International Journal of Scientific and Research Publications, Volume 5, Issue 6, June 2015 1
ISSN 2250-3153

Synthesis and I-V characterization of cuprous oxide nanocomposites

Monica Debbarma and Mitali Saha

Department of Chemistry, National Institute of Technology, Agartala -799046, Tripura, India

Abstract- The present research work is based on the studies of various nanocomposites and their I-V characterization for solar applications. Copper oxide (Cu_2O) were synthesized and used, to prepare nanocomposites using titanium dioxide (TiO_2) and GO. The composites have been synthesized in different ratios by applying simple mechanical stirring followed by ultra sonication. In this work, Cu_2O nanoparticles were prepared under microwave irradiation by our reported method which further used, to prepare copper oxide nanocomposite thin films. The prepared nanocomposites were further characterized using scanning electron microscopy and the current–voltage (I–V) characteristics of the thin films of Cu_2O /TiO_2 and Cu_2O /TiO_2 / GO nanocomposite were investigated. Various characteristics such as fill factor (FF), short circuit current (Isc), open-circuit photo-voltage (V_{OC}), and efficiencies (η) were measured for all the nanocomposites. The efficiencies of various ratios of Cu_2O /TiO_2 and Cu_2O /TiO_2/GO viz. 1:3, 1:1:1, 1:2:1 and 1:3:1 were found to be 1.98%, 1.16%, 1.45% and 1.55% respectively. During investigation it was found that Cu_2O /TiO_2/ GO nanocomposite with the ratio of 1:3 showed better efficiency (η as compared to other ratios.

Index Terms- Cu_2O, TiO_2, GO, nanocomposites, current-Voltage

I. INTRODUCTION

The transition metal oxides are an important class of semiconductors having applications in magnetic storage media, solar energy transformation, electronics, catalysis etc [1, 10]. A rare earth oxide such as TiO2 has been applied widely in many fields. Titanium Oxide is also well known for its optical properties and is a semiconductor with a band gap of 3.95 eV [11-13]. Among various metal nanoparticles, oxides of copper have attracted many researchers and scientists, because of its importance in modern technologies, availability and also due to their optical, catalytic, mechanical and electrical properties [14-16]. The oxides are also of great interest due to their advantages such as non toxicity, abundance, high optical absorption coefficient and low band gap energies [17-19]. These characteristics make them prospective candidates for different applications such as catalysis, semiconductor equipment, solar/photovoltaic energy conversion, gas sensing, luminescence sources field, emission devices, lithium-ion electrode materials and dye-sensitized solar cells [20-23].

Cuprous oxide (Cu2O) is mostly p-type with band gap energy of ~2 eV and have been used as one of the basic material in superconductors . Optical or magnetic characteristics can change the particle sizes to very small dimensions, which are in general of major interest in the area of nanocomposite materials. Composites have excellent properties such as high hardness, high melting point, low density, low coefficient of thermal expansion, high thermal conductivity, good chemical stability and improved mechanical properties such as higher specific strength, better wear resistance and specific modulus and have good potential for various industrial fields [24-26].

Graphene is Carbon material with a one–atom thick and two-dimensional conjugated honeycomb lattice structure increasingly attracting scientists for its special characteristics [27-30]. Graphene oxide is a chemically modified graphene which is an atomically thin sheet of graphite that has traditionally served as a precursor for graphene [19]. Graphene, a single sheet composed of sp2 hybridized carbon, has drawn great attention owing to its outstanding electronic, optical, thermal and mechanical properties. Due to its unique and superior optical and electronic properties, much attention is focused on its application in the field of photovoltaic cells applications. Potential application of Graphene Oxide and its reduced forms have an extremely high surface area; because of this, these materials are under consideration for usage in photovoltaic cells [31].

In this paper, we have prepared nanocomposites of Cu_2O with TiO_2 and GO, taking different ratios viz. 1:3, 1:1:1, 1:2:1 and 1:3:1, via mechanical stirring and ultra-sonication methods and studied their current-voltage performances.

