Effect of Dilution on Thermovoltage Generation using Homeopathic Nanomedicine *Zincum Oxydatum*

Poonam Bandyopadhyay[1,2], Papiya Nandy[2] , Ruma Basu[2,3], Durga Sankar Dhar[2], Sukhen Das[1,2,4*]
[1]Physics Department, Jadavpur University, Kolkata, India 700 032
[2]Centre for Interdisciplinary Research and Education, Kolkata, India 700 068
[3]Physics Department, Jogamaya Devi College, Kolkata, India 700 026
[4]Indian Institute of Engineering Science and Technology, Howrah, India 711103
*Corresponding author: Dr. Sukhen Das, e-mail: sukhendasju@gmail.com

Abstract— **Utilization of alternate energy sources has become a matter of great concern in a rapidly industrializing world. In this endeavor different materials are synthesized and utilized in a variety of systems which are being continuously improvised in order to get higher efficiency values. As a new and novel addition we have utilized here for the first time a well-known homeopathic medicine, Zincum oxydatum as an agent for thermovoltage generation. We have shown that this drug can generate thermovoltage and the magnitude increases with the potency of the drug as well as temperature. Using a very specially designed electrochemical cell, we have been able to obtain energy conversion efficiency of 0.39% for 30C potency of the drug, when the temperature is maintained at 40^{o}C. Using synthesized ZnO nanoparticles under similar conditions, the efficiency of the cell was reported to be 0.37%.**

Keywords- ***Zincum oxydatum*****; nanomedicine; thermovoltage; efficiency**

I. INTRODUCTION

The increasing demand of energy in our modern lifestyle along with exhaustion of fossil fuels and negative impact of conventional energy sources, force us to seek environmentally clean alternative source of which solar energy is the most abundant one. In recent era, many new techniques and different materials have been developed to achieve maximum utilization of solar energy [1].

In search of newer materials for efficient conversion of solar energy into electrical energy, several nanomaterials have been engineered and their properties have been characterized. These nanomaterials have the potential to higher solar energy conversion efficiencies, providing incentive for designing new and more effective light energy harvesting devices [2-8]. An important issue in selection of new materials is the band gap of the material. Minimum energy for optical absorption by silicon of example is 1.1 eV, which can therefoe absorb the entire visible spectrum and a part of the near infrared. So in the earlier devices, stress was given to convert UV-Visible light to electrical energy. However direct thermal-electrical energy conversion via thermoelectricity is coming up, using suitable materials, where heat from different sources such as solar heat, geothermal heat, or the exhaust gases of automobiles are being directly converted into electricity.

While looking for nanomaterials we hit upon a very novel idea of using for the first time, the well known homeopathic medicines. The fact that the potency of these medicines increase with dilution followed by succussion (together termed as potentization) has thrown challenge to the scientific community at large. It was later proved from experimental evidences that the size of the constituent materials decrease with increase in potency, achieving a nano dimension [9-14].

In our earlier work, for converting heat energy to electrical energy, ZnO has proved to be a very suitable material [15] because of its special physico-chemical properties [16-18]. In the present unique venture of ours, we chose *Zincum oxydatum*, a well known homeopathic medicine as the agent for thermovoltage generation. As the basic requirement of any solar to electrical conversion system is obviously the absorption of a significant part of the incident radiation, our study of thermovoltage generation using *Zincum oxydatum* at different potencies shows that both thermovoltage generation and efficiency of the cell increases with increase in potency at a specific temperature, as the aspect ratio of the drug particles increases with the potency. The efficiency of the thermovoltage cell containing this medicine at potency 30C and temperature 40^{o}C is comparable (0.39%) to the one using synthesized ZnO nanoparticles (0.37%), as reported earlier [15].

II. MATERIAL & METHODS

A. Materials

Freshly prepared two potencies (6C and 30C) of homeopathic medicine *Zincum oxydatum* were obtained from Hahnemann Publishing Company, India and were used without further purification. HCl was purchased from Merck, India. Deionsed water has been used for dilution of the acid.

B. Methods

Thermovoltage generation was recorded for both potency 6C and 30C at $40^{o}C$ in a specially devised electrochemical cell, kept in a temperature controled chamber [15]. The two arms of the U-shaped glass cell were separated by a platinum foil barrier. Two platinum electrodes were placed symmetrically on two sides of the barrier. Diluted hydrochloric acid (0.1 N) was poured in one arm of the cell and the medicine of specific potency in ethanol was poured in the other arm. The variation of generated voltages and currents were measured by means of Keithley digital multimeter (DM196). The best result was obtained for 30C potency of *Zincum oxydatum* and all further experiments were performed with this potency only.

