VOL. 10, NO. 8, MAY 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

APPLICATION OF RENEWABLE ENERGY CONSTANT CURRENT SOURCE IN THE FORMATION OF UNIFORM SURFACED V2O5 NANOBELTS

Josephine R. L.[1], Suja S.[1] and Dhayal Raj A.[2]
[1]Department of Electrical and Electronics Engineering, Coimbatore Institute of Technology, Coimbatore, India
[2]Department of Physics (PG and Research), Sacred Heart College, Vellore, India
E-Mail: josephinedhayal@gmail.com

ABSTRACT

Constant and continuous power is a major problem faced by the young researchers. Though many uninterrupted power supplies (UPS) exists to back up, the problem of power fluctuation during the synthesis has a very predominant effect in the synthesis of Nanomaterials. Herein a renewable energy-constant current source incorporating solar and wind energy has been applied for the preparation of uniform and smooth surfaced V_2O_5 nanobelts by simple hydrothermal method. The prepared nanobelts have been characterized by SEM, XRD, FTIR and TGA. The SEM images show that these nanobelts are with highly uniform surface and of length around 5µm. The XRD pattern shows the high crystalline nature of the prepared nanobelts. The material confirmation of the prepared samples was carried out using FTIR analysis which proved that the resulting nanobelts are vanadium pentoxide. V_2O_5 nanobelts are used as applications in the field of desalination, microelectronics, optoelectronics, sensors, lithium batteries, etc. Hence the resulting nanobelts proved to be successful outcome of material science and renewable technology.

Keywords: V_2O_5 nanobelts, renewable energy, formatting, insert.

1. INTRODUCTION

Interdisciplinary works always has best out comings. Especially combining science and technology has always been an eye-opening in the field of research. In this research an interdisciplinary work combining the engineering research outcome with the material scientists in nanomaterial syhthesis to study the effect of constant current source with negligible variation in power supplied during the material synthesis has been reported. Vanadium pentoxide (V_2O_5) is the most stable crystallization form and is also the most applicable in the industry among vanadium oxide systems such as VO, VO_2 and V_2O_3. Vanadium pentoxide has drawn considerable interest in recent years due to its wide spread applications in the fields of microelectronics [1], solid field emitters [2, 3], Photoconductivity [4], optoelectronics [5], lithium batteries [6], sensors [7, 8], cathode materials [9, 10], thermochromic [11], Cation-Induced Coiling [12], Photochromic [13], etc. The unique features of V_2O_5, such as its orthorhombic layered structure, high electrochemical activity, insertion reaction with lithium, high stability and ease of thin-film formation by numerous deposition techniques, has led to its use as a highly promising material in solid-state applications. Vanadium pentoxide is generally a non-stoichiometric material, which is known for its catalytic properties in oxidation reactions. The crystallite structure of V_2O_5 shows that an orthorhombic unit cell structure belongs to Pmnm space group. The orthorhombic V_2O_5 is usually described as made up of chains of edge sharing V_2O_5 square pyramids. These chains are linked together via corner sharing. It is seen that the optoelectronic properties and other properties of V_2O_5 are highly structure sensitive which in turn can severely influence the device performance. Despite numerous scientific works, new routes of fabrication and the fundamental understanding of these materials are much more essential so that they can be integrated into contemporary and emerging technologies. Therefore, an attempt has been made in our present investigations to prepare V_2O_5 nanowire powders by simple hydrothermal method and to characterize them.

2. METHODS

The experimental part has been divided into two parts. Initial stage involves the designing and construction of constant energy source from renewable energy and the second part is to apply it for the synthesis of V_2O_5 nanobelts and to study its effect on the properties of the material. Two samples of V_2O_5 nanobelts have been synthesized by applying the constant current source from renewable energy and the other by applying ordinary grid supply containing fluctuations.

