Synthesis and Photovoltaic Properties of TiO_2 Nanoparticles in dye sensitized Solar Cells: Effect of Tertiary Amines

Noshin Mir[a], Masoud Salavati-Niasari*[b]
[a]*Department of Chemistry, University of Zabol, Zabol, Iran*
[b]*Institute of Nano Science and Nano Technology, University of Kashan, Kashan, P.O. Box 87317-51167, Islamic Republic of Iran*
[*]Corresponding author: Tel.: +98 361 5555 333, Fax: +98 361 555 29 30.
E-mail address: salavati@kashanu.ac.ir (Masoud Salavati-Niasari).

Nanocrystalline TiO_2 semiconductors are well-known for various applications such as photovoltaics, photocatalytics, photonic crystals, and photochromics. Recently, photovoltaic application for dye sensitized solar cells has become the focus of considerable research efforts. It has been determined that the energy conversion efficiencies of the photovoltaic devices that benefit nanocrystalline TiO_2 are critically dependent on the size of the particles. A wide variety of methods have been developed for the synthesis of titania nanoparticles, so far. Sol–gel, reverse micelle method, and hydrothermal are some examples of chemical routs for production of well-define TiO_2 nanoparticles. Two-step sol-gel is a similar adopted method of conventional "gel-sol" method, developed by Sugimoto.

In this paper, TiO_2 nanoparticles were synthesized using two different amines as complexing agents by a two-step sol-gel method. The purpose of this study is investigating the role of differenttertiary amines on the size of the TiO_2 nanocrystals and the performance of corresponding dye-sensitized solar cells. The effect of tertiary tripodal tetaamines as well as different numbers and types of active sitesof primary amines and their effect on the size and morphology of TiO_2 products have already been investigated by this group. The selected amines are chosen in a way that we investigate the effect of tertiary amine with one and two nitrogen active sites. Unlike the chosen diamine, the monoamine benefits the long hydrocarbon chain. The long carbon chain of amines can provide great steric hindrance to control the size of nanoparticles. This difference provides a comparison between the influences of the length of hydrocarbon chain versus the number of nitrogen head groups in a tertiary amine on photovoltaic properties of DSSCs. The obtained products were characterized by XRD, SEM, TEM, FT-IR and (UV-vis) spectroscopy.The overall conversion efficiency of the long- chain-based DSSC (5.04%) appeared to be 45% higher than that obtained for the tertiary short-chain diamine. Fig. 1 show the TEM images of the TiO_2nanocrystals. Fig. 1 shows small ellipsoidal nanoparticles with low aspect ratio obtained from TDA as a tertiary long-chain monoamine. The size of ellipsoids is about 30–40 nm in length and 15–30 nm in diameter. On the other hand, using TMED as a tertiaryshort-chain diamine leads to formation of larger ellipsoids with size of 35–80 nmin length and 20–40 nm in diameter. The results contribute to understanding the significant effect of the chemical structure of the complexing agents on the size and agglomeration control of the products as well as their photovoltaic properties. As was confirmed in the literature, given the absence of a scattering particle layer, of blocking layer and of co-absorbents, this result demonstrates that the two-step sol-gel process-derived anatase nanoparticles are very suitable for achieving DSSCs with appreciable efficiency. Coming work is in progress to gain further mechanistic insight into effect of other organic compounds on the shape and size control and photovoltaic properties of products.

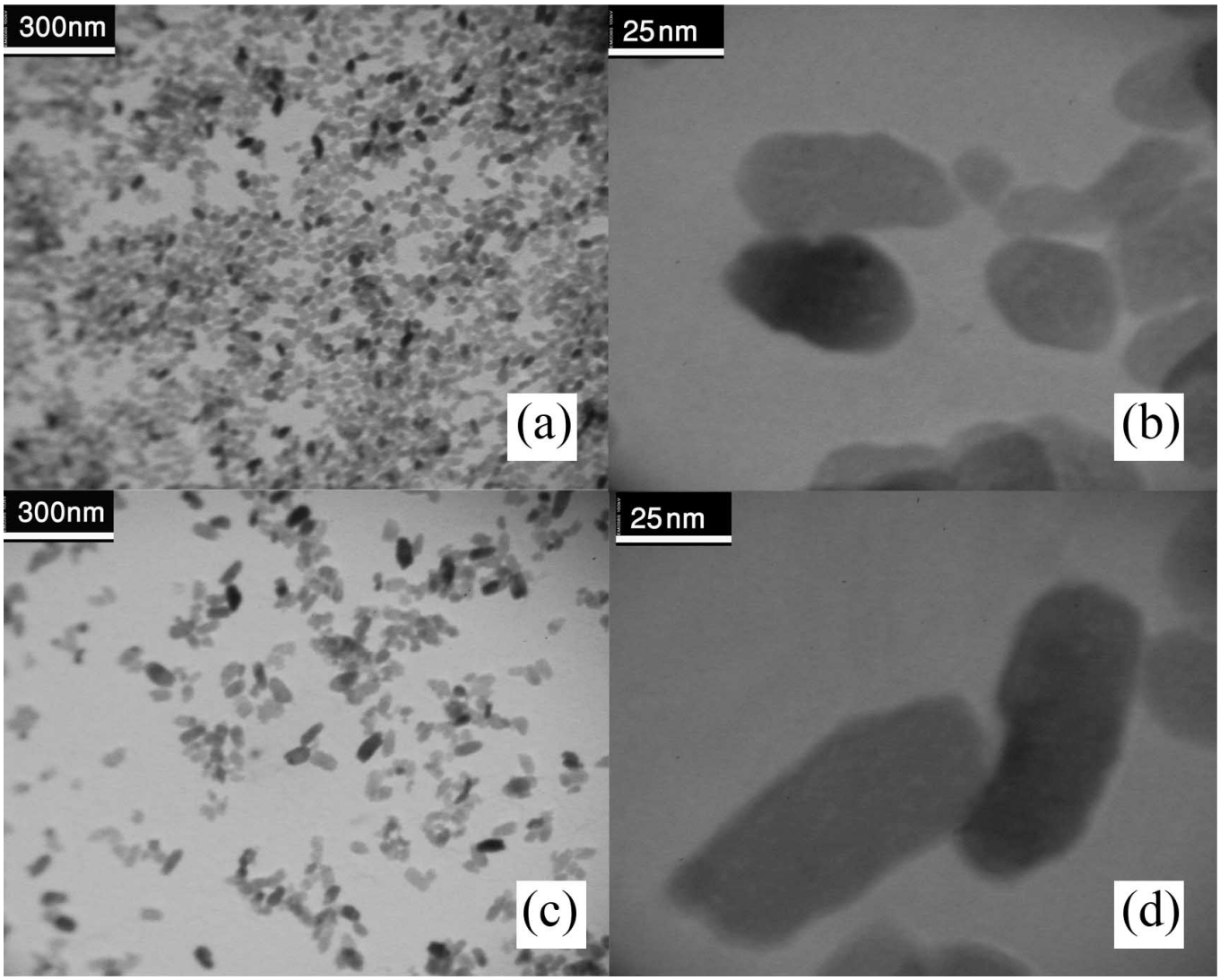

Fig. 1. TEM images of the TiO_2 samples: (a) and (b) S_{TDA}, (c) and (d) S_{TMED}