III. CHARACTERIZATION

The homeomedicines have been examined with Dynamic Light Scattering technique (DLS) and Field Emmision Scanning Electron Microscopy (FESEM) for particle size and morphology respectively.

A. Dynamic Light Scattering (DLS) measurement

The sample was examined using a Zetasizer Nano ZS (Malvern Instruments, Malvern UK) light scattering system.

B. Field Emission Scanning Electron Microscopy (FESEM)

The morphology of the sample was examined with Field Emission Scanning Electron Microscopy (FESEM) (Model. FEI- Inspect F50).

IV. RESULT & DISCISSION

From the DLS measurement, the hydrodynamic diameter was estimated ~ 5nm from the average of at least three measurements at $25^{o}C$ (Fig.1).

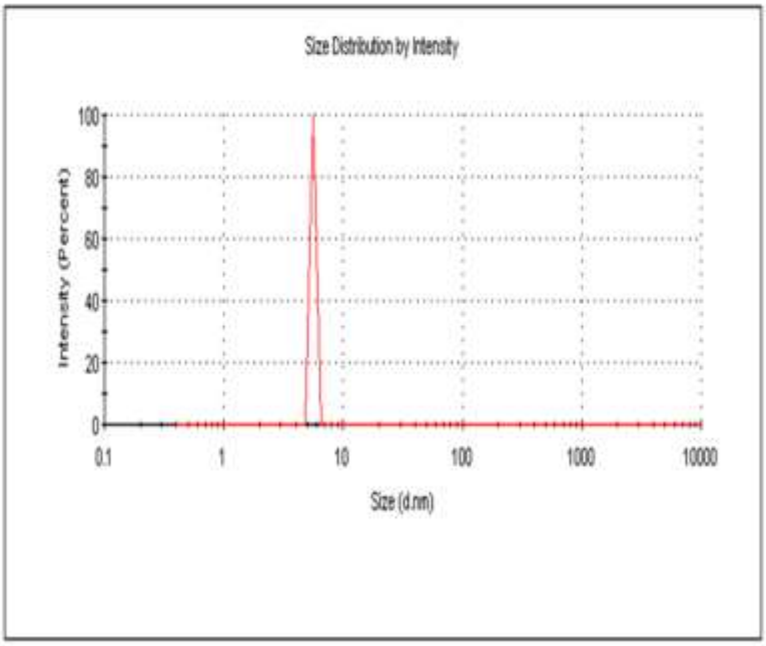

Figure 1. Particle size distribution from DLS of the *Zincum oxydatum* of potency 30C.

Particle size and morphology of the sample was determined by using FESEM micrographs (Fig.2), which indicated that the sample was almost regular spherical in shape and the particle size was slightly higher than that measured by DLS. This perhaps due to the fact that during preparation for FESEM, agglomeration takes place, causing the increase in the particle size with respect to the ones as in the case of DLS.

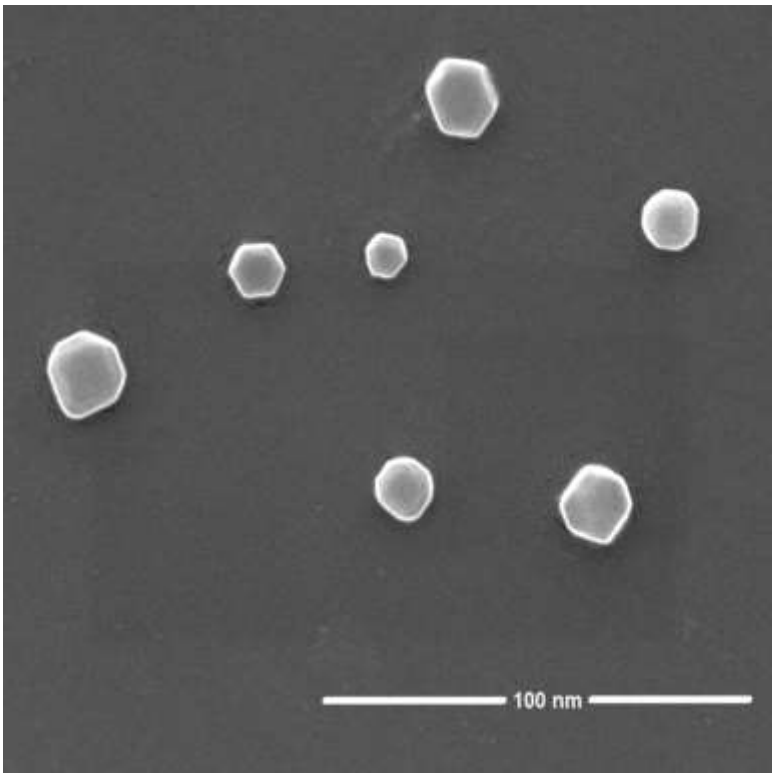

Figure 2. FESEM image of the nanomedinecine *Zincum oxydatum* of potency 30C.