II. MATERIALS AND METHODS

2.1 Preparation of Cu2O/TiO2 nanocomposites

The prepared Cu_2O nanoparticles and TiO_2 were taken in 1:3 ratio in water and was mixed with small amount of polystyrene in dichloroethane. The solution was then subjected to mechanical stirring for 3-4 hours, followed by sonication for 2 hours. Thin film of Cu_2O/TiO_2 nanocomposite was prepared using reported doctor blade method and the thickness of the film was found to be of around 1 µm.

2.2 Preparation of Cu2O/TiO2/GO nanocomposites

The Cu2O nanoparticles, TiO2 and GO were taken in different ratios of 1:1:1, 1:2:1 and 1:3:1, respectively, in water and mixed with small amount of polystyrene in dichloroethane. The solution was first mechanical stirred for 3-4 hours and then sonicated for 2 hours. The volume of the water was removed by evaporation and finally kept for drying in hot air oven for 24 hours. Thin films of Cu_2O/TiO_2/GO nanocomposite were then prepared using reported doctor blade method. The thickness of the films were found to be of around 1 µm.

III. CURRENT-VOLTAGE PERFORMANCES OF CU2O/TIO2 AND CU2O/TIO2/GO NANOCOMPOSITES

The photovoltaic measurements of thin films of 1:3, 1:1:1, 1:2:1 and 1:3:1 ratio of Cu_2O/TiO_2 and Cu2O/TiO2/GO nanocomposites, respectively were carried out using a solar simulator with an irradiance of 100 mWcm−2. The current–voltage characteristics of the cell was measured by applying external potential bias to the cell and measuring the generated photocurrent. The monochromator was incremented through the visible spectrum to generate the incident photon to current conversion efficiency (PCE). Parameters such as fill factor (FF), short circuit photocurrent (I_{SC}), open-circuit photovoltage (V_{OC}), and efficiency (η) were measured for both Cu_2O/TiO_2 and Cu_2O/TiO_2/GO nanocomposites.

IV. RESULTS AND DISCUSSION

4.1 Current-voltage (I-V) analysis

The I-V characteristics of the nanocomposites of 1:3, 1:1:1, 1:2:1 and 1:3:1 ratios of Cu_2O/TiO_2 and Cu_2O/TiO_2/GO were determined and the measured UV-illuminated I–V characteristics were shown in Figs. 1 a, b, c and d respectively. Thin film of Cu_2O/TiO_2 of 1:3 ratio as shown in fig.1a gave the FF value of 0.535, Isc of 7.5, Voc value of 0.265 and η value of 1.98%. Fig. 1b shows the I-V curve of 1:1:1 ratio of Cu_2O/TiO_2/GO and the value of FF, Isc and Voc were found to be 0.513, 5.08 and 0.230 respectively and the calculated efficiency increased upto 1.16% %. Efficiencies of Cu_2O/TiO_2/GO of 1:2:1 and 1:3:1 were also investigated. The values of FF was found to be 0.51 and 0.52, respectively. Isc of 5.29 and 5.57, Voc value of 0.275 and 0.280 and efficiencies (η) of 1.45% and 1.55% respectively (fig.1 c and d). The increase and then decrease of the efficiency may due to presence of graphene oxide. Depending upon the conditions, the results may have varied. As the ratio of the titanium oxide increases the efficiencies also increases keeping the quantity of the GO same in all the mixtures.Since GO is insulator,it may have less effect in conductivity.

