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Facile synthesis of 1D-architecture of silver-vanadates in carbon nest for enhanced visible light driven photo-oxidation process

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ABSTRACT

Ag/AgCl/V_2O_5 nanocatalysts with one dimensional (1D) architecture was synthesized in carboxylic acid functionalized multi-walled carbon nanotubes for methylene blue dye degradation. The growth of uniformly distributed nanoparticles along the carbon-nanotubes was revealed from high resolution transmission electron microscopy and atomic force microscopy analyses. Raman spectroscopy and transmission electron microscopy analyses also confirmed for the creation of defects in the multi-walled carbon nanotube. The hybrid nanocomposite appeared as a suitable photocatalyst for degradation of methylene blue dye absorbing the light in the visible range of solar spectrum. The presence of interactions within the nanoparticles and with the nanotubes was believed to enhance the photo-oxidation process. The creation of defects in the carbon nanotube on modification with Ag/AgCl/V_2O_5 improved the photocatalytic activity by enhancing the photoelectron transfer process. About ~90% of the total organic carbon of the dye molecule was found to decompose into CO_2, H_2O and inorganic ions within 25 min under sunlight.

1. Introduction

Drainage of coloured dye like methylene blue (MB) from textile industries into various drinking water sources is considered to be one of the major threats to the human health causing several diseases [1–6]. These types of dye molecule are very stable and are difficult to decompose under ambient conditions [7]. Therefore, mineralization of these carcinogenic carbon compounds applying some greener approach is urgently required for waste-water treatment [8–10]. So far different chemical methods as well different types of materials have been employed to remove MB from water [2,8–12]. Among the various reported techniques, photocatalytic degradation of coloured dye molecule is considered to be one of the best techniques [13–15]. As per the photocatalyst are concerned, semiconducting materials *viz* TiO_2, CdS, ZnO are known to decompose MB with high efficiency, however, these are effective only in the ultra-violet region [9,16–18]. Therefore, more emphasis has been put towards the synthesis of new photocatalyst that can promote the oxidation of hazardous water pollutants absorbing light in the visible range [10].

Silver-vanadates ($AgVO_x$) are found to be useful materials for trapping visible light because of the presence of suitable band gap in the range of 1.35–2 eV [19,20]. Silver in combination with halogens (Cl, Br, I) can be more effective for these applications due to surface plasmon resonance (SPR) effect [21–26]. From our group it was reported that Ag/AgCl supported on amorphous vanadium oxide (VOx) can decompose methylene blue (MB) and methyl orange (MO) utilizing the solar energy [10]. However, the complete mineralization of the organic components was not achieved highlighting one of the major challenges in the photodegradation of dye molecules [10,27]. To alleviate this problem, the use of functionalized carbon-nanotubes (*f*-CNT) has been investigated due to their high adsorption ability towards organic dye molecules [23,28,29]. Monodispersed hierarchical CNT microspheres synthesized by a microwave (MW) assisted hydrothermal method are found to remove organic pollutants as dyes under visible light irradiation which maintained a high level of photocatalytic activity after multiple reaction cycles. [30] Therefore, in this report a simple and an efficient method has been adopted to improvise the photocatalytic ability of Ag/AgCl/V_2O_5 by supporting over −COOH functionalized

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