Fig. 3 shows the heat induced voltage generation for *Zincum oxydatum* both potency 6C and 30C at 40^{o}C. The maximum values of thermovoltage (V_{oc}) for 6C and for 30C were 168.1 mV and 325.8 mV respectively.

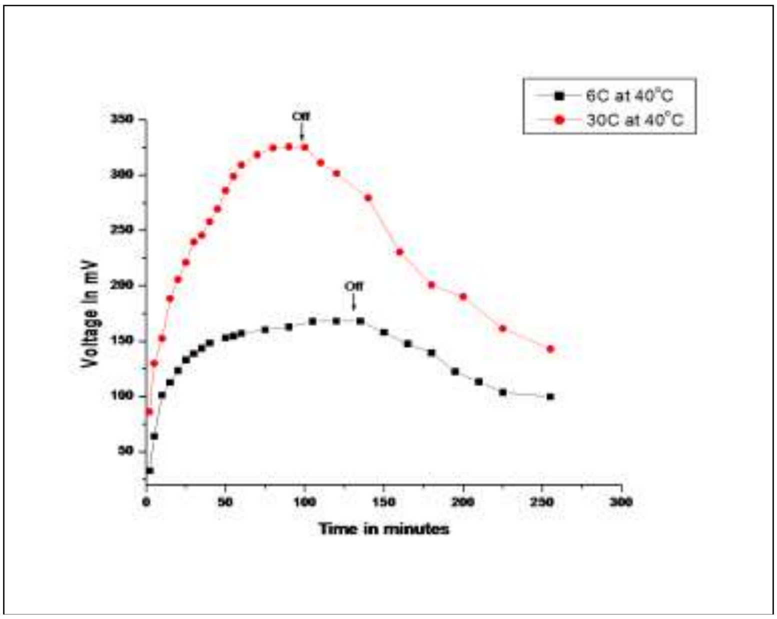

Figure 3. Growth and decay curve of V_{oc} (thermoovoltage) generation using platinum barrier for the *Zincum oxydatum* of potency 30C.

In both the cases, voltage generation started rising with time and reached a maximum saturation value and remained constant at that value. When the source was switched off the voltage decreased slowly. Result shows that the medicine at 30C potency gave the best result in the study as far as the maximum voltage generated and growth times are concerned. So other parameters like Current (I_{sc}), fill factor (FF) and energy conversion efficiency (η%) f the cell were calculated only for that potency using the following equations:

$$FF = \frac{V_{pp} \times I_{pp}}{V_{oc} \times I_{sc}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots. (1)$$

and $$\eta\% = \frac{V_{oc} \times I_{sc} \times FF}{\text{Input heat energy}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

where V_{oc} = open circuit voltage, I_{sc} =short circuit current, V_{pp} = voltage at power point, I_{pp} = current at power point. The maximum power point was obtained by plotting the V–I curve and choosing the values of I and V which gave the largest area under the V–I curve. I_{pp} and V_{pp} were the current and voltage corresponding to the maximum power point (Fig.4).

