Biomaterial Interfaces
Room: Milo - Session BI-ThM

Plasma Bio, Medicine & Agriculture
Moderator: Ellen Fisher, Colorado State University

8:40am **BI-ThM3 Diagnostics of Nonthermal Atmospheric Pressure Plasma Jet and Dielectric Barrier Discharge Sources for Plasma Bioscience and Medicine by Collisional Radiative Model and Stark Broadening Method**, ***Eun Ha Choi**, Y.J. Hong, G. Cho, H. Uhm,* KwangWoon University, Korea **INVITED**

Nonthermal biocompatible plasma (bioplasma) sources and their characteristics operating at atmospheric pressure have been introduced and overviewed for plasma bioscience and medicines, especially used in Plasma Bioscience Research Center (PBRC), Korea. The electron temperature and density have been measured, respectively, by the atmospheric collisional radiative model and Stark broadening method in this experiment. The electron temperatures and plasma densities are measured to be 0.2 ~ 0.7 eV [1] and 1×1014 ~ 2×1015 cm-3, respectively, for the nonthermal bioplasma jet and DBD plasma sources in PBRC. Herein, we have also introduced the basic generation mechanism of reactive hydroxyl radical OH species and hydrogen peroxide H2O2 by plasma-initiated ultraviolet photolysis of water[1] inside the biological solutions, which are main species of interactions with microbial[2] and mammalian cells resulting in apoptotic cell death [3].

REFERENCES:

[1] Y. H. Kim, et. al., Plasma Chemistry Plasma Processing, 34:457 (2014).

[2] Y. H. Ryu et. al., Plos One, 8, e66231 (2013).

[3] K. Pangomm, et.al., Cell Death & Desease 4, e642 (2013).

9:20am **BI-ThM5 Surface Modification of Drug-Delivery Systems to Optimize Device Performance**, ***Adoracion Pegalajar-Jurado**, M.J. Hawker, B.S. Neufeld, M.M. Reynolds, E.R. Fisher*, Colorado State University

Current medical device are often affected by biofouling issues, including blood clot formation and bacterial infection. To combat undesirable side effects and severe medical complications related to the fouling of the devices, a dual approach is required where tuned surface properties and localized delivery of specific biomolecules are combined to enhance device performance. To accomplish this, advanced material platforms are needed to achieve localized therapeutic action and customizable surface properties. Although several wet chemical methods have been explored for surface modification, these methods can produce irreproducible surface modifications resulting from non-uniform coatings and/or can interfere with drug delivery mechanisms. An alternative technique that alleviates many of these issues is plasma surface modification, which offers a tunable and versatile parameter space for tailored and reproducible surface modifications for specific applications while retaining the bulk properties of the material. Herein, we describe the surface modification of a variety of drug delivery systems (including S-nitrosated polymer derivatives) via plasma treatment, resulting in a device that maintained their releasing capabilities (i.e. release of nitric oxide (NO)), but exhibited tailored surface properties for specific applications. As a prototype drug delivery system, we have used *S*-nitrosated poly(lactic-*co*-glycolic acid)-based hydrophobic polymer to achieve a material capable of releasing the therapeutic agent NO. The *S*-nitrosated polymer derivative was modified via H_2O plasma treatment, resulting in a superhydrophilic material (water droplet spread completely in <100 ms) that retained 90% of its initial *S*-nitrosothiol content. Under thermal conditions, NO release profiles were identical to controls. Under buffer soak conditions, the NO release profile was slightly lowered for the plasma-treated materials; however, they still result in physiologically relevant NO fluxes. Correlations between this data and those recorded from other plasma treated drug delivery systems will also be discussed.