A. Construction of constant energy source from renewable resource

The typical configuration of the proposed scheme integrating Variable Speed Wind Turbine (VSWT) based Permanent Magnet Synchronous Generator (PMSG) and Photo Voltaic (PV) array is shown in Figure-1. PMSG rating 2.7kW wind turbine @6m/s wind speed is chosen. Solar PV array is installed for 6kW. Hence the overall load Power that can be handled is 8.7kW. Both the input powers are fed to the load through the inverter of rating 10kVA. The proposed model depicts a hybrid renewable energy system deploying Photo Voltaic Array and Wind energy system incorporating with the battery backup. The energy utilization from these power sources varies with various instants of times along the entire day. The solar power from PV system is utilized during day time. The PV system is combined with wind system on a cloudy day and

also during monsoons. The battery power is used during the absence of the both renewables. In case of solar, wind and battery outages and when the battery discharges and reaches the lower limit, the grid supply is utilized to charge the battery and to handle the necessary loads.

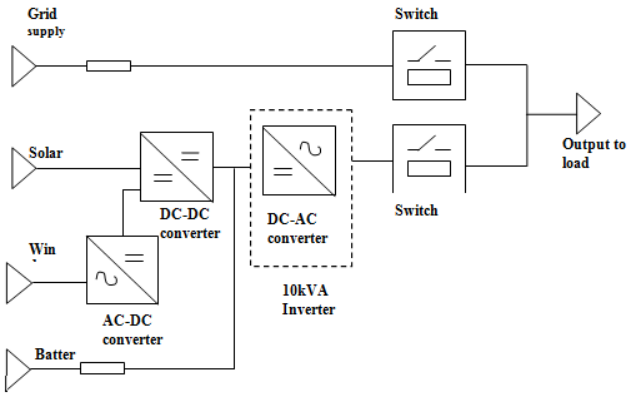

Figure-1. Modeling and control of PMSG WTs and PV Array.

3. SYNTHESIS OF V_2O_5

In a typical synthesis of V_2O_5 nanobelts, 0.1 mol of ammonium metavanadate was taken and adjusted to a pH value of 2 by adding Sulphuric acid (H_2SO_4) drop wise under constant stirring at room temperature. Now the entire reaction mixture was transferred to Teflon lined stainless steel autoclave of 50 ml capacity and ensured that it is packed well. The autoclave was then maintained at a temperature of about 200°C for 24 hours. The precipitate formed at the end of the reaction was separated and washed repeatedly with double distilled water and ethanol to remove the traces of unreacted starting compounds. Finally the precipitate was separated by centrifuging and dried in hot air oven at a temperature of 75°C for 5 hours. The same procedure has been adopted to prepare two samples. Sample A was prepared by applying the constant current source obtained from the renewable energy, by avoiding the fluctuations in the power supply. Sample B was prepared with ordinary current supply with fluctuations and variations. Both the samples have been characterized for their structure, morphology, thermal stability and composition. Thus this work focuses on the importance of constant current source and to study the effect of preparing the samples with and without current fluctuations.

4. RESULTS AND DISCUSSIONS

The Raman scattering spectra for the V_2O_5 nanobelts prepared with and without constant energy source show similar pattern as can be seen in Figure-2.

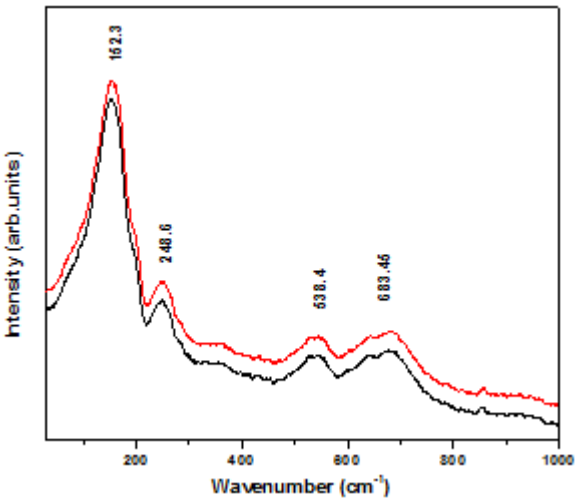

Figure-2. Raman spectrum of V_2O_5 nanobelts a) Sample A and b) Sample B.

