The Use of Biotemplates and Sol-Gel method for the preparation of Titanium Dioxide (TiO_2)

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Abstract:

Solar photovoltaics is nowadays, viewed as one of the most important renewable energy sources in terms of global. The most common material for these is Silicon which have dominated PV solar energy converters. On the other hand, it has been found that the light-induced degradation of silicon materials limits the device stability. An alternative that has been rising attention is the use of inorganic semiconductors. TiO_2 nanomaterial appears to be a distinguishing candidate because of its high chemical and optical stability, nontoxicity, low cost, and corrosion resistance. Our goal is to synthesizes TiO_2 nanoparticles to improve the efficiency of the photoelectrode in solar cells. Our experimental approach involves the use of leaves biomass as templates. The use of the bio templates is combined with the sol- gel method for the preparation of these particles. Calcinating temperatures were investigated to determine the structural and properties of titanium nanoparticles using X-ray diffraction powder (XRD), to check diffraction patterns and determine if TiO_2 crystalline structure is present and Transmission electron microscopy (TEM) for characterizing particle size and elemental composition.

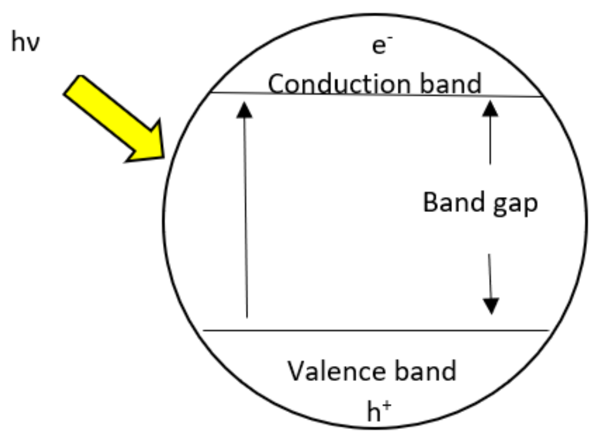

Figure a. Schematic illustration of photo-generation of charge carriers in a photocatalyst.

Introduction:

Titanium dioxide (TiO_2) has always been a semiconductor of much interest since it has photocatalytic properties. TiO_2 has three crystal phases: anatase (tetragonal), rutile (tetragonal) and brookite (orthorhombic). We have been exploring a new method to synthesize TiO_2 nanostructures using a combination of biotemplates and sol-gel method. Templates consists of a mold that modify nanostructure properties. Some reasons to use natural materials as our template are that they have a high orderly structure, are inexpensive and are easily removed with temperature. Also, the sol–gel method has shown to have many advantages in terms of purity, it's fast, uses a neutral pH, room temperature and doesn't generate an alcohol byproduct. In this study, TiO_2 nanoparticles were prepared using the methods previously mentioned.

Synthesis:

To obtain these particles the oregano (*Plectranthus amboinicus*) leave was dried at 60˚C until it reached constant weight followed by grinding. The obtained biomass was sieved, and different sizes were used (less than 80 µm, 80 µm-120 µm and 120 µm-130 µm). Later the biomass was saturated with the Ti precursor followed by an acid hydrolysis of the compound. The mixture was sonicated and dried at 120˚C overnight. To remove the bio template samples were incinerated at 1200˚C. The synthesis of titanium dioxide particles doped with Silicon had a similar procedure. First the precursor was prepared with 50:50 of TiO_2 – Si, pure nano water and HCl. The oregano leave was dried for 3 days at 62˚C. Later the precursor was sonicated for 1 hour. Approximately 3mL of the precursor was added to the biomass. The sample was incinerated at different temperature, 3 hours at 400˚C and 3 hours at 700˚C.

Measurement were performed on the XRD, Cu /40kV/ 44 mA. We also used the TEM to have a better observation of the particle size and crystallinity.

Results:

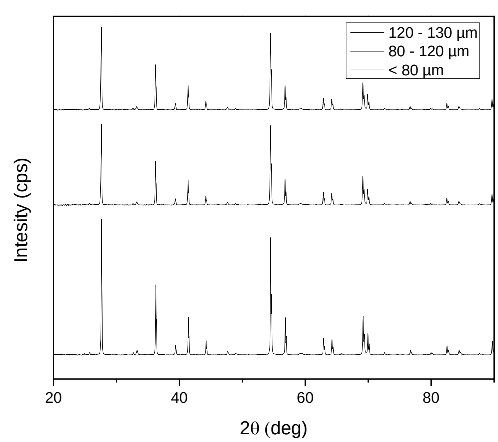

Figure 1. X- ray diffraction of nano-TiO_2 (<80 µm, 80 µm - 120µm, 120 µm- 130 µm) in rutile phase.

