Applied Surface Science xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Applied Surface Science

journal homepage: www.elsevier.com/locate/apsusc

Full Length Article

Studies on the structural, morphological and optical properties of HCl assisted vanadium oxide/tin oxide nanocomposites prepared by sol-gel method

Mohana Priya Subramaniam, Geetha Arunachalam*, Ramamurthi Kandasamy

Crystal Growth and Thin Film Laboratory, Department of Physics and Nanotechnology, SRM Institute of Science and technology, Kattankulathur 603203, Tamil Nadu, India

ARTICLE INFO

Article history:
Received 29 October 2017
Received in revised form 25 January 2018
Accepted 21 February 2018
Available online xxx

Keywords:
V_2O_5/SnO_2
Nanocomposites
HCl
Nano-rods
Optical
Raman

ABSTRACT

Nanocomposites have gained much importance in different fields, commercially and technologically, due to the possibilities in tuning the properties of nanocomposites. In the present work, vanadium oxide (V_2O_5)/tin oxide (SnO_2) nanocomposites were synthesized using simple sol-gel method. Two independent experiments were carried out to synthesis the V_2O_5/SnO_2 nanocomposites. The V_2O_5/SnO_2 nanocomposites were prepared from the precursors of tin chloride, ammonium metavanadate and ethanol (Experiment 1). A few ml of concentrated hydrochloric acid (HCl) was added in the precursors with and V_2O_5/SnO_2 nanocomposites were prepared (Experiment 2) using ethanol as a solvent. Effect of HCl on the modifications of structural, morphological and optical properties of the V_2O_5/SnO_2 nanocomposites was studied. Coexistence of V_2O_5 and SnO_2 phases was confirmed by the X-ray diffraction studies. Thermogravimetric analysis (TGA) shows the stability of the as-synthesized V_2O_5/SnO_2 nanocomposites from 350 °C. The crystallinity and the surface morphology of the synthesized V_2O_5/SnO_2 nanocomposites were improved effectively due to addition of HCl in the preparation of the precursor solution. UV-DRS absorption spectra showed that the absorbance is modified and the band gap is decreased with increase in crystallite size due to the addition of HCl. The predominant Raman peaks at 140 cm^{-1} and 991 cm^{-1} confirm the presence of orthorhombic V_2O_5 phase. Further, the addition of HCl in the preparation of precursor solution revealed marked difference in the surface morphology of the nanocomposites.

1. Introduction

Nanocomposites are the combination of different materials exhibiting unique properties, which a single material cannot exhibit [1]. Nanocomposites find applications in different areas. Among the various semiconducting metal oxides, tin oxide (SnO_2), an n-type potential material, belongs to rutile structure and possesses wide band gap (~3.6 eV). SnO_2 finds applications in solid-state gas sensors, transparent conducting electrodes, solar cells, lithium ion batteries and optoelectronic devices [2–5]. Among the transition metal oxides, vanadium pentoxide undergoes a metal-insulator transition process and exhibits changes in the optical, magnetic and electrical properties [6]. Vanadium pentoxide has applications in solid-state ionics, sensing, energy storage devices and catalysis [7]. Vanadium exists in +2, +3, +4 and +5 oxidation states and forms VO, VO_2, V_2O_5 and V_2O_3 phases; among them the stable V_2O_5 phase possesses low band gap of 2.2 eV [8,9]. Previous works show that vanadium mixed metal oxides exhibit unique physical and chemical properties and many researchers have reported the usefulness of the vanadium oxide composites. V_2O_5/MgO composite is used for photocatalytic degradation of methylene blue [7]. V_2O_5/TiO_2 nanotube arrays [10] and polyaniline/V_2O_5 layer-by-layer electrodes are used for energy storage [11]. Nb/V_2O_5 nanocomposites exhibit improved rate performance and cycling stability in lithium ion batteries [12]. V_2O_5 impregnated on multiwall carbon nanotubes is used in electrochemical supercapacitors [13]. Vanadium/tin mixed oxide plays an active part in the mechanism of hydrocarbon detection and acts as a catalyst in sensor fabrication [14,15]. Vanadium oxide/tin oxide composites were tested as catalysts for the ethane oxidative dehydrogenation, which showed enhanced properties [16]. The SnO_2/V_2O_5 system was used as a binary catalyst to study

* Corresponding author.
E-mail address: geetha.a@ktr.srmuniv.ac.in (G. Arunachalam).