The peak around 538 cm^{-1} can be assigned to the triply coordinated oxygen (V_3–O) mode in pure V_2O_5. Which is a strong evidence that the product obtained is in the V_2O_5 phase. The Raman spectrum of Samples show a general broadening of the Raman bands. The spectrum displays a very strong Raman bands observed in the frequency range 200–1000 cm^{-1} corresponding to those expected for polycrystalline V_2O_5. There are 21 modes of vibration possible in the Raman spectrum of orthorhombic V_2O_5 crystal. Internal modes can be described in terms of stretching and bending of V-O bonds. These vibrations of atoms give rise to the high-frequency Raman lines. The lines located at 248, 538 and 683 cm^{-1} can be assigned to the bending vibrations of the O-V bonds, the bridging V-O-V, and the three-coordinated O-V_3 bonds, respectively [14, 15]. The bridging oxygen (O-V_3) corresponds with three-coordinated groups. The modes associated with these (O-V_3) entities have motion parallel and perpendicular to the ab-plane. The broad band at 507 cm^{-1} can be decomposed into two components located at 493 and 516 cm^{-1} which probably trace their origin back to the two peaks at 476 and 525 cm^{-1} in polycrystalline V_2O_5. The peaks observed at 248 cm^{-1} can be related to polycrystalline V_2O_5. The most stable oxygen composition for vanadium oxide is V_2O_5 which obviously has a larger O/V ratio. The prominent peak at 152 cm^{-1} is attributed to a deformation of the bond between different molecular units in the plane of the layers and can be called as skeleton vibration.

The scanning electron microscope was used to examine the shape and morphology of the prepared samples. Figure-3a corresponds to the SEM image of the sample (sample A) prepared by applying the constant current source obtained from the renewable energy. It is clearly seen that smooth surfaced uniform nanobelts having an average diameter of 80nm and have a length of 5 µm have formed.

The formation of nanobelts seems to be complete and very systematic. The SEM image in Figure-3b corresponds to sample B, i.e., the sample prepared with

ordinary power supply with fluctuations. The effect of power fluctuations on the morphology of the sample can be clearly seen. Due to power fluctuations the formation of nanobelts is not complete. Many smaller broken or unformed nanobelts can be seen. The average diameter of the nanobelts as calculated from the SEM images was found to be around 80 nm. However the average length was around 3 µm only. Also some agglomerations due to unreacted precursor compound can be witnessed. Thus it can be concluded that controlled and constant current source during the synthesis of Nanomaterials has a very prominent effect on the properties of the prepared Nanomaterials.

The insert image in Figure-3a shows the XRD pattern of the sample prepared by applying the constant current source obtained from the renewable energy. The well resolved peaks match with JCPDS # 09-0387, confirming the formation of V_2O_5 with a orthorhombic structure. The lattice parameter values of the prepared samples were a=11.51, b=3.559, c=4.371 Å. The insert image in Figure-3b shows the XRD pattern of the sample prepared with ordinary power supply with fluctuations. The average crystallite size as calculated by Scherrer's formula is approximately 40 nm and 23 nm for sample A and sample B respectively.

Figure-4 (a and b) corresponds to the DTA spectra of sample A and sample B. There is an exothermic peak around 370°C which may be due to the phase transformation from VO_2 in to V_2O_5 [7]. The oxidation of VO_2 in to V_2O_5 has occurred around 370°C. Pavasupree *et al.*, have reported similar results [16]. The endothermic peak at 666°C suggests that the melting point for V_2O_5 is at 670°C. This is in agreement with results reported earlier. The DTA spectrum in Figure-4b corresponds to sample B. The spectrum shows one additional endothermic peak at 666°C which may be due to the presence of unreacted precursor compound in the sample .This in turn shows that uninterrupted power source ensures complete reaction and thereby complete formation of vanadium oxide without impurities.

