Next Generation Biomaterials : Next Generation Biomaterials I
Sponsored by: ACerS Bioceramics Division, TMS Biomaterials Committee
Program Organizers: Roger Narayan, University of North Carolina; David Dausch, RTI International; Sanjiv Lalwani, Lynntech, Inc.

Monday 8:00 AM
November 2, 2020
Room: Virtual Meeting Room 12
Location: MS&T Virtual

Session Chair: Weiping Ren, Wayne State University; Masanori Kikuchi, National Institute for Materials Science

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8:00 AM Invited
Functionalization of Titanium for Biomedical Use: *Masanori Kikuchi*[1]; [1]National Institute for Materials Science

Affinity of titanium and its alloys (Ti-s) to bone tissue is called "osseointegration" that means indirect bonding to bone via very thin "electron microscopic-scale" encapsulation by collagen fibers. Although titania formed on Ti-s could be a reason of good osseointegration than other metals, improvement of their osseointegration ability and hemocomatibility are desired from surgeons. Recently, we found two interesting "biocompatible" behaviors of Ti-s induced by simple treatments. One is coating of Ti-s with the hydroxyapatite/collagen bone-like nanocomposite (HAp/Col) that we had invented and reported in 2001. The HAp/Col coating on Ti-s accelerates osseointegration at sub-periosteum 3-times faster than biomimetic hydroxyapatite coating. The other is electric polarization of Ti nanotubes formed on Ti surface improved anti-thrombogenicity than bare and as-annealed Ti nanotubes.

8:40 AM Invited
A Failing Healthcare System with Decreasing Life Expectancies: Are Conventional Biomaterials to Blame?: *Thomas Webster*[1]; [1]Northeastern University

As has been well-established, life expectancy in many industrial nations is decreasing with many reasons such as a lack of personalized medicine, too much dependency on drugs to solve every health problem, lack of proactive (versus faulty reactionary medicine), and the list goes on. Moreover, there has been a lack of translation to real commercial products. This talk will summarize how nanotechnology with FDA approval can be used to increase tissue growth and decrease implant infection without using antibiotics. Studies will also be highlighted using nano sensors (while getting regulatory approval). Our group has shown that nanofeatures, nano-modifications, nanoparticles, and most importantly, nanosensors can reduce bacterial growth without using antibiotics. This talk will summarize techniques and efforts to create nanosensors for a wide range of medical and tissue engineering applications, particularly those that have received FDA approval and are currently being implanted in humans.

9:20 AM

Bioceramics in the Ca2P2O7 – Mg2P2O7 System with a Tailored Architecture for Bioimplantation: *Gilyana Kazakova*[1]; Tatiana Safronova[1]; Tatiana Shatalova[1]; Vladimir Zaitsev[2]; Irina Selezneva[3]; [1]Lomonosov Moscow State University; [2]Priorov National Medical Research Center of Traumatology and Orthopaedics; [3]Institute of Theoretical and Experimental Biophysics of RAS

Reconstructive surgery and orthopedics need a new generation material for bone replacement and grafting with a personalized architecture. This study aim is to develop resorbable bioceramics in the Ca2P2O7 – Mg2P2O7 system with a tailored pore space architecture. Substitution of calcium phosphates ceramic with alternative cations, such as magnesium, coupled with condensed phosphate ions plays a significant role in the bone remodeling process, affecting the early-stage of bone regeneration through stimulating osteogenic differentiation, prohibiting osteoclastic activity, and transforming into mechanically enhanced hydroxyapatite bone tissues. Osteoconductivity of the implants and sufficient strength are also achieved by obtaining a macroporous material with a specific architecture, in which pores are connected. For these bioceramics, the composition of suspension for DLP-printing is revealed, rheological, mechanical and toxicological tests are carried out and in vivo study is done. RFBR partially supported this study under Grant No. 19-38-90274, 18-29-11079, 20-03-00550.

9:40 AM

Biomimetic Patterns of Metallic Nanoparticles for Antimicrobial Applications: *Srikanthan Ramesh*[1]; Chaitanya Mahajan[1]; Iris Rivero[1]; Denis Cormier[1]; [1]Rochester Institute of Technology

Biomimetic patterns such as the ones found in sharkskin, insect wings, and crab carapace, by virtue of their roughness and shape discourage bacterial growth. Biomimicry has been used to prevent bacterial attachment in marine applications but their translation to tissue-engineered substrates has been limited due to the thermal and chemical sensitivity of biomaterials. We validate a scalable process consisting of aerosol jetting followed by photonic sintering allowing the patterning of biocompatible substrates. As a first step, shark fin-like structures have been created on polycaprolactone using silver and copper nanoparticles to study their antibacterial efficacy against Staphylococcus aureus and Escherichia coli. Our results suggest that the proposed approach allows the patterning and sintering of nanoparticles on substrates without damaging the thermoplastic substrates. Topographical analysis and the accuracy of deposition were analyzed using microscopy and profilometry. Bacterial studies indicate that the patterned substrates are effective against resisting bacterial growth responsible for osteomyelitis.

10:00 AM Invited
Fibrin-modulating Nanogels for the Treatment of Disseminated Intravascular Coagulation: *Ashley Brown*[1]; [1]North Carolina State University

Disseminated intravascular coagulation (DIC) is a pathological process causing systemic coagulopathy through excessive thrombin generation. While over-activation of clotting causes microthrombi throughout the body and multi-organ failure, DIC can also contribute to bleeding as clotting factors are consumed. Treatment for either presentation is opposing, creating therapeutic dilemmas in management. Different clinical events can lead to DIC, including cancer, trauma, and infection, including SARS-CoV-2 infection. DIC is associated with increased mortality and has arisen as a potential contributor to morality in COVID-19. This study developed fibrin-specific core-shell nanogels (FSNs) loaded with tissue plasminogen activator (tPA) for targeted clot dissolution to manage microthrombi and the potential consumptive coagulopathy in DIC. tPA-FSNs decreased multiorgan microthrombi presentation, recovered platelet counts, and improved bleeding outcomes in a DIC rodent model. When incorporated with human DIC patient plasma, tPA-FSNs restored clot properties. Together, these data demonstrate that tPA-FSNs could improve DIC outcomes.

10:20 AM
Corrosion Modelling of Coated Pure Magnesium Towards Degradation-Controlled Bone Fixation Implants: *Moataz Abdalla*[1]; Hamdy Ibrahim[1]; [1]University of Tennessee at Chattanooga

Biodegradable metals have been under research as alternatives to the currently-in-use non-biodegradable materials for medical implants. Considerable research was done to develop numerical models towards an inexpensive and fast designing tool to assess the change of the implant's geometry and mechanical strength during degradation. However, the effect of coating was not investigated before in the literature in terms of modeling the corrosion behavior. The model developed in this study is capable of simulating the corrosion behavior of implants made of pure magnesium coated with a ceramic coating prepared by the micro arc oxidation coating processes. The saturation limit of magnesium ions was measured experimentally under conditions simulating the human body. Diffusivity of magnesium ions were experimentally calibrated inside a simulated body fluid for uncoated and coated pure magnesium samples using a 2D finite element model. The developed model can then be scaled up and tested for bulk and 3D-printed parts.