Photocatalytic and Self-Cleaning Properties of Ag-Doped TiO_2

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Abstract: Commercially available TiO_2 of anatase structure produced in the Chemical Factory Police S.A. was modified by doping Ag from $AgNO_3$ solution *via* photodeposition method. The obtained amount of deposited Ag on TiO_2 was in the range of 0.11 to 0.98 mass %. Deposition of Ag on TiO_2 resulted in the retarding of the recombination reaction and formation of the higher amount of OH radicals on the photocatalyst surface during irradiation with UV light. The photocatalytic activity of samples was tested for the decomposition of phenol and Reactive Black in the water solution under both, UV and artificial solar light radiation. Deposition of Ag on TiO_2 surface increased its photocatalytic activity towards the Reactive Black decomposition but not for phenol. High adsorption of Reactive Black on Ag modified TiO_2 photocatalysts, which was higher than on TiO_2, could enhance the photocatalytic activity of these samples. The solution with 1% slurry of TiO_2-Ag was sprayed on the surface of concrete. For concrete impregnated with TiO_2-Ag slurry the both, fungicidal and self-cleaning effect for dyes were observed.

Keywords: Ag doped TiO_2, self-cleaning, reactive black decolourisation, photocatalysis.

1. INTRODUCTION

TiO_2 has many applications in the environment. TiO_2 under ultraviolet irradiation exhibits photocatalytic activity that enables the oxidative destruction of a wide range of organic compounds (phenols, pesticides, herbicides, dyes, pharmaceutics, organic acids, alcohols, etc.) and biological species (bacteria, viruses, cyanobacteria, algae, and fungi), causing self-decontamination effect [1-4]. In addition, TiO_2 exposed under UV exhibits photocatalytically induced superhydrophilicity that converts the hydrophobic character of the surface to hydrophilic and forms the uniform water film, which prevents the adhesion of inorganic or organic components on its surface, which retains clean [5, 6]. The powdered TiO_2 may be deployed on the surfaces of various substrates, such as glass, ceramics, metals, textiles, cement, bricks or fibres to provide layer that exhibits self sterilisation and self cleaning properties, when it is exposed to the light [7-10]. This creates a large commercial potential for TiO_2 application: in medicine, automotive and food industries, environmental protection, but especially in the architecture (cultural heritage purposes, facade paints, indoor, wall paper, tiles, etc.).

It has been proved that TiO_2 doped with Ag can sufficiently decompose some dyes and organic acids, such as oxalic and salicylic acids, as well as the other organic compounds, like saccharose, phenol, etc. [11-15]. TiO_2 doped with Ag and mounted on the ceramics can also work as a gas filter for removing some odours like H_2S, CH_3SH or toxic N_2O gas [16, 17]. Ag deposited on the surface of TiO_2 can prevent the recombination reaction between photogenerated holes and electrons, enhancing the yield of photocatalytic activity of the semiconductor [18]. Nanoparticles of Ag can also work as a catalyst in the photocatalytic reaction [13]. Some of the photocatalytic oxidation reactions are carried out with simultaneous reduction of Ag ions during its deposition on the surface of TiO_2 [14, 15].

In the present work, Ag was deposited on the commercial TiO_2 of an anatase structure by the photodeposition method under UV from $AgNO_3$ solution under flow of Ar gas. The prepared Ag-doped TiO_2 have been tested for the decomposition of the Reactive Black and phenol under both, UV, and artificial solar light irradiation. The titania slurry with doped Ag have been spread on the concrete of the house and the self-cleaning and fungicidal effects have been observed.

2. MATERIALS AND METHODOLOGY

2.1. Photocatalyst Preparation

Commercially produced TiO_2 in Chemical Factory Police S.A. in Poland has been used for preparation. 3g of powdered TiO_2 has been placed in a quartz beaker together with $AgNO_3$ solution (75 mL) with different concentrations, $7.4\cdot10^{-3}$- $4.6\cdot10^{-4}$ mol/L. KOH (0.1 M) was added to obtain pH = 6.3. The mixture was magnetically stirred by 15 min, after that 1 mL of methanol was added and the mixture was rinsed with argon by 45 min. Then UV lamp was switched on and the solution was irradiated for 2h with simultaneous flow of argon gas. The obtained Ag-doped TiO_2 after photodeposition has been filtered through the membrane filter 0.45 µm, rinsed with distilled water and dried in oven at 105ºC for 12 h.

2.2. Photocatalytic Activity

The activity of photocatalysts in both visible and UV light was conducted in a beaker filled with 500 ml of phenol (0.1 g/L) or Reactive Black (0.03 g/L) solutions and photocatalyst (0.1 g/L). In case of phenol solution, there was observed almost no adsorption on the photocatalyst surface and reaction was carried out under irradiation for 5 h. In case

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a)

uncoated

coated with Ag-TiO$_2$

b)

uncoated

coated with Ag-TiO$_2$

Fig.(4). Photos of the concrete partly coated with titania slurry solution and stained with a dye on the coated and a uncoated parts, **a**) after stained, and **b**) after exposure to solar light.

coated with Ag-TiO$_2$ **uncoated**

Fig. (5). Photo of concrete partly coated with titania slurry solution (1% of Ag-TiO$_2$).

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