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Synthesis of Silver Doped TiO_2 Nanostructured Composites for Photocatalytic Applications

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Titanium dioxide nanomaterials have received great attention in the past few years due to their unique properties such as high chemical stability, photocatalytic activity and high specific surface area [1,2]. Recently, TiO_2 has been utilized as a photocatalyst in dye sensitized solar cells (DCCSs) [2] due to its electronic properties and low cost. Performance of TiO_2-based DCCSs depends mainly on their band gap energy. Many efforts have been directed to dope TiO_2 with various elements in order to shift its absorbance edge and hence to improve its efficiency in the visible region. Our previous work has shown ~23% improvement in efficiency when anatase-TiO_2 is doped with ~7% wt. carbon [3]. In our research, we continue the effort in tuning the electronic properties of TiO_2-based nanocomposites via doping different elements. In this paper, we describe the doping and characterization of nanostructured TiO_2 with silver nanoparticles. Advanced characterizations techniques have been utilized to analyze the Ag-doped TiO_2 nanocomposite and correlate structure with properties of the produced powder. This method will also be compared to novel laser-based doping technique developed recently in our laboratory.

The Ag-TiO_2 nanocomposite was prepared following standard technique [4] with some modification. Silver nitrate ($AgNO_3$) (≥99% purity from sigma-Aldrich) was used as a precursor of the silver. Acidified water was prepared by adding 6 Cm3 0.05M of nitric acid to 500 Cm3 of deionized water. Then, 4.55 mg of silver nitrate was dissolved in acidified water. After that, 200 mg of TiO_2 (P25 from Sigma-Aldrich) was added to the solution and stirred for 12 hrs. to form a dispersion. The solution left to dry in a furnace under oxygen atmosphere at 80 C° for 36 hrs. In order to study the effect of processing temperature on the crystallite size and phase stability, the produced powder was heat treated at 450 and 600 °C for 2 hrs. X-Ray diffraction (XRD) and high resolution transmission electron microscopy (HRTEM) techniques were used to characterize the produced powder.

XRD patterns, Fig. 1, display the effect of doping and heat treatment on the phase development of processed TiO_2 powders. The data shows a transformation from anatase to rutile is initiated at 450C° for both the doped and un-doped TiO_2 powder. The volume fraction of the rutile phase becomes dominant at 600°C for the Ag-doped nanopowder, probably due to Ag rule in accelerating the reaction kinetics. Ag doping was traced by following the appearance of isolated and distinguished Ag reflections (77.50°, 81.57), Fig. 1 and measuring their relative intensities for quantitative analysis. Crystallite size of various phases was estimated from Shcerrer formula and as expected a small grain growth was observed with increased heat treatment temperature. Fig. 2 (a), is a HRTEM image of TiO_2 powder heat-treated at 600C showing surface distribution of Ag at TiO_2 particles. Quantitative elemental analysis of the sample shows that the Ag concentration is ~6 wt. %. The size of the silver crystallites varies from 3-7nm with an average of ~5 nm. The electron diffraction pattern, Fig. 2 (b) exhibits continuous rings decorated with large spots. Careful indexing of the pattern shows that the diffraction spots correspond to the larger TiO_2 crystallites. Work is underway to study the effect of dopant concentration and processing temperature on the photovoltaic activity of these TiO_2-based nanocomposites.