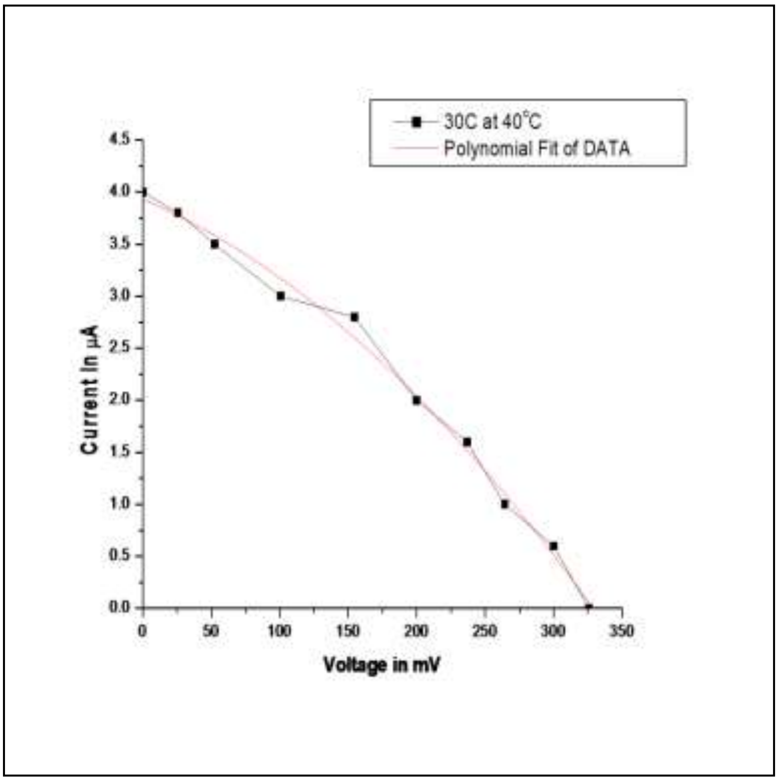

Figure 4. Current versus voltage characteristic curves for the *Zincum oxydatum* of potency 30C at 40°C using platinum barrier.

Details of the results have been shown in Table 1.

TABLE I.

THE CHARACTERICTICS OF EC CELL CONTAINING *ZINCUM OXYDATUM* OF POTENCY 30C

Sample used	Table Diferrent Parametres				
	Peak value of thermovoltage in mV	***Short circuit current in µA***	***Growth duration in minutes***	***Fill factor***	***Efficiency (η%)***
Zincum Oxydatum of 30C potency	325.8	4	90	0.33	0.39

The upper limit of temperature was chosen at 40^{o}C as the solvent evaporates at higher temperature and the system gets damaged. The thermovotlage generation cycle was reproducible. Maximum energy conversion efficiency (η%) calculated for potency 30C at 40^{o}C was 0.39%. In our earlier work on thermovoltage generation with synthesized ZnO nanoparticles, the efficiency was 0.37% at 40^0 C using the same experimental arrangement [15].

We propose that as in case of our previous work [15], A possible explanation for the observed effect lies in the fact that the homeopathic medicine *Zincum Oxydatum,* acts as an n-type semiconductor and can function both as an electron acceptor as well as an electron donor [19]. The carrier concentration increases when the system gets thermally excited. Charge separation takes place when the electrons are transferred from the side containing the nanoparticle of *Zincum Oxydatum* through the platinum barrier to the side containing HCl. This gives rise to the observed voltage difference.

CONCLUSION

In our present study, we have shown that *Zincum oxydatum,* a well known homeopathic medicine, can serve as a potential energy harvesting material. Our study of thermovoltage generation using *Zincum oxydatum* at different potencies shows that both thermovoltage generation and efficiency of the cell increases with increase in potency, as the aspect ratio of the drug particles increases with potency. The maximum magnitudes of generated thermovoltage (Voc) for 6C and for 30C were 168.1 mV and 325.8 mV respectively. The efficiency for potency 30C and temperature 40 ^{0}C is comparable (0.39%) to the one using synthesized ZnO nanoparticles (0.37%).
Thus since the inception of homeopathic medicine about two hundred years ago, we have put these nanomedicinal particles into technical application. In this way we have been able to connect an important, old unquantifiable effect with the latest quantifiable technology and opened up an era of application with unending possibilities.
Energy is never destroyed during a process; it changes from one form to another. A lot of heat energy gets wasted in industry. Exergy (Greek *ex* and *ergon* meaning "from work) is the energy that is available to be used. The ideal case will be to convert all the extra heat energy into electrical energy and increase exergy to maximum.
Our future plan is to improvise thermovoltage cells using different materials by trial and error and use the cell where excess heat energy as a byproduct of industries is available and convert it into electrical energy. Emphasis should be given to maximize exergy so that all the excess heat energy gets utilized. Also the geometry of the thermovoltaic cell should be modified from the laboratory model to an industrial scale model.

