## Coatings for Biomedical and Healthcare Applications
## Room Palm 3-4 - Session MD1-1-WeA

### Surface Coatings and Surface Modifications in Biological Environments I

**Moderator: Mathew T. Mathew**, University of Illinois College of Medicine at Rockford and Rush University Medical Center, USA

2:00pm **MD1-1-WeA-1 Synergistic Antibacterial Activity and Ion Release of Ag-Cu and Ag-Cu-Mg Coatings***, **Serdar Sonay Ozbay (sozbay@deakin.edu.au)**, G. Rajmohan,* Deakin University, Australia*; A. Cobley,* Coventry University, UK*; J. Sharp,* Deakin University, Australia*; G. Azar,* Coventry University, UK

Silver (Ag) and Copper (Cu) thin films have been widely studied as antibacterial coatings to functionalise textile surfaces to fight antibiotic-resistant bacteria and healthcare-acquired infections (HAI) in hospitals. The release of metallic ions is considered to be the main antibacterial mechanism for both metals. Therefore, maintaining a steady ion release from the metallic coatings is necessary to achieve a sustained antibacterial activity. Despite the high effectiveness of Ag ions as antibacterial agents, Ag coatings suffer from a limited antibacterial activity due to the decreasing Ag ionisation rate caused by surface passivation. In contrast, Cu coatings exhibit rapid but brief antibacterial action due to the fast release of Cu ions. Recently, studies on combined Ag-Cu systems have reported an enhanced Ag ionisation and a synergistic antibacterial activity between Ag and Cu.

This study investigates how different compositions of Ag-Cu alloy thin film coatings can improve the limitations of pure metals to achieve a steady and long-term antibacterial efficacy. The Ag-Cu ($Ag_{75}Cu_{25}$-$Ag_{50}Cu_{50}$-$Ag_{25}Cu_{75}$) alloys were deposited on PET textiles using magnetron sputtering technique. The growth process and microstructures of the thin films were characterised by XRD and TEM/EDS. Additionally, the galvanic relationship and antibacterial synergy between the Ag and Cu components in different alloys were investigated through the ion release studies and antibacterial tests. Finally, the effects of a more electrochemically active metal on the properties of Ag-Cu alloys were studied by co-sputtering Mg into Ag-Cu thin films.

The results showed that both $Ag_{75}Cu_{25}$ and $Ag_{50}Cu_{50}$ coatings improved the plateauing of Ag ion release and provided a steady Cu ion release. Antibacterial efficacy of Ag-Cu thin films followed the order: $Ag_{50}Cu_{50}$ > $Ag_{25}Cu_{75}$ > $Ag_{75}Cu_{25}$ > Ag ≈ Cu. Due to the sufficient release of both Ag and Cu ions in the $Ag_{50}Cu_{50}$ coating, this sample demonstrated superior antibacterial performance compared to both other alloys and pure metal coatings. Moreover, this coating maintained a >90% bacterial reduction rate after two antibacterial test cycles, outperforming the other coatings. The ion release studies of Ag-Cu-Mg ternary alloys showed a further reduction in both Cu and Ag ion release, with the effect of less noble Mg on the Cu ion release being more significant compared to that on the Ag ion release. Overall, our results suggest that Ag-Cu and Ag-Cu-Mg thin films are promising candidates for hospital textiles that require a steady and prolonged antibacterial activity.

2:20pm **MD1-1-WeA-2 Iridium Oxide Based Electrodes for Bio-Interface Applications***, **Po-Chun Chen (cpc@mail.ntut.edu.tw)**,* National Taipei University of Technology, Taiwan **INVITED**

Iridium oxide has attracted extensive attention due to its unique advantages including excellent chemical stability and sensitivity, impressive electrochemical catalytic activity, sufficient electric conductivity, and desirable biocompatibility. To date, iridium oxide has been widely explored in applications such as anodes for water electrolysis, electrochromic layers for smart windows, and pH sensors. In addition, iridium oxide is known for its superb charge storage capacity and long-term stability renders it a desirable candidate as a bio-interface electrode for implantable bio-medical electronic devices. In this study, we developed solution processes to prepare iridium oxide film for bio-interface applications. We also characterized the electrochemical properties of the iridium oxide films and examined its stability. The iridium oxide film was found to be robust and revealed excellent charge storage capacity and charge injection capability. Additionally, the solution process allows the synthesis of iridium oxide hybrid film by combining plasma protein with enhanced electroactivity, improved cytocompatibility, and controllable electrically responsive protein release to enhance neuronal activity. Therefore, the iridium oxide film plays a multifunctional role as an electrode for bio-interface applications.