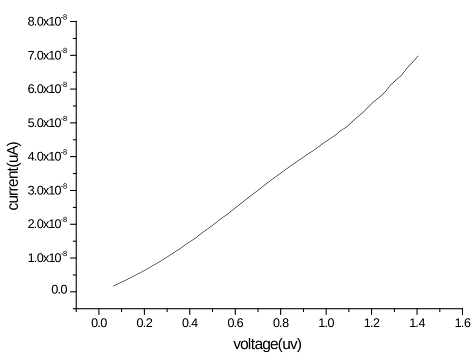

Figure 1a: I-V curve of 1:3 ratio of Cu2O:TiO2

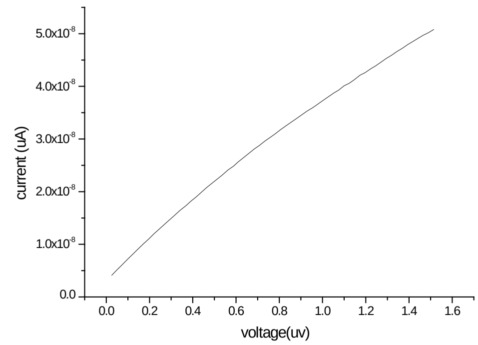

Figure 1b: I-V curve of 1:1:1 ratio of Cu2O:TiO2:GO

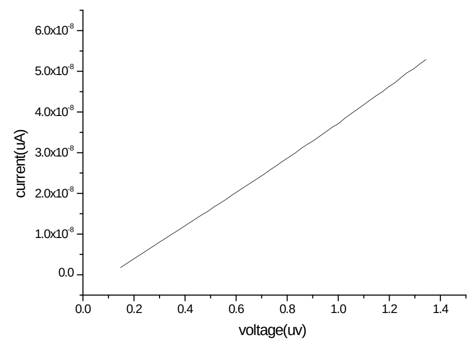

Figure 1c: I-V curve of 1:2:1ratio of $Cu_2O:TiO_2$: GO

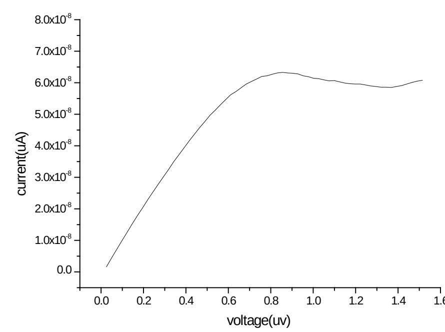

Fig 1d: I-V curve of 1:3:1 ratio of Cu_2O/TiO_2/GO

4.2 SEM analysis

The SEM image of flower shaped aggregates of Cu_2O nanoparticles, where the size of the particles were found to be below 50 nm as shown in fig.2. Similarly 1:3 and 1:3:1 ratio of Cu_2O/TiO_2 and Cu_2O/TiO_2/GO nanocomposites shown in Figs 3a and 3b indicated the presence of Cu_2O nanoparticles on the surface of thin films.

