doi:10.1017/S1431927611009421
Microsc. Microanal. 17 (Suppl 2), 2011

Synthesis and Characterization of Electrospun TiO_2/Ag Composite Nanofibers for Photocatalysis Applications

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Electrospinning is an electrical, jet-based method of fabricating nanofibers that involves the application of a very high electrostatic force on the capillary containing the polymer solution or polymer-melt. The fibers are created by an electrically charged jet of the polymer solution, which can be collected on the surface of a grounded template. The incorporation of metal nanoparticles produces functional nanofibers. Among the noble metal nanoparticles, silver nanoparticles are promising because they have electronic and catalytic properties [1].

Poly(vinyl pyrrolidone) (PVP) and amorphous TiO_2 nanofibers with Ag nanoparticles were prepared by electrospinning precursor solutions of PVP and titanium isopropoxide (TiIP) with varying concentrations of Ag nanoparticles in ethanol (Fig. 1A). Ag nanoparticles were prepared by the polyol synthesis. The morphology and distribution of silver nanoparticles were observed by transmission electron microscopy (TEM) and scanning electron microscopy (SEM). Titania nanofibers with Ag nanoparticles were annealed at 510 ^{o}C to produce crystalline anatase TiO_2 nanofibers with Ag nanoparticles (Fig. 1B). Lattice fringe measurements from high-resolution TEM images showed the presence of Ag nanoparticles in its elemental form, and TiO_2 as a combination of rutile and anatase phases. This result was also supported by EDX.

Photocatalytic effect of pure TiO_2, and TiO_2/Ag nanofibers was studied by tracking the decay of methyl red dye in a photocatalytic reaction, under ultraviolet light (Fig. 2). Methyl red dye decayed by 24% by the activity of pure TiO_2, and 30% by TiO_2/Ag nanofibers, in a span of 265 min (Fig. 3). This increase in the dye-decay can be attributed to the presence of Ag nanoparticles in the nanocrystalline TiO_2 fibers, which enhanced the photocatalytic activity of titania. We propose to perform high-angle annular dark-field (HAADF) on the TiO_2/Ag nanofibers to further characterize the fibers and to understand the mechanism behind the enhanced photocatalytic effect.

References

[1] Y. Lu, et al., *Macromol. Chem. Phys.* 208 (2007) p. 254-261
[2] This research was supported by the Department of Energy: "Establishment of the *South Dakota Catalysis Group* at the University of South Dakota and South Dakota School of Mines and Technology: Advanced Catalyst Materials for Solar Energy Utilization"