https://doi.org/10.1016/j.apsusc.2018.02.214
0169-4332/

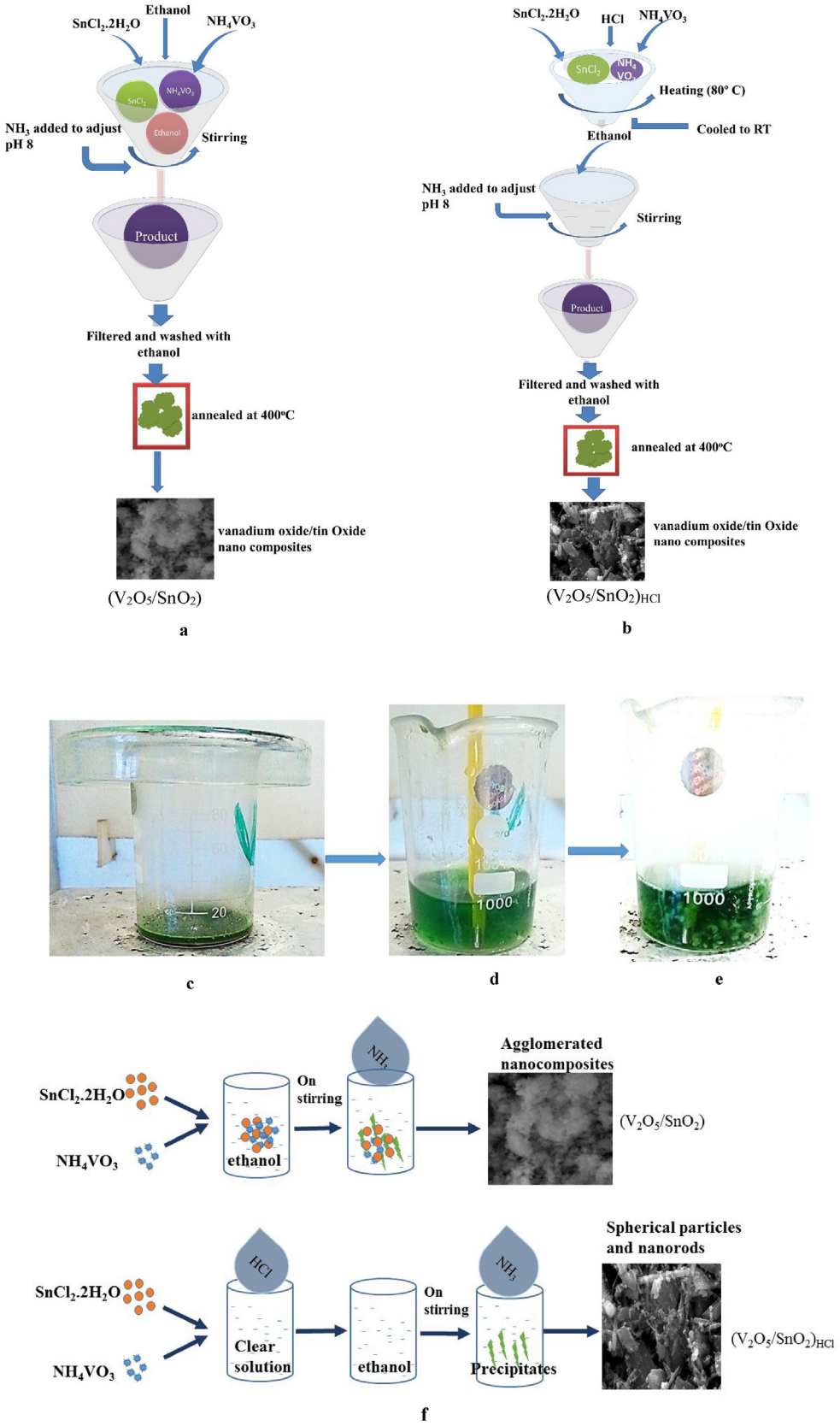

Fig. 1. a. Schematic representation of preparation of the vanadium oxide/tin oxide nanocomposites (V_2O_5/SnO_2) and b. $(V_2O_5/SnO_2)_{HCl}$. c. Shows the clear solution obtained adding HCl in the $SnCl_2 2H_2O$ and NH_4VO_3 precursor material and boiled at 80 °C. d. Shows the precursor ethanol solution containing HCl. e. Shows NH_3 added (HCl + ethanol) solution. f. formation mechanism of V_2O_5/SnO_2 nanocomposites.

Please cite this article in press as: M.P. Subramaniam, et al., Studies on the structural, morphological and optical properties of HCl assisted vanadium oxide/tin oxide nanocomposites prepared by sol-gel method, Appl. Surf. Sci. (2018), https://doi.org/10.1016/j.apsusc.2018.02.214