University of Colorado Boulder

Water Energy Nexus IRT

2018 Seed Grant Final Report

Title: Enhanced UV-LED Water Purification Using Retrievable Nano Photo-catalysts

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Research Objective(s): Particle ALD synthesized Pt/TiO2/Fe3O4 nanoparticles can substantially enhance UV-LED water purification, can be retrieved using a magnetic filter, and will maintain their magnetic and catalytic properties for re-use.

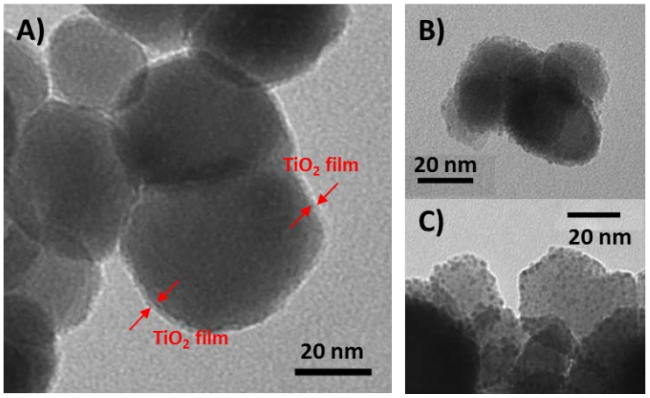

Fig. 1: a) TiO_2/Fe_3O_4 nanoparticles; b) as-made $Pt@TiO_2/Fe_3O_4$; c) crystallized $Pt@TiO_2/Fe_3O_4$.

Research Activities/Methodology: The contamination of wastewater streams with organic pollutants is a significant challenge that requires research into scalable, cost-effective methods for degrading these pollutants. One promising strategy to address this problem is by utilizing photocatalytic semiconductors, such as TiO2, for UV water treatment. It was previously observed that the photocatalytic properties of TiO2 could be enhanced with the addition of Pt nanoparticles to the surface via an atomic layer deposition (ALD) process. In light of these results, this project aimed to develop a magnetically retrievable photocatalyst by using ALD to coat magnetic Fe3O4 nanoparticles with TiO2 nanofilms. The TiO2/Fe3O4 particles were then decorated with Pt nanoparticles in a second ALD reaction to promote synergistic photocatalytic effects.

Initially, 63 TiO2 ALD cycles were applied to the Fe3O4 nanopowder. This produced a material with approximately 9 wt% TiO2, as measured by ICP-MS. Evidence of the TiO2 film was observed through TEM (Fig. 1a). The TiO2/Fe3O4 nanoparticles were split into two groups for different treatments; the first group underwent no crystallization (as-made) and was then coated with 3 cycles of Pt ALD, while the second was crystallized at 700°C under Ar for 3 hours and was then also coated with cycles of Pt ALD. Analysis of these two final Pt@TiO2/Fe3O4 catalysts through TEM (Fig 1b and c) showed a much higher concentration of Pt nanoparticles on the crystallized sample, indicating that the crystalline TiO2 surface was more favorable for Pt growth.

Results: When tested for hydroxyl radical formation under UV exposure, neither as-made nor crystallized Pt@TiO2/Fe3O4 were observed to decrease the concentration of pCBA (Fig. 2). Further experiments showed that these materials also did not enhance the inactivation of MS-2 microorganism. Unfortunately, it appears that these ALD-synthesized Pt@TiO2/Fe3O4 materials did not have the catalytic properties required for UV water purification. This may be due to insufficient thickness of the deposited TiO2 films or inability to evenly disperse the nanoparticles in solution.

Accomplishments: Pt can be deposited, but not clear why UV exposure was unsuccessful

Conclusions/Next Steps: Further investigation will be required to determine why these materials did not perform as expected.