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Plasma-induced reduction of impregnated silver ions on support matrices

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Immobilized silver nanoparticles (AgNPs) have proven to be valuable in a variety of applications such as biomedicine, water treatment, biosensing, catalysis, and optoelectronics [1-4]. Hence, several routes for AgNPs synthesis have been explored including physio-chemical and biological methods. A green, dry, and facile method for plasma-induced reduction of silver ions (Ag^+) in titanium dioxide (TiO_2) [1-2] and zeolite [3-4] support matrices using a 13.56 MHz radio-frequency sub-atmospheric pressure plasma system was demonstrated in a series of studies. The Ag^+ ions were impregnated in the support matrix (TiO_2 NPs and zeolite particles) using silver nitrate ($AgNO_3$). Prior to the next step, the particles were dried. For the TiO_2, the NPs were immobilized in electrospun poly(vinyl alcohol) (PVA) nanofiber mats. The embedded particles were exposed via plasma ablation of the fiber. The coupling of Ag with TiO_2 shifted the sensitivity of the NPs to visible light. This was demonstrated via the degradation of methylene blue under visible light irradiation (Fig. 1).

On the other hand, the zeolite particles were pelletized prior to plasma treatment. As shown in Fig. 2, the untreated pellet (0 min) became brown in color after plasma exposure. This signifies the reduction of Ag^+ to metallic Ag. Moreover, as the exposure time was increased, the shade of brown became darker signifying more Ag^+ were reduced to Ag^0. The pellets were characterized and tested for their antibacterial properties.

The composite materials were extensively characterized through Optical Emission Spectroscopy, UV-Vis Spectroscopy, Fourier Transform Infrared Spectroscopy, X-ray Diffraction Spectroscopy, Raman Spectroscopy, Transmission Electron Microscopy, Scanning Electron Microscopy, Energy Dispersive X-ray Spectroscopy, X-ray Photoelectron Spectroscopy, and Brunauer-Emmett-Teller Analysis. Results show the successful reduction of Ag^+ into its more stable zero valent form, Ag^0. This route for reduction is cheaper because it does not require complicated equipment nor require high energies compared to conventional heat treatment processes.

References

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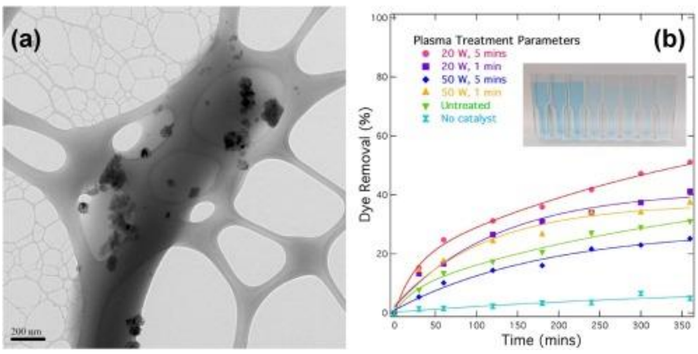

Figure 1. (a) Transmission electron micrograph of a PVA/Ag-TiO_2 fiber. (b) Comparison of methylene blue degradation using untreated and plasma-treated nanofiber mats under visible light irradiation [1].

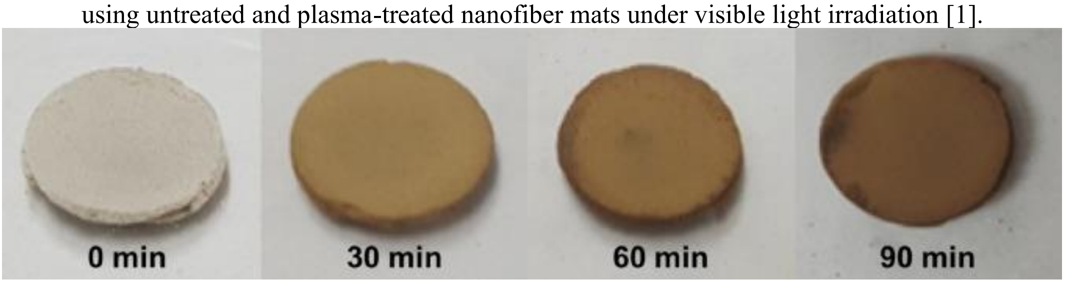

Figure 2. Images of AgZ pellets over different plasma exposure times compared to the untreated sample [3].