



RESEARCH ARTICLE

TECHNOHOMEOPATHY, THE SCIENCE OF APPLICATION OF HOMEOPATHY IN TECHNOLOGY – A SHORT REVIEW

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ABSTRACT

It has been established earlier that at higher potency homeopathic drug aggregates achieve nanodimension. For the first time we have utilized this nanoparticle aspect of homeopathic drug in various technical applications, giving birth to the science of Technohomeopathy. We have shown that the thermo- and photo- voltage generation gets enhanced in presence of the homeopathic medicine, triturated *Zincum oxydatum*- thus making itself an agent for efficient solar energy conversion. Similarly incorporation of the homeopathic medicines *Cuprum metallicum* (triturated Cu) and *Cobaltum metallicum* (triturated Co) in a polymer PVDF, which is commonly used as filler material for capacitors in electronic industry, enhances the electrical properties.

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INTRODUCTION

Because of its negligible side effects, low cost, easy availability and easier applicability, homeopathic medicines have been used universally for more than 200 years. The molecular basis of the medicinal action of the drug at very high potency, which is dilution, followed by vigorous shaking (succussion), has been a subject of controversy as the possibility of existence of any starting material at high dilution can be ruled out. This leads to various complicated theories which remain to be confirmed. In order to explain why this process increases the potency of homeopathic medicines, we realized that a large amount of mechanical energy is transferred to the system during succussion. This in all probability causes the size reduction of the original aggregated drug particles to nanodimension (Nandy, 2015). Using two different kinds of homeopathic medicines of hydrophobic and hydrophilic nature, we have shown that the liposomal membrane anisotropy gets modulated with the potency, thereby indicating facilitated

permeation of potentised drugs through the membrane (Nandy *et al.*, 2011; Ghosh *et al.*, 2014; Bhandary *et al.*, 2011). Later, experimental evidence of formation of nanoparticle at higher potency was reported by us which was supported by several other research groups and thus the nanoparticle aspect of homeopathic medicine was firmly established (Kar *et al.*, 2015; Chikramane *et al.*, 2012; Chikramane *et al.*, 2010; Upadhyay and Nayak, 2011). For the first time we have taken this property of nanoparticle formation of homeopathic medicine one step further, by utilizing them in the following technological applications.

(A) Homoeopathic medicine *Zincum oxydatum* used as an agent for enhancement of thermo- and photo- voltage generation

Harnessing solar energy using inexpensive techniques is an important challenge, and newer concepts, newer materials are being developed for solar to electrical energy conversion. In search of such newer materials for efficient conversion of solar energy into electrical energy, several nanomaterials have been engineered (Kamat, 2007). The invention of nanoparticles,

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which possess the unique chemical and physical properties with size and shape variations, has a strong impact in photovoltaic technology as they can facilitate the conversion process of solar energy to electrical energy. While searching for novel suitable materials, the idea of utilization of the nanoparticle aspect of the homeopathic medicine *Zincum oxydatum*, (triturated ZnO) was hit upon by us (Bandyopadhyay et al., 2010). Field emission scanning electron microscopy image shows the morphology of the medicine (Fig. 1).

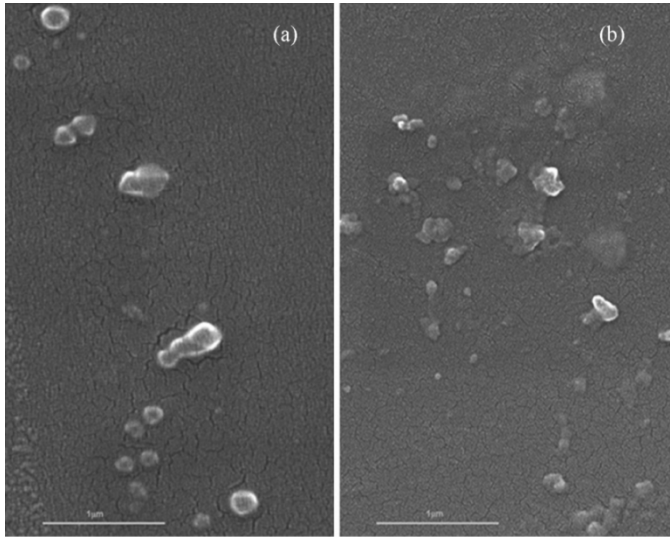


Fig.1 FFESEM image of *Zincum oxydatum* (a) 6C potency and (b) 30C potency. Measured average values of sizes of *Zincum oxydatum* nano particles for 6C and 30 C potency are 83.1 nm and 11.01 nm respectively (Nandy, 2015)

A specially devised electrochemical (EC) cell was used for the study of thermo- and photovoltage generation is shown Fig.2

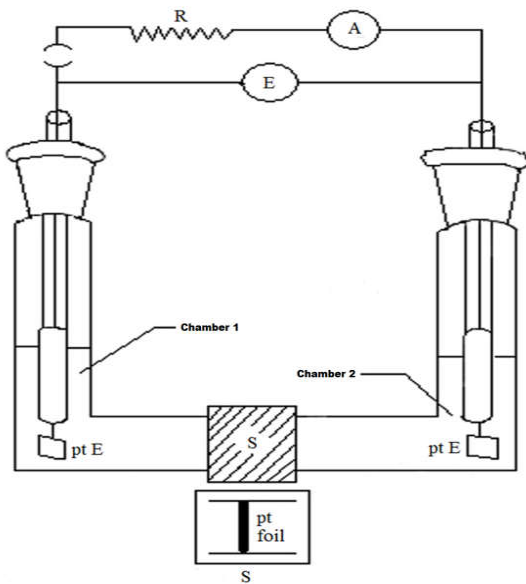


Fig.2. The electrochemical cell used for the experiments for solar energy conversion (thermo and photo voltage generation)

