Hydrothermal Synthesis and Structural Properties of V$_2$O$_5$ Nanoflowers at Low Temperatures

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Abstract. Vanadium pentoxide nanoflowers were synthesized through a simple hydrothermal method at low temperatures. The structure was fabricated by using NH$_4$VO$_3$ and oxalic acid as precursors with 0.1 M solution concentration. The morphology and structural properties of the nanoflowers were characterized using FESEM, XRD, Raman, and UV-Visible spectroscopy. The results reveal an orthorhombic structure with preferred orientation along (001) plane of the prepared V$_2$O$_5$ nanoflowers. Raman peaks also expressed the same structural features. FESEM images showed the V$_2$O$_5$ nanoflower with diameters in the range of 60-80 nm and length in 600-800 nm. A red-shift was observed in the characteristic absorption peak of V$_2$O$_5$ nanoflowers, which are attributed to the decrease of the bandgap of the samples.

1. Introduction

V$_2$O$_5$ has been gained significant interest in the applied research to range of applications [1]. V$_2$O$_5$ is the most stable among all vanadium oxides and has high oxidation state [2, 3]. The outstanding properties such as a direct band gap in the visible-light region ($E_g = 2.2$ to $2.7$ eV) [4], multi-valance, good chemical and thermal stability, excellent thermoelectric property make V$_2$O$_5$ nanostructure is a suitable material for solar cells [5], gas sensor [6], optical-electrical switches [7], chemical sensing [8], electrochromic devices [9], and optoelectronic devices [10]. Therefore, one dimensional (1D) nanostructures of V$_2$O$_5$ are considered to be more appropriate for the device applications as compared with its other forms. Among these, V$_2$O$_5$ nanoflowers are being considered for applications in optoelectronic and electrochemical devices [11]. V$_2$O$_5$ nanostructures have been prepared by different techniques including chemical vapor deposition [12], magnetron sputtering [13], sol-gel method [14], pulsed laser deposition [15], electron beam evaporation [16], electrospinning [17], spray pyrolysis [18], and hydrothermal synthesis [19]. Among the various deposition techniques for the preparation of vanadium oxide nanostructures, hydrothermal technique is a relatively simple, cost-effective and environmental friendly route to prepare metal oxide nanostructures at low temperature and short reaction time [20].

Many researchers in the field have been developed to obtain 1D-V$_2$O$_5$ nanostructures. Parida et al. [21] synthesized of the V$_2$O$_5$ nanoflowers by a simple and novel cost-effective low temperature