9:40am **BI-ThM6 Generation and Transport of Reactive Oxygen Species in Plasma Irradiated Liquid**, *I. Ikuse, **Satoshi Hamaguchi***, Osaka University

Numerical simulations of chemical reactions and diffusion of reactive species in water exposed to an atmospheric-pressure plasma (APP) have been performed based on one-dimensional reaction-diffusion equations. When a living tissue is exposed to a low-temperature APP, there is almost always a liquid layer, such as blood, lymph, or other body fluid, that separates the gas phase and the tissue. Therefore charged and chemically reactive species generated by the plasma are transported through the liquid before reacting with the tissue surfaces. The aim of this research is to understand how and where such chemically reactive species that affect biological matters are generated and transported through a liquid. While a variety of ions, excited atoms and molecules as well as chemically reactive charge-neutral species (including free radicals) are generated in the gas phase, the majority of highly reactive species may decay or be converted to more stable species before reaching the liquid surface. On the other hand, charged species and highly reactive charge-neutral species generated in the gas phase near the plasma-liquid interface are likely to be adsorbed by the liquid surface and to generate highly reactive species in a very thin layer (with a thickness 10 ~ 100 nm) of liquid just below the liquid surface. In the simulation, gas phase species generated by APP are assumed to enter pure water at their thermal velocities and dissolved without any barrier. The model incorporates 37 species and 111 chemical reactions in water at room temperature. The simulation has indicated the presence of such a thin liquid layer (which we call a “reaction boundary layer”) at the plasma-liquid interface, only in which highly reactive species such as OH radicals and solvated electrons exist and rapidly generate less reactive species such as H2O2, which are then transported to the bulk liquid by diffusion.

10:20am **BI-ThM8 Short-Pulsed Uniform Atmospheric Pressure Dielectric Barrier Discharges in Medical and Biological Surface Treatment**, ***Gregory Fridman***, Drexel University, USA **INVITED**

Engineering innovation has produced startling advances in healthcare. Lasers, ultrasound, ionizing and electromagnetic radiation are examples of life saving diagnostics and treatments that originated in engineering disciplines outside of medicine. In this vein, it was demonstrated that specific types of strongly non-equilibrium nanosecond pulsed atmospheric air plasmas have unique therapeutic effects and hold the promise for new medical diagnostic tools. For example, this presentation will be focused on therapeutic effect of plasmas based on their ability to deactivate pathogens directly in the wound bed, stop bleeding without damage to healthy tissue, promote cell migration and proliferation into the wound bed, angiogenesis, growth factor release, stem cell differentiation and specialization, and other effects leading to the improved healing of wounds and diseases. Mechanisms of plasma-tissue interaction through liquid medium, nanosecond plasma uniformity, and generation and control of reactive oxygen and reactive nitrogen species in plasma will be discussed in this presentation, based on results of the current DARPA and NIH-funded projects.

11:00am **BI-ThM10 Plasma Applications to Agriculture: Plasma Farming**, ***Sukjae Yoo***, National Fusion Research Institute, Korea, Republic of Korea **INVITED**

Plasmas have been applied to various fields: The surface modification and thin film deposition, semiconductor and display fabrication, development of new energy sources, and environmental improvements, plasma medical treatments, etc. In addition to the above mentioned fields, the plasma can be well applied to the agriculture and food.

In case of the semiconductor industry, the first technical innovation was caused by invention of the transistor and integrated circuit (IC) based on chemical wet processes, and the second technical innovation with the very large scale integrated circuit (VLSI) has been realized by adopting plasma processes.

We can draw an analogy between the semiconductor industry and agriculture: The traditional agriculture was innovatively replaced by the chemical agriculture with much higher productivity owing to the invention of agricultural pesticides and chemical fertilizers. Due to the pesticide residue, however, the chemical agriculture has been increasingly replaced by the inorganic agriculture which has even the disadvantage of lower productivity. The problems of both the pesticide residue of chemical agriculture and the low productivity of the inorganic agriculture can be innovatively overcome by adopting the plasma technology.

In this paper, a new concept of the plasma application to the agricultural phases, ‘Plasma Farming’, will be introduced and some case studies of how to apply the plasma technology to the agriculture will also be given

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