3:00pm **MD1-1-WeA-4 An Electrochromic IrOx Nanofibrous Film for Multifunctional Bio-Interface Sensing Applications***, **Yu-Jen Tao (stephanie881111@gmail.com)**, P. Chen,* National Taipei University of Technology, Taiwan

Bio-interface sensing has attracted a lot of attention in recent years. For example, hydrogen peroxide ($H_2O_2$) and pH variation are essential detection targets in various fields, including clinical control and environmental protection. This present work reports a design of a non-enzymatic $H_2O_2$ electrochemical sensor and an electrochromic pH sensor with IrOx nanofibrous film. Additionally, the electrochemical performance of the IrOx nanofibrous film can be manipulated by the annealing parameters. The resultant materials are characterized through field emission scanning electron microscopy, X-ray diffraction analysis, and X-ray absorption spectroscopy. Furthermore, the electrochemical sensing performance of the IrOx nanofibrous film is evaluated by cyclic voltammetry, electrochemical impedance spectroscopy, and chronoamperometric (i-t) techniques. The sensitivity of the IrOx nanofibrous film is checked to investigate the effect of annealing parameters on the $H_2O_2$ sensing. The performance of the nanofibers in the electro-reduction of $H_2O_2$ is programmable by controlling the metallic Ir contents. The IrOx nanofibrous film annealed at 550°C with a ramping rate of 2.5 °C exhibits better electrocatalytic activity towards the electro-reduction of $H_2O_2$. Further, the broad linear range (0.1 to 1000 μM), low detection limit (LOD) of 0.16 μM with an excellent sensitivity is successfully achieved. The IrOx nanofibrous film can electrochromically detect the pH variation with a super-Nernst sensitivity of 80 mV/pH. Additionally, the IrOx nanofibrous film has appreciable selectivity in the presence of potentially interfering biological molecules, and its practical applicability is demonstrated in MCF-7 human breast cancer cells.

3:20pm **MD1-1-WeA-5 Bespoke Atmospheric Pressure Plasma Polymerization Process with an Acrylic Acid-Based Hybrid Precursor on Polylactic Acid Nonwoven for Antibacterial Scaffolds***, **Wei-Yu Chen (wychen@mail.mcut.edu.tw)**, Y. Chiang, T. Chu, L. Chang, J. Lee,* Ming Chi University of Technology, Taiwan

There is presently considerable interest in applying polylactic acid (PLA) nonwoven as a scaffold material in biomaterials due to its porous structure, biodegradability, favourable mechanical properties and renewable nature. However, the chemically-inert and hydrophobic surface of PLA limits its biocompatibility and poses challenges to improve its antibacterial ability through modification for inhibiting postoperative infection. In addition, PLA nonwoven is sensitive to most chemical methods for both functionalization and sterilisation. To tackle these issues without impairing the PLA nonwoven, a tailored atmospheric pressure plasma (APP) system along with a hybrid precursor of acrylic acid and silver nitrate was designed and employed for surface functionalization. In this system, electrons and reactive species created during the APP process were utilised for reducing silver nanoparticles from the hybrid precursor. By performing APP polymerization and reduction simultaneously, a silver nanoparticle-embedded and carboxyl-rich polymerized film was prepared and deposited on the PLA nonwoven surface. This study presents a comprehensive analysis of the wettability, hydrophilicity stability, surface elemental composition, biocompatibility and antibacterial efficacy of the PLA nonwoven surface functionalized using the proposed APP method. Compared with conventional methods, this process is capable of immobilising a higher percentage of carboxyl functional groups with improved efficiency on enhancing antibacterial properties.

Keywords: atmospheric pressure plasma, textile functionalization, biodegradable polymers, polylactic acid, scaffolds, acrylic acid, silver nitrate, antibacterial property

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