Dimension of the Cell :

- Diameter of the connecting tube: 1.27 cm (d_1)
- Diameter of each arm : 1.83 cm (d_2)
- Length of each arm : 11.0 cm (l_1)

Length of the connecting tube : 3.4 cm (l_2)

Dimension of the rectangular platinum electrode:

- Length : 5.8 mm
- Width : 4.9 mm
- Thickness: 0.27 mm

Dimension of the platinum separator:

- Circumference: 126.6 sq. mm.
- Thickness: 0.3 mm

(a)Thermo-voltage generation: Using triturated ZnO, we have been able to generate thermo-voltage (Bandyopadhyay et al., 2010). Maximum voltage generated was found to increase with potency of the medicine (Fig. 3). The efficiency of the cell with the medicine at potency 30C at 40°C was calculated from the current-voltage curve (Fig. 4) and the value of efficiency is ~0.39%.

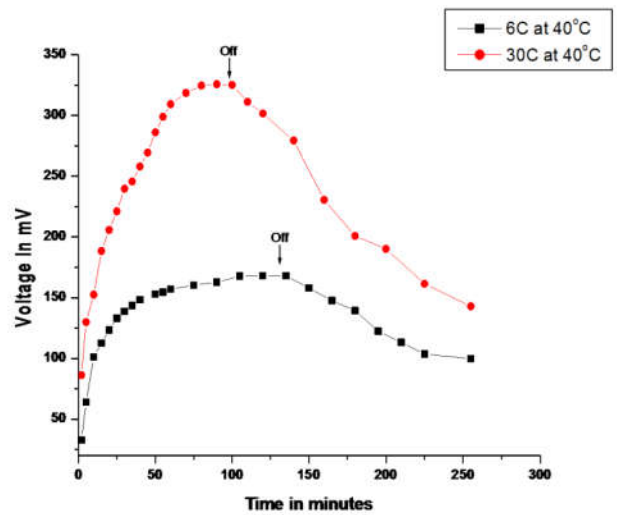


Fig.3. Growth and decay curve of V_{oc} (thermo-voltage) generation using triturated ZnO at potencies 6C and 30C (Bandyopadhyay et al., 2010)

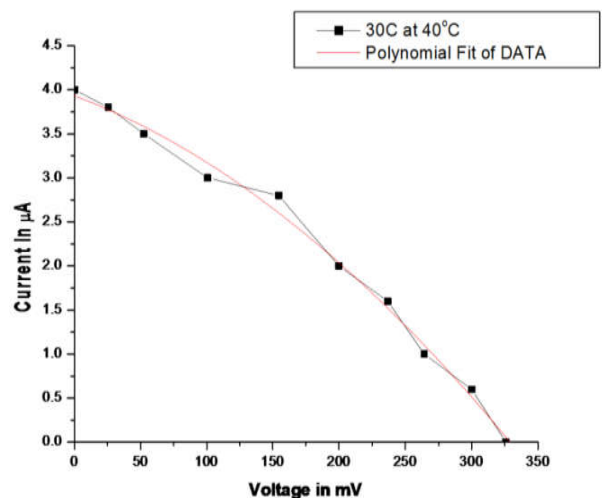


Fig.4. Current vs. voltage characteristic curves for the *Zincum oxydatum* of potency 30C at 40°C using platinum barrier (Bandyopadhyay et al., 2010)

b) Enhancement of efficiency of solar energy converter utilizing the broad solar spectrum range

To ensure the performance of the electrochemical cell over a broad solar spectrum range, two dyes Azure C and Rose bengal, having absorption bands in two different spectral regions 545 nm and 610 nm respectively, were chosen in order to overcome the band absorption limits of each dye and were combined together. These dyes were used in conjunction with triturerated ZnO. Our result shows that photo induced voltage with significant efficiency is generated when triturerated ZnO is used in combination with these two different photosensitive organic dyes. The photovoltage generation in EC cell has been observed using Azure C and Rose bengal solution and triturerated zinc oxide (Fig. 5). The I-V characteristic of the cell was studied (Fig. 6) and the energy conversion efficiency ($\eta\%$) of the cell has been calculated for all four cases (Table 1). In all cases, photo induced voltage generation upon illumination started rising with time and reached a maximum saturation value and remained constant at that value. When the light was cut off the voltage decreased slowly and the storage duration for 30C was more than 4 hrs to reach the initial value. Also at this potency, higher efficiency of PEC cell was obtained. The photovoltage cycle was reproducibile upon further illumination.

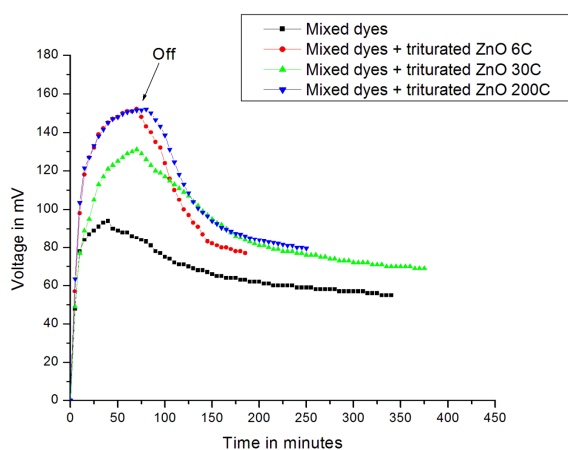


Fig.5. Growth and decay curve of V_{oc} (photovoltage) generation for mixed Azure C, Rose bengal and triturerated zinc oxide of potency 6C, 30C and 200C

