Visible-activated dye-modified TiO₂ photocatalyst

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Abstract

Dye-modified TiO₂ samples were synthesized through a chemical reaction using dye Chrysoidine G (CG), tolylene-2,4-diisocyanate (TDI) and commercial TiO₂ (Degussa P25) as starting materials. TDI was used as a bridging molecule whose two –NCO groups reacted with Ti–OH of TiO₂ and –NH₂ groups of CG, respectively. As a result, special organic complexes were formed on the TiO₂ surface via stable π−conjugated chemical bonds between TiO₂ and dye molecules, confirmed by FT-IR, XPS and UV-Vis spectra. The as-synthesized dye-modified TiO₂ samples were designated as CTPX, X indicated the molar ratio of TDI to TiO₂.

Figure 1 gave the UV-visible diffuse reflectance spectra of TiO₂ and the dye-modified TiO₂. The pure TiO₂ exhibited neglectable absorption in visible region, and the dye-modified TiO₂ showed strong absorption in the band of 420-600 nm, which was attributed to the formation of π−conjugated surface complexes on TiO₂ surface, and the absorption intensity of the dye-modified TiO₂ increased with the increase of dye content. Figure 2 showed the adsorption amounts of MB on the dye-modified TiO₂. With the increase of the TDI/TiO₂ molar ratio, namely the dye modification amount to TiO₂ gradually enhanced, the adsorption capacity of dye-modified TiO₂ catalysts gradually increased and then decreased. It was noticeable that the adsorption amounts of MB on all CTP catalysts were all higher than that on bare TiO₂ and reached the highest values at TDI/TiO₂ molar ratio 0.5. The photodegradation percentage of the dye-modified TiO₂ was shown in Figure 3. From Figure 3, it was found that bare TiO₂ had poor photocatalytic activity, but the dye-modified TiO₂ showed a notably enhanced activity compared with bare TiO₂. Moreover, as the molar ratio of TDI/TiO₂ was ≤ 0.5, the photocatalytic activity gradually increased, which should be attributed to the roles of the improved visible absorbance and the enhanced adsorption capacity (See Figure 1 and 2). When the TDI/TiO₂ molar ratio was beyond 0.5, the gradually decreased photocatalytic activity was assigned to the collective effect from the increasing absorbance and the declined adsorption capacity (See Figure 2). As a result, the CTP0.5 showed the highest photocatalytic activity due to the strongest visible absorption and adsorption capacity.

In conclusion, the dye-modified TiO₂ can absorb the visible light and show the photocatalytic activity under the visible light irradiation.

![Figure 1](image1.png)

**Figure 1.** UV-visible diffuse reflectance spectra of the dye-modified TiO₂.

![Figure 2](image2.png)

**Figure 2.** The adsorption amount as a function of various molar ratio of TDI/TiO₂

![Figure 3](image3.png)

**Figure 3.** The photodegradation yield as a function of different TDI/TiO₂ molar ratio.