Applied Physics A (2020)126:586
https://doi.org/10.1007/s00339-020-03770-5

**Applied Physics A**
**Materials Science & Processing**

# Structural and optical properties of $V_2O_5$ nanostructures grown by thermal decomposition technique

**K. M. Shafeeq[1] · V. P. Athira[1] · C. H. Raj Kishor[1] · P. M. Aneesh[1]**

Received: 28 March 2020 / Accepted: 28 June 2020



## Abstract

Vanadium pentoxide ($V_2O_5$) is a widely used industrial catalyst and a promising substitute to the acidic and hygroscopic PEDOT: PSS hole transport layer in organic solar cells. In this work, $V_2O_5$ nanostructures were synthesized by thermal decomposition of ammonium metavanadate ($NH_4VO_3$) at various temperatures. Structural and morphological studies confirmed the formation of orthorhombic structure of $V_2O_5$ nanorods. The UV–Vis–NIR reflectance spectra show a temperature dependent red-shift in band gap corresponding to indirect optical transitions. The peaks corresponding to band edge emissions were obtained from photoluminescence spectra. From Fourier-transform infrared (FTIR) studies, the vibrational modes involved in $V_2O_5$ nanostructures were identified. Temperature dependence of the precursor $NH_4VO_3$ was evaluated from thermogravimetric–differential (TGA/DTA) curves.


**Keywords** Vanadium pentoxide · Nanorods · X-ray diffraction · Optical properties · Organic solar cells

## 1 Introduction

Solar cells are devices that generate electric current when exposed to the light through photovoltaic effect. Development of conductive organic polymers led to the discovery of organic solar cells which made solar cells more flexible, light weight and cost effective [1, 2]. Fabrication of solar cells with organic materials improved the solar cell (or photovoltaic) technology to generate electricity in a cheaper way. Organic solar cells (OSCs) are made up of an active material along with different inorganic or organic interfacial layers. Organic solar cells are now gaining more interest due to their low production cost, mechanical stability, flexibility and light weight. Previously, the power conversion efficiency and stability of OSCs are much lower to the inorganic counterparts [3]. Using the inorganic interfacial layers like $V_2O_5$, $MoO_3$, ZnO, etc. in solar cells, the performance and stability have been improved and these materials can be easily deposited through simple solution processes [4].

✉ P. M. Aneesh
aneeshpm@cukerala.ac.in

1 Department of Physics, Central University of Kerala, Tejaswini Hills, Periye, Kasaragod, Kerala 671320, India

In OSCs, the role of an interfacial layer is to transport holes or electrons with less contact resistance between the active layer and respective electrode. $V_2O_5$ thin films are used as hole transport layer (HTL) in organic solar cells due to its lower band gap (2.3 eV) [5]. PEDOT: PSS is the commonly used hole transport layer in organic solar cells which is a costly organic material and it is not much stable on ITO electrode surface due to its acidic and hygroscopic nature causes etching of ITO coating on the substrate, thus affecting the overall performance of a solar cell. Moreover, the oxidation of the back contact (Al) and hygroscopic nature of PEDOT: PSS are detrimental to the device performance [6, 7]. $V_2O_5$ thin films are potential replacement for PEDOT: PSS as a hole transport layer in organic solar cells. $V_2O_5$ is inorganic and easily synthesizable through simple solution processed techniques which makes a reduction in the overall production cost of solar cells. Some research shows that the mixture of oxides $WO_3$–$V_2O_5$ can be used as a hole transport layer which provides a remarkable stability in inverted organic solar cells [8], and their cells retained more than 90% of the initial efficiency even after 1000 h of air exposure.

Depending on the oxidation states of the vanadium metal, it forms different number of compounds along with oxygen. The most common are vanadium monoxide (VO), vanadium dioxide ($VO_2$), vanadium trioxide ($V_2O_3$) and