ISSN 2250-3153

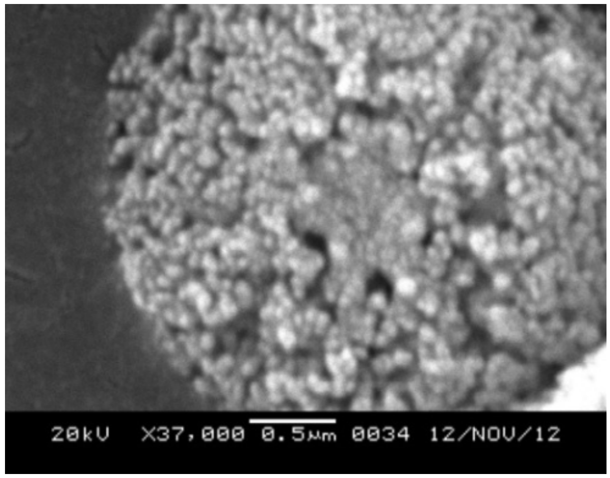

Fig.2: SEM of Cu_2O nanoparticles

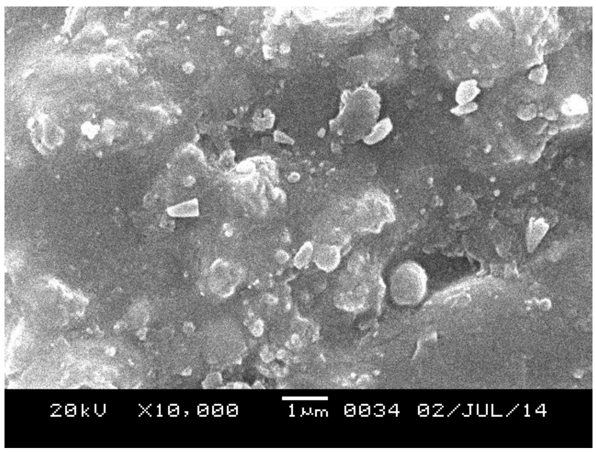

Fig. 3a: SEM of 1:3:1 ratio of Cu_2O/TiO_2/GO nanocomposite

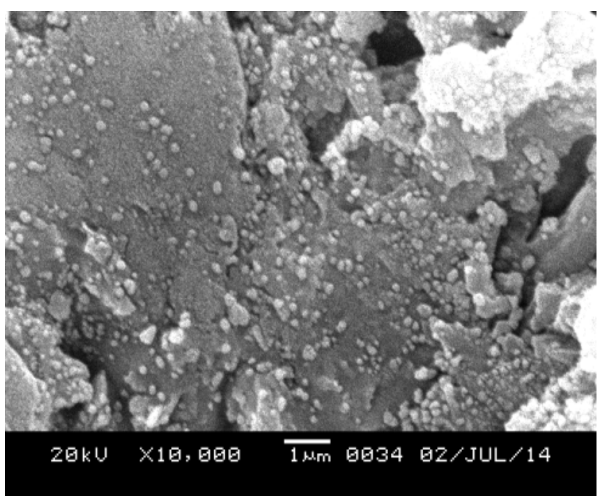

Fig. 3b: SEM of 1:3:1 ratio of Cu_2O/TiO_2/GO nanocomposite

V. CONCLUSIONS

For the first time, nanocomposites of Cu_2O with TiO_2 and GO have been synthesized in different ratios using simple method of mechanical stirring and ultra sonication. The structural and electrical properties of thin films of Cu_2O nanocomposites have been investigated and were found to be influenced by the ratios of the materials doped. The more titanium oxide is used ,the better the conductivity. Graphene oxide was used to see the variations and its effect in electrical conducticity ,although they are insulators. The 1:3 ratio of Cu_2O with TiO_2 have efficiency value of 1.98%. After doping of GO, the ratios of Cu_2O/TiO_2/GO exhibited efficiencies but low compaired with 1:3 ratio of Cu_2O /TiO_2.

ACKNOWLEDGEMENT

Authors express their gratitude to the Director, National Institute of Technology, Agartala to allow for publishing the results. SEM analysis from Tezpur university and NEHU, Shillong are greatly acknowledged.

