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Preparation and characterization of platinum doped porous titania nanoparticles for photocatalytic oxidation of carbon monoxide

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ABSTRACT

TiO_2 samples doped with platinum oxide were obtained by using a sol–gel low temperature approach. The photocatalytic oxidation of CO in the presence of O_2 was monitored to study the influence of the Pt doping on the photocatalytic degradation performance of TiO_2. The obtained results were compared with those obtained with TiO_2 Degussa (P-25). Photocatalytic studies of the prepared mesoporous Pt/TiO_2 nanoparticles for the photooxidation of CO revealed notable photocatalytic activity, which was 3 times higher than that of Pt photodeposited onto commercial TiO_2 Degussa P-25. Also quantum yield for CO_2 formation for mesoporous Pt/TiO_2 calcined at 500 °C is higher than that of Pt photodeposited onto commercial TiO_2 Degussa P-25 by about three times. The structure and textural properties Pt/TiO_2 were studied by X-ray powder diffraction (XRD), N_2 adsorption (BET), Transmission electron microscopy (TEM) and UV.

1. Introduction

One of the most active areas in environmental research is the development of highly efficient methods for the elimination of hazardous pollutants from air, soil and water. The semiconductor photocatalysis is recognized as one of the promising techniques for this purpose. The photocatalytic activity of semiconductors is observed when electrons and the corresponding positive holes are generated in the conduction and valence band of the semiconductors respectively, as a result of UV irradiation [1].

Nanocomposite composed of semiconductor oxides and noble metals has found important applications in catalysis and the generation of photocurrent and photovoltage. In particular, TiO_2 coupled with noble metals, such as Pt, Pd, Au, or Ag, has been served as excellent visible-light photocatalysts [2–17] or CO oxidation catalysts [18–20].

It is well known that TiO_2 adsorbed with noble metals can improve the efficiency of electron-transfer dynamic and also enhance the efficiency of photocatalytic redox processes [21–24].

Titanium dioxide (TiO_2) is a very important semiconducting photosensitive material, which has undergone extensive investigation over the past two decades owing to its many outstanding physicochemical properties [25]. In particular, photoinduced reactivity of and photocatalytic activity of various TiO_2 phases have been widely investigated and utilized in many technological applications such as dyesensitized solar cells, water-splitting, synthesis of organic compounds, and decomposition/degradation of organic pollutants etc. [25].

For example, TiO_2 is a well-known UV absorbing transition-metal oxide and the bulk anatase TiO_2 has a direct transition optical band gap of 3.2 eV. When it works as a catalyst in photocatalysis under ultraviolet (UV) light irradiations, the charge separation between the photon-generated carriers becomes a crucial factor in determining the ultimate catalytic performance of TiO_2 catalysts [25]. In order to increase its surface area and thus light absorbing ability, TiO_2 has been coated or deposited onto different types of support materials or carriers.

Being a model reaction, the photocatalytic oxidation of CO using platinized TiO_2 has been studied by many scientists [26,27]. It is well known that Pt deposits on TiO_2 not only increase the photo-induced electron transfer rate at the interface but also provide catalytic sites. Hwang et al., concluded that Pt nanoparticles deposited on TiO_2 in enhancing the CO photooxidation rate provides surface sites on which active oxygen species photogenerated from adsorbed O_2 are stabilized [26]. Vorontsov et al., found that CO photocatalytic activity increases with lowering of Pt oxidation state (highest with Pt^0/TiO_2) [27]. Gan et al. observed that both TiO_2 surface structure and Pt nanocluster size have profound effects on CO surface chemistry [27]. Photocatalysis is an environmentally friendly method for CO oxidation since such a system can operate at ambient temperatures under clean and abundant solar light irradiation. TiO_2 as a photocatalyst has been applied for a variety

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