopy, and cyclic polarization. For banded samples the experiments were run at a constant potential of -0.7V and for homogeneous samples, it was run at -0.68V. The banded structure exhibited higher current values than the homogeneous structure, indicating that CoCrMo alloys with a homogeneous microstructure have greater corrosion resistance. Furthermore, among normal, inflammatory, and infectious conditions, the inflammatory condition resulted in the greatest alloy loss (µg) for both banded and homogeneous structures. Specifically, the banded structure showed a loss of 37.53 µg, while the homogenous structure exhibited a loss of 5.69 µg, indicating inflammatory conditions have the least corrosion resistance.

MD-ThP-20 Effect of Current Density Variation on Cu-Incorporated Mao Coatings on Ti-30nb-5mo Alloy, *Giovana Collombaro Cardoso,* Universidade Estadual Paulista, UNESP, Bauru, Brazil; *Gustavo da Silva Diniz,* Universitdade Estadual Paulista, UNESP, Bauru, Brazil; ***Carlos Roberto Grandini [carlos.r.grandini@unesp.br]***, Universidade Estadual Paulista, UNESP, Bauru, Brazil

Titanium and its alloys are widely used as biomaterials due to their excellent mechanical performance and corrosion resistance [1]. However, their inert surfaces limit biological interactions after implantation [2]. Surface modification by Micro-Arc Oxidation (MAO) is a versatile and cost-effective approach to produce porous TiO_2 coatings that can incorporate bioactive elements, enhancing osseointegration and antibacterial behavior [3]. This study investigates the effect of current density on the properties of MAO coatings formed on Ti-30Nb-5Mo alloy substrates. The process was carried out at 300 V for 3 minutes in an electrolyte containing calcium acetate, sodium glycerophosphate, and copper chloride, with current densities ranging from 1.0 to 2.5 A/cm^2. X-ray diffraction (XRD) revealed that higher current densities promoted the formation of rutile TiO_2 and increased surface roughness. Consequently, the water contact angle decreased, indicating improved hydrophilicity and potential for better cell adhesion. X-ray photoelectron spectroscopy (XPS) confirmed copper incorporation into the coatings, suggesting that the modified surfaces may provide antibacterial functionality. These results demonstrate that tuning the current density during MAO treatment is an effective strategy for tailoring the surface morphology, chemistry, and biological performance of Ti-based alloys for biomedical applications. (Financial Support: CNPq and FAPESP).

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