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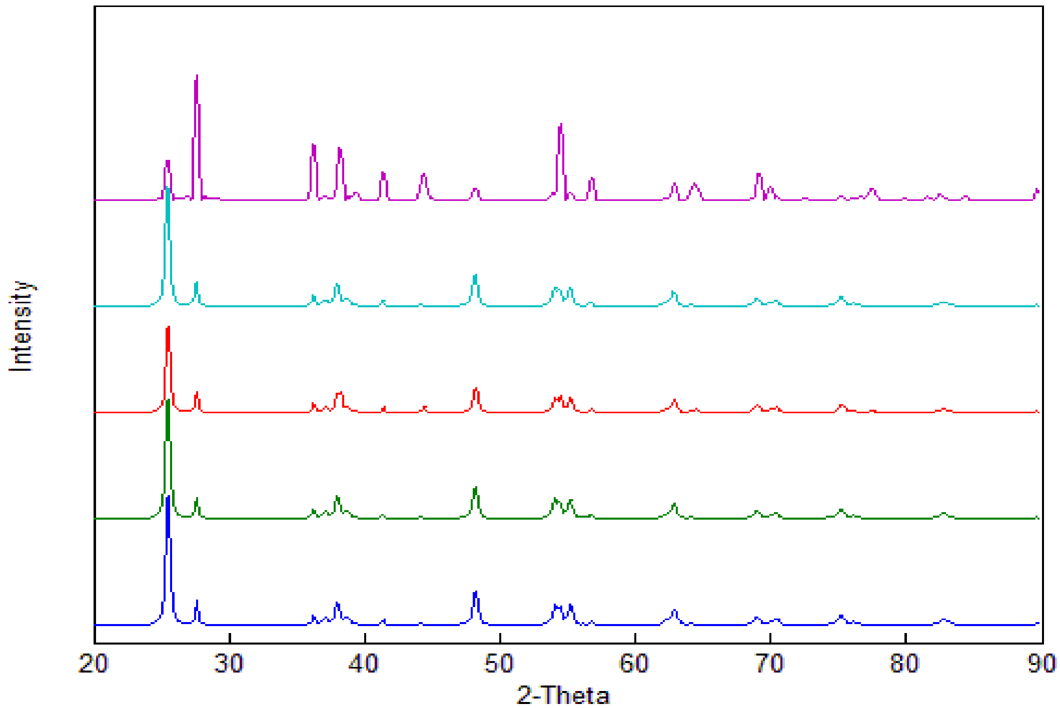
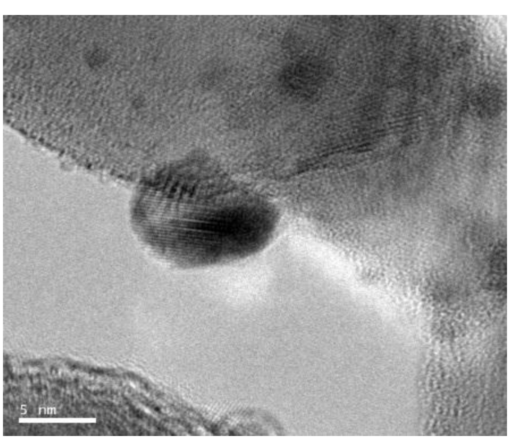


Figure 1. XRD Patters of various nanostructured TiO_2 samples heat treated 450 and 600°C. Phases were identified using standard PDF cards (97-009-3097-Rutile, 97-009-3098-Anatase, and 97-004-4387-Ag).

(a) 

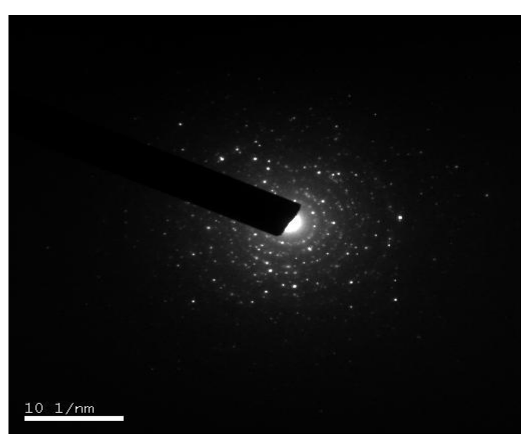
(b) 

Figure 2. (a) HRTEM image, and (b) corresponding diffraction pattern of nanostructured Ag-TiO_2 nanocomposite processed at 600 °C

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