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Facile synthesis of nano-crystalline anatase TiO_2 and their applications in degradation of Direct blue 199

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Abstract Nano-crystalline anatase TiO_2 has been successfully synthesized by solution combustion synthesis using solid TiO_2 powder as raw material. XRD patterns confirmed the formation of anatase phase of the calcined powder at 500 °C for 5 h. The bright-field TEM image revealed that the particle size was in the range of 10–25 nm, which is in nearly good agreement with the average crystallite size obtained from XRD. SEM image of the calcined TiO_2 powder showed the average grain sizes in the range of 150 nm–0.5 µm and spherical in shape. XPS studies showed the presence of titanium and oxygen which confirmed the purity of the material. The obtained nanoparticles were used for photodegradation of dye Direct blue 199. TiO_2 nanoparticles degraded about 99.33 % Direct blue 199 by using solar rays in 3 h.

1 Introduction

In recent years, there is a challenge in material science to synthesize nanoscale material with high crystalline quality. The synthesis of nano-materials with diameters ranging from 1 to 100 nm with strict control over size, shape, and crystalline structure has inspired the application of nanotechnology to numerous fields. The transition metal oxides in nanometer scale have been gathered a lot of scientific interest due to the large variety of applications including catalysis, gas sensors, biochemistry, optoelectronic, spintronic etc. [1–6]. Transition metal oxide materials have been still increasingly studied in nano-structured forms [7]. Transition metal oxide nanoparticles exhibit unique chemical, optical and electrical properties due to their strong size and shape dependence. Highly efficient materials for modern technology can be achieved by producing suitable size transition metal oxide nanoparticles such as Fe_2O_3, MgO, ZnO and TiO_2. Scientific research efforts have been focusing on searching for transition metal oxide-based materials. The structural characterization of these nanostructures becomes very important in order to produce and develop new low cost and effective materials for future technology. The titanium dioxide (TiO_2) is used as a pigment in paints, cosmetics etc. [8]. It is used for beam splitters optical coating and anti-reflection coating because of its high dielectric constant and refractive index [9, 10]. It is also used in humidity sensor, gas sensor [11, 12], dye sensitized solar cell [13–15] and photochromic glass [16]. TiO_2 nanoparticles are much effective as a photocatalyst than in bulk powder. The different methods mentioned in literature for preparation of TiO_2 nanoparticles include sol–gel [17, 18] hydrothermal [19–22] and precipitation [23, 24]. Various technique have been used to enhance the photocatalytic activity include chemical surface modification, creation of nano-heterogeneous junction by doping the materials with noble metal or with semiconductor on the TiO_2 surface [25–38]. The present work is restricted to synthesis of TiO_2 nanoparticles from the conversion of low cost solid TiO_2.The nanoparticles are characterized using various physiochemical chanctenzations. The properties of TiO_2 nanoparticles materials are dependent on the crystal structure, nanoparticle size, morphology and it is also strongly dependent on the method of preparation. To the best of our knowledge, this work

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