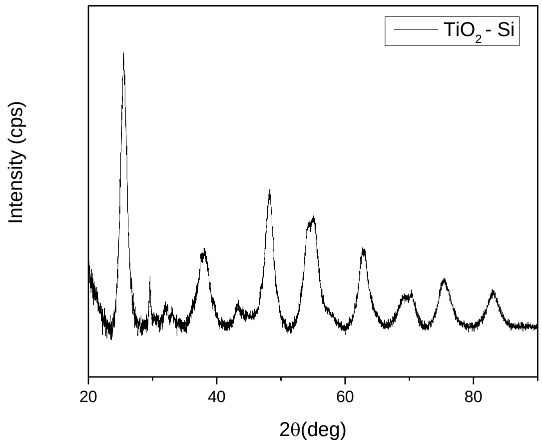

Figure 2. X-ray diffraction of Titanium dioxide doped with silicon. The obtained pattern is consistent with the anatase phase of TiO_2.

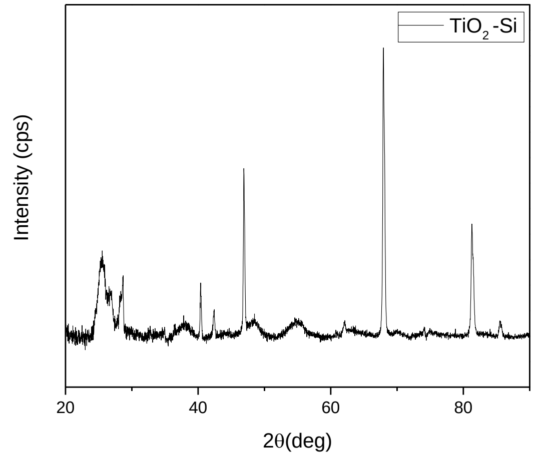

Figure 3. X-ray diffraction of Titanium dioxide doped with silicon after grinding.

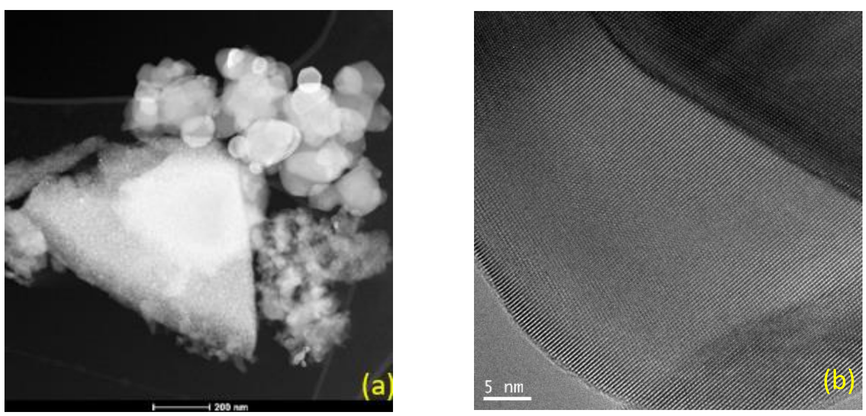

Figure 4. TEM images of (a) Si doped TiO_2 nanoparticles (b) High resolution TEM images of Si doped TiO_2 nanoparticles.

Conclusions:

A. **XRD**

From Powder X-Ray Diffraction (pXRD) we can say that TiO_2 is not affected by the biomass particle sizes. All the obtained material showed a rutile crystalline phase as shown in Figure 1. This result is in accordance with reports that indicate the phase change from anatase to rutile occurs around 700°C.

On the other hand, Si doped TiO_2 particles showed an anatase like diffraction pattern when analyzed as obtained from the describe experimental setting. These results changed significantly for the sample after grinding to obtain a fine powder. This difference can be seen when comparing diffraction patterns before and after grinding as shown in Figures 2 and 3, respectively.

B. **TEM**

TEM images of the Si doped TiO_2 sample (after grinding) showed two different particles sized and a crystalline arrangement. EDS results indicate the presence of both silicon and titanium on the sample. Particles sizes ranged between 100 and 200 nm are crystalline (Figure 4).

References:

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