REFERENCES

[1] X.G. Zheng, C.N. Xu, Y. Tomokiyo , E. Tanaka, H. Yamada and Y. Soejima, Phys. Rev. Lett. ,2000,pp. 5170.
[2] A.E. Rakhshni, Solid State Electron,1986 pp.7.
[3] O. Regan, M. Gratzel, Nature, 1991, pp.737.
[4] K. Naazeeruddin, A. Kay, M. Gratzel, J. Am. Chem. Soc. 1993, pp. 6832.
[5] U. Bjoerksten, J. Moser, M. Gratzel, Chem. Mater. 1994, pp.858.
[6] F. Parmigiani and G. Samoggia, Europhys. Lett., 1988, pp. 543.
[7] E. Borrodo, F., Prieto, J, Madina, F, A,Lapoz , J.Alloys.Comp.,2002,pp. 203
[8] Sanjay Kumar, Ashwani Sharma, M.Singh, Pooja Dhimen, R.K.Kotnala, Nano Vision 2011,pp.101-114
[9] Ashwani Sharma, Pallavi, Sanjay Kumar , Nanoscience and nanotechnology.20 l2 ,pp.82-85.
[10]
[11] Ashwani Sharma, Pallavi, Sanjay Kumar and Sonia, Archives of Applied Science Research . 2012,pp.2557 -2563
[12] Qing Hua1, Fucheng Shi1, Kai Chen, Sujie Chang, Yunsheng Ma, Zhiquan Jiang, Guoqiang Pan, and Weixin Huang, Nano Res. 2011,pp. 948–962
[13] M. J. G. Pacheo, J. E Morales-Sanchz, J. Gernandez and F. Ruiz,Material Letters,2010,pp. 1361-1364
[14] Y. Xi, C. Hu, P. Gao, R. Yang, X. E., X. Wang and B Wan, (2010) Material Science and Engineering B.2010, pp. 113-117
[15] Y. He, Materical Research Bull. 2007, pp.190-195.
[16] A.S. Lanje, R.S. Ningthoujam, S.J. Shrama, R.K. Vatsa, R.B. Pode, Int. J. Nanotechnol. 2010 pp.79
[17] E.P. Wolhfarth., Ferromagnetic Materials, Vol. II, North-Holland, Amsterdam, New York, Oxford, Tokyo, 1980.
[18] T. Mitsuyu, O. Yamakazi, K. Ohji, K. Wasa, Ferroelectrics. 1982,pp.233.
[19] O. Regan, M. Gratzel, Nature . 1991,pp.737.
[20] K. Naazeeruddin, A. Kay, M. Gratzel, J. Am. Chem. Soc. 1993, pp. 6832.
[21] U. Bjoerksten, J. Moser, M. Gratzel, Chem. Mater.,1994, pp. 858.
[22] W.P. Dow, T.J. Huang, J. Catal., 1996, pp. 171.
[23] P.O. Larsson, A. Andersson, R.L. Wallengerg, B. Svensson, J. Catal. 1996, pp. 279.
[24] Y. Jiang, S. Decker, C. Mohs, K.J. Klabunde, J. Catal.1998, pp. 24.
[25] Omar H. Abd-Elkader and N. M. Deraz, Int. J. Electrochem. Sci. 2013,pp. 8614 – 8622.
[26] J. T. Chen, F. Zhang, J.Wang, G.A. Zhang, B.B. Miao, X.Y. Fan, D. Yan, P.X. Yan, J. Alloys Compds. 2008, pp. 268.
[27] A. K. Geim and K. S. Novoselov, “The rise of Graphene,” Nat. Materials.2007,pp.183.
[28] A. Reina, X. Jia, J. Ho, D. Nezich, H. Son, V. Bulovic, M. S. Dresselhaus, and J. Kong, “Large Area Few layer Graphene films on Arbitrary Substrate by Chemical Vapor Deposition,” Nano Lett. 2009, pp. 30.
[29] L. J. Cote, F. Kim, and J. X. Huang, “Langmuir-Blodgett Assembly of Graphene Oxide single layer,” J. Am. Chem. Soc. 2009,pp. 1043.
[30] A. Lerf, H. He, M. Forster, and J. Klinowski, J. Phys. Chem.1998, pp. 4477-4482.
[31] Y.-W. Zhu, S. Murali, W.-W. Cai, X.-S. Li, J. W. Suk, J. R. Potts, and R. S. Ruoff, “Graphene and Graphene Oxide: Synthesis, Properties, and Applications,” Ad-vanced Materials 2010,pp. 3906.
[32] Hummers Jr WS, Offeman RE.“ Preparation of Graphitic Oxide”. J Am Chem Soc. 1958, pp. 1339–1339.
[33] M. Debbarma and M. Saha, Journal of Materials Science & Surface Engineering.2014, pp.49-51.

AUTHORS

First Author – Monica Debbarma, Department of Chemistry, National Institute of Technology, Agartala -799046, Tripura, India, db.moni@gmail.com , Contact: +8794664263
Second Author – Mitali Saha, Department of Chemistry, National Institute of Technology, Agartala -799046, Tripura, India