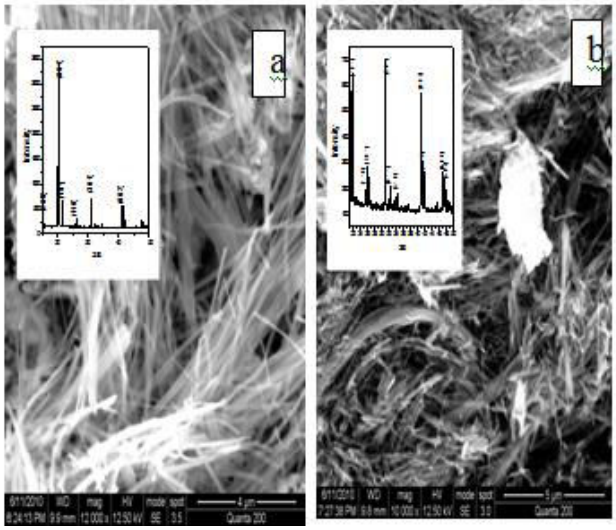

Figure-3. SEM images of V_2O_5 nanobelts a) Sample A and b) Sample B.

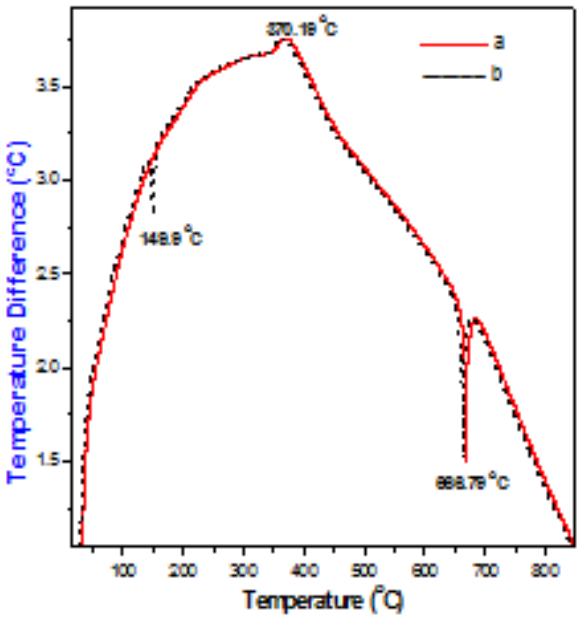

Figure-4. TG/DTA spectrum of V_2O_5 nanobelts (a) sample A and (b) sample B.

5. CONCLUSIONS

The collaboration of material scientist with technologist yielded successful results. Through this work the impact of constant current supply from renewable energy for the synthesis of V_2O_5 nanobelts have been investigated and reported. From the investigations conducted it can be concluded that the application of constant current source from renewable energy has greater impacts on the formation and properties of V_2O_5 nanobelts. The studies revealed that the V_2O_5 nanobelts prepared with constant current sources yielded bundles of smooth surfaced, uniform nanobelts with very good crystallinity. These uniform V_2O_5 nanobelts can be applied

for various applications like desalination, gas sensing, etc., which will be our future focus.

ACKNOWLEDGEMENT

The authors wish to thank All India Council for technical Education (AICTE) in funding this research.

REFERENCES

[1] T. Zhai, H. Liu, H. Li, X. Fang, M. Liao, L. Li, H. Zhou, Y. Koide, Y. Bando, D. Golberg, "Centimeter-Long V_2O_5 Nanowires: From Synthesis to Field-Emission, Electrochemical, Electrical Transport, and Photoconductive Properties" Adv Mater., Vol. 8,pp. 2547-2552, June 2010.

[2] C. Díaz-Guerra, J. Piqueras, "Influence of doping level on the cathode luminescence of Se-doped GaSb crystals" J. Appl. Phys., vol. 102, pp. 084307-084308, December 2007.

[3] W. Chen, C. Zhou, L. Mai, Y. Liu, Y. Qi, Y. Dai , "Field Emission from $V_2O_5 \cdot nH_2O$ Nanorod Arrays" J Phys Chem. C. vol. 112, pp.2262-2265, December 2008.

