7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Biofunctionalization of Chitosan-Acrylic Acid Hydrogel through Atmospheric Pressure Plasma-initiated Polymerization

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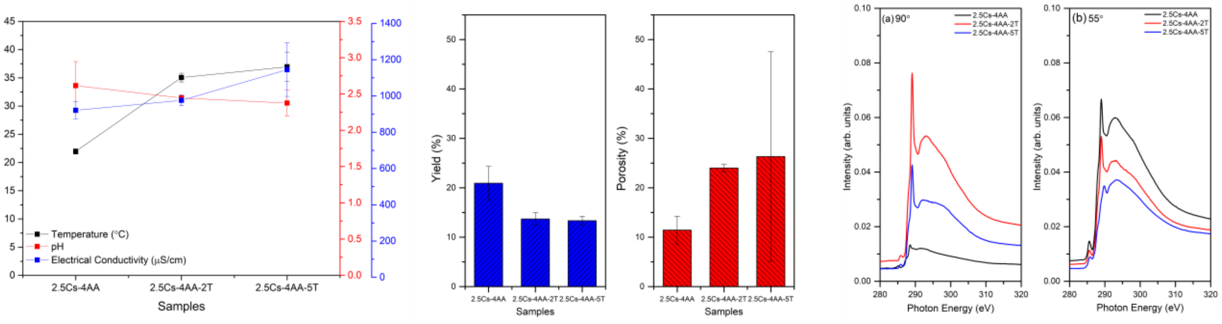
Hydrogel is among the early polymeric biomaterials considered for human use. This is because its functionality resembles the natural extracellular matrix (ECM). The 3D hydrophilic network of hydrogel, however, depends on the polymer selection and the crosslinking approach. These factors are critical in controlling the properties of hydrogel, such as porosity and swelling capacity. In this study, chitosan-acrylic acid (2.5Cs-4AA) blends were transformed into hydrogels for possible use in biomedical applications. Chemical crosslinkers such as glutaraldehyde and N,N'-methylenebisacrylamide (MBA) can leave traces in the network of the Cs-AA hydrogel, leading to possible adverse effect of hydrogel when used to humans. Hence, the study employs an atmospheric pressure plasma (APP) treatment step as an alternative to the chemical crosslinking route of Cs-AA hydrogels.

There is an increasing interest in modifying polymer solutions using atmospheric pressure plasma (APP). APP sources create a rich environment of reactive species even at low temperatures. As shown in Figure 1 (i), increasing the treatment time to 5 min (2.5Cs-4AA-5T) reaches a process temperature of about 36.95±2.62°C. Possible change in the reactive species was observed in the change in the pH and electrical conductivity values of the 2.5Cs-4AA-T blends. The change in the pH and electrical conductivity may be attributed to the possible formation of reactive species such as electrons, hydrogen peroxides, and nitrates.

Since the APP treatment creates a humid atmosphere for the reactive species generation, it also caused the plasma-treated 2.5Cs-4AA samples to evaporate. Hence, the pristine 2.5Cs-4AA hydrogel has a higher yield but with the cost of having decreased porosity percentage, shown in Figure 1 (ii). The plasma-treated samples resulted to more pores possible because there were more bubbles formed during the plasma process. Lastly, Figure 1(iii) shows the NEXAFS C K edge measurement of 2.5Cs-4AA-T samples collected at (a) normal and (b) magic incidence angles. The angular-dependent NEXAFS was acquired in this study since the orientation of the chemical groups of 2.5Cs-4AA-T along the surface is crucial for biomedical applications. Based on the spectra, the surface molecular orientation of the 2.5Cs-4AA-T samples was altered when plasma treatment was employed in the hydrogel synthesis. Summarizing these results, the use of plasma treatment during hydrogel synthesis improved the functionality of the 2.5Cs-4AA hydrogels. This work is supported by the Department of Science and Technology-Science Education Institute (DOST-SEI) through the Accelerated Science and Technology Human Resource Development Program (ASTHRDP).



(i) (ii) (iii)

Figure 1 Physicochemical properties of the 2.5Cs-4AA-T samples. (i) Temperature, pH, and electrical conductivity; of the 2.5Cs-4AA-T samples (liquid state), (ii) yield and porosity of 2.5Cs-4AA-T samples (solid state), (iii) angular-dependent NEXAFS of 2.5Cs-4AA-T samples (solid state).