ES Energy & Environment

DOI: https://dx.doi.org/10.30919/esee8c639

Hydrothermally Prepared Vanadium Oxide Nanostructures for Photocatalytic Application

Bapuso M. Babar,[1] Komal B. Pisal,[1] Suhas. H. Sutar,[1] Sarfraj H. Mujawar,[1] Laxman D. Kadam,[2] Habib M. Pathan,[3] Udayraj T. Pawar,[4] Prakash M. Kadam[4,*] and Pramod S. Patil[5,*]

Abstract

In the present work, vanadium pentoxide (V_2O_5) nanoparticles have been successfully prepared by a simple hydrothermal method. The effect of annealing on the photocatalytic degradation of methylene blue (MB) dye is studied. The structure of V_2O_5 is confirmed by X-ray diffraction (XRD) and Raman spectroscopy, while Fourier transforms infrared (FTIR) spectroscopy is used for functional group detection. Agglomerated nanoparticle morphology is observed via scanning electron microscopy (SEM). The direct band gap of V_2O_5 is 2.63–2.81 eV calculated using ultraviolet-visible (UV) spectra. Finally, the photocatalytic degradation of MB dye by V_2O_5 is studied. The results indicate a promising and enhanced degradation property of calcinated V_2O_5. A very small quantity of calcinated V_2O_5 shows about 68% degradation of MB within 80 min, and the rate constant for the calcinated product is 9.9×10^{-5} s^{-1}.

Keywords: Hydrothermal method; Vanadium pentoxide; Methylene blue; Photocatalysis; Dye degradation.
Received: 29 October 2021; Accepted: 26 January 2022.
Article type: Research article.

1. Introduction

In recent years due to industrialization, the world faces a dire water pollution problem. Due to drastic progression in the industrial and agricultural sectors, a lot of pollutants such as organic dyes, pesticides, and medicines are polluting potable water.[1,2] The level of these hazardous and irrevocable pollutants in the atmosphere as well as in water increases day by day.[3] The problem associated with these pollutants is that they do not degrade naturally and remain in the environment for a long duration.[4] There are various sources of dyes such as methylene blue (MB), rhodamine B (Rh-B), and Congo red that are generally released in potable water.[5,6] MB is one of the main sources of dye regularly produced by the textile industry and it is carcinogenic and harmful to human life as well as to the environment. There is a need for the degradation of such hazardous pollutants to reduce water pollution and convert it into usable water. Due to great improvement in research areas, various methods have been invented to degrade dyes and convert contaminated water into usable ones, namely photocatalytic degradation, biological methods, and membrane filtration.[4] The oxidation-reduction process plays an important role in degradation. The advanced oxidation process includes photocatalytic dye degradation which is effective for reduction in water pollution using the decomposition of dyes into CO_2 and H_2O.[7] The photocatalytic dye degradation process has several advantages such as low cost, fast and low temperature.[8,9] The preferred photocatalysts used in the degradation process have an appropriate bandgap, large surface-to-volume ratio, low-cost synthesis, high oxidizing properties, *etc*. Many researchers and scientists are attracted to metal oxide materials such as TiO_2, WO_3, V_2O_5, ZnO, *etc*. due to their certain promising properties like high surface area, low working temperature, good stability, and favorable semiconductor nature.[10] Vanadium pentoxide (V_2O_5) has several applications in a supercapacitor, gas sensor, solar cell, dye degradation, electrochromic device, *etc*. Vanadium pentoxide has attracted the attention of many researchers due to its promising properties like appropriate bandgap (~2.3 eV), large surface area, advantageous

[1] *Department of Physics, Yashavantrao Chavan Institute of Science, Satara, Maharashtra 415001, India.*
[2] *Arts, Science and Commerce College, Ramanandnagar (Burli),Sangli, Maharashtra 416308, India.*
[3] *Department of Physics, Savitribai Phule Pune University, Pune, Maharashtra 411007, India.*
[4] *Smt. Kasturbai Walchand College Sangli, Maharashtra 416416, India.*
[5] *Thin Film Materials Laboratory, Department of Physics, Shivaji University, Kolhapur, Maharashtra 416004, India.*
**Email:* kprakash5229@rediffmail.com (P. M. Kadam)
psp_phy@unishivaji.ac.in (P. S. Patil)