[4] R. S. Chen, W. C. Wang, C. H. Chan, H. P. Hsu, L. C. Tien, Y. J. Chen, "Photoconductivities in monocrystalline layered V_2O5 nanowires grown by physical vapor deposition" Nanoscale Res. Lett., Vol. 8, pp. 443-451, December 2013.

[5] T. P. Jaya, P. Jayaram, T. Ramachandran, P. Hajira, C. N. Anumol, P. P. Pradyumnan, Physica, "Synthesis of solid solutions of Mn and Bi substituted V_2O_5 and substitutional effect in structural and optoelectronic behavior" Physica B: Condensed Matter, vol.407, pp. 1214-1218, April 2012.

[6] F. Huguenin, E. M. Girotto, M. Torresi, D. A. Buttry, "Xps Study of $V_{1.67}Ti_{0.33}O_{5\pm\Delta} \cdot NH_2O$ Xerogels Intercalated With Hydroquinone", J. Electroanal. Chem., vol.536, pp.37-45, June 2002.

[7] A. Dhayal Raj, T. Pazhanivel, P. Suresh Kumar, D. Mangalaraj, D. Nataraj, N. Ponpandian, "Self assembled V2O5 nanorods for gas sensors", Curr. Appl. Phys., vol. 10, pp. 531-537 March 2010.

[8] Raible I, Burghard M, Schlecht U, Yasuda A, Vossmeyer T, "V_2O_5 nanofibres: novel gas sensors with extremely high sensitivity and selectivity to amines", Sens. Actuators B., vol. 8 730-735, November 2005.

[9] D. W. Su, S. X. Dou, G. X. Wang, "Hierarchical orthorhombic V_2O_5 hollow nanospheres as high performance cathode materials for sodium-ion batteries", J. Mater. Chem. A**,** vol. 2, pp. 11185-11194, May 2014.

[10] D. Pham-Cong, K. Ahn, S.W. Hong, S.Y. Jeong, J.H. Choi, C.H. Doh, J.S. Jin, E.D. Jeong, C.R. Cho, "Cathodic performance of V_2O_5 nanowires and reduced graphene oxide composites for lithium ion batteries" Curr. Appl. Phys., vol.14, pp. 215–221, October 2014.

[11] C. Batista, M. R. Ribeiro, V. Teixeira, "Vanadium oxide thin films synthesized by reactive ion beam sputter deposition: Influence of processing parameters", Nanoscale Res. Lett., vol. 6, pp. 301-308, April 2011.

[12] J. Liu, D. Xue, "Cation-Induced Coiling of Vanadium Pentoxide Nanobelts", Nanoscale Res. Lett. Vol.5, pp. 1619–1626, July 2010.

[13] M. Kang, E. Oh, I. Kim, J. W. Ryu, Y. Kim, "Optical Characteristics of Amorphous V_2O_5 Thin Films Coloured by an Excimer Laser", CURR. APPL. PHYS., vol. 12 pp. 489–493, August 2012.

[14] A. Dhayal Raj, P. Suresh Kumar, Q. Yang , D. Mangalaraj, N. Ponpandian, A. Albert Irudayaraj, "Compositional, microstructural, and vibrational characteristics of synthesized V_2O_5 microspheres with nanorod formation" Journal of Physics and Chemistry of Solids. Vol. 74, pp. 897-901, January 2013.

[15] C. Navone, J.P. Pereira-Ramos, R. Baddour-Hadjean, R. Salot,"Electrochemical and Structural Properties of V_2O_5 Thin Films Prepared by DC Sputtering," J. Power Sources, vol, 146, pp. 327–330, March 2005.

[16] S. Pavasupree, Y. Suzuki, A. Kitiyanan, S. Art, S. Yoshikawa, "Synthesis and characterization of vanadium oxides nanorods", J. Solid State Chem., vol. 178, pp. 2152-2158 April 2005.