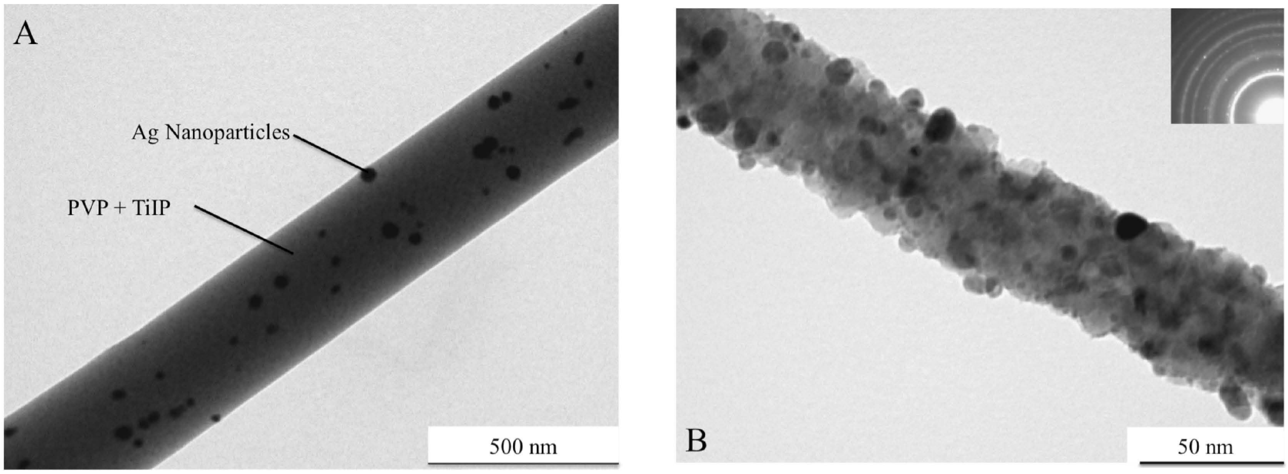

FIG. 1. TEM images of (A) as-spun amorphous PVP/TiIP/Ag nanofiber with 2.0% Ag, and, (B) TiO_2/Ag nanofibers after annealing at 510 °C for 24 h.

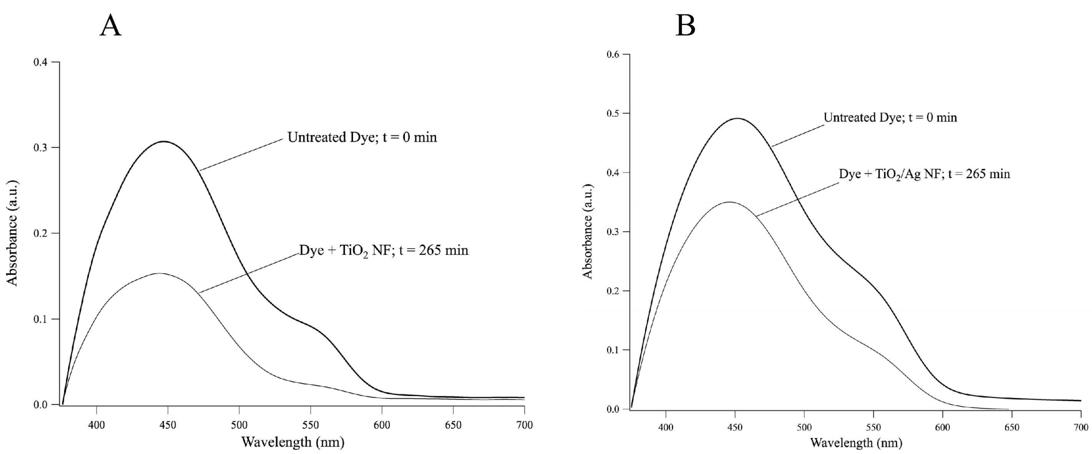

FIG. 2. Absorbance spectra of methyl red dye, (A) when treated with pure TiO_2 in a photoreactor, collected at different time intervals, and, (B) when treated with 2.0% Ag-doped-TiO_2 calcined nanofibers, in a photoreactor, at different time intervals. In both cases, it can be observed that the absorbance intensity maximum has decreased with time.

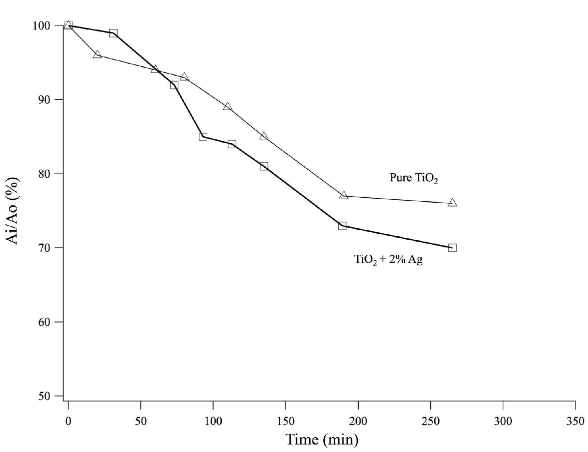

FIG. 3. Comparison of the photocatalytic degradation of methyl red dye in presence of pure TiO_2, and TiO_2/Ag nanofibers.

https://doi.org/10.1017/S1431927611009421 Published online by Cambridge University Press