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REFERENCES

[1] P. V. Kamat, "Meeting the Clean Energy Demand: Nanostructure Architectures for Solar Energy Conversion", J. Phys. Chem. C, vol. 111, pp. 2834-60, 2007.
[2] U. Bach, D. Lupo, P. Comte, J.E. Moser, F. Weissortel, J. Salbeck, H. Spreitzer, and M. Gratzel, "Solid-state dye-sensitized mesoporous TiO_2 solar cells with high photon-to electron conversion efficiencies", Nature, vol. 395, pp. 583-585, 1998.
[3] V. Cauda, D. Pigliese, N. Garino, A. Sacco, S. Bianco, F. Bella, A. Lamberti, and C. Gerbaldi, "Multi-functional energy conversion and storage electrodes using flower-like zinc oxide nanostructures", Energy, vol. 65, pp. 639-646, 2014.
[4] S. Chappel, A. Zaban, "Nanoporous SnO_2 electrodes for dye-sensitized solar cells: improved cell performance by the synthesis of 18nm SnO_2 colloids", Sol. Energ. Mater. & Sol. Cells, vol. 71, pp. 141-152, 2002.
[5] M. Aklalouch, A. Calleja, X. Granados, S. Ricart, V. Boffa, F. Ricci, T. Puig, and X. Obradors, "Hybrid sol–gel layers containing CeO_2 nanoparticles as UV-protection of plastic lenses for concentrated photovoltaics", Sol. Energ. Mater. & Sol. Cells, vol. 120, pp. 175-182, 2014.
[6] Z. Liu, S. Seo, and E-C. Lee, "Improvement of power conversion efficiencies in Cr_2O_3-nanoparticle-embedded polymer solar cells", Appl. Phys. Lett., vol. 103, pp. 133306 (1-5), 2013.
[7] M. Notarianni, K. Vernon, A. Chou, M. Aljada, J. Liu, and N. Motta, "Plasmonic effect of gold nanoparticles in organic solar cells", Sol. Energ., vol. 106, pp. 23-37, 2014.

[8] B.V.K. Naidu, J.S. Park, S.C. Kim, S-M. Park, E-J. Lee, K-J. Yoon, S.J. Lee, J.W. Lee, Y-S. Gal, and S-H. Jin, "Novel hybrid polymer photovoltaics made by generating silver nanoparticles in polymer: fullerene bulk-heterojunction structures", Sol. Energ. Mater. & Sol. Cells, vol. 92, pp. 397-401, 2008.
[9] S. Bhandary, R. Basu, S. Das, and P. Nandy, "Effect of aconitum napellus on liposomal microviscosity", Int. J. of Emerg. Technol. in Sci. and Eng., vol. 3, pp. 1-5, 2011.
[10] P. Nandy, S. Bhandary, S. Das, R. Basu, and S. Bhattacharya, "Nanoparticle and membrane anisotropy", Homeopathy, vol. 100, pp. 194, 2011.
[11] S. Ghosh, M. Chakraborty, S. Das, R. Basu, and P. Nandy, "Effect of Different Potencies of Nanomedicine Cuprum metallicum on Membrane Fluidity – a Biophysical Study", American J. Homeopathic medicine, vol. 107, pp. 161-169, 2014.
[12] P.S. Chikramane, A.K. Suresh, J.R. Bellare, and S.G. Kane, "Extreme homeopathic dilution retain starting materials: A nanoparticulate perspective", Homeopathy, vol. 99, pp. 231-242, 2010.
[13] R.P. Upadhyay, C. Nayak, "Homeopathy emerging as nanomedicine", Int. J. High Dilution Res., vol. 10, pp. 299-310, 2011.
[14] P.S. Chikramane, D. Kalita, A.K. Suresh, S.G. Kane, and J.R. Bellare, "Why extreme dilution reach non-zero asymptotes: A nanoparticulate hypothesis based on Froth Flotation", Langmuir, vol. 28, pp. 15864-15875, 2012.
[15] A. Mondal, R. Basu, S. Das, and P. Nandy, "Heat induced voltage generation in electrochemical cell containing zinc oxide nanoparticles", Energy, vol. 35, pp. 2160-2163, 2010.
[16] P. Suri, M. Panwar, and R.M. Mehra, "Photovoltaic performance of dye-sensitized ZnO solar cell based on Eosin-Y photosensitizer", Mater. Sci. –Poland, vol. 25, pp. 137-144, 2007.
[17] Y. Lin, D. Wang, Q. Zhao, M. Yang, and Q. Zhang, "A study of quantum confinement properties of photogenerated charges in ZnO nanoparticles by surface photovoltage spectroscopy", J. Phys. Chem. B, vol. 108, pp. 3202-3206, 2004.
[18] T.P. Chou, Q. Zhang, G.E. Fryxell, and G. Cao, "Hierarchically structured ZnO film for dye- sensitized solar cells with enhanced energy conversion efficiency", Adv. Mater., vol. 19, pp. 2588-2592, 2007.
[19] Y. Ozgur, I. Alivov, C. Liu, A. Teke, M.A. Reshchikov, and S. Dogan, "A comprehensive review of ZnO materials and devices", J. Appl. Phys., vol. 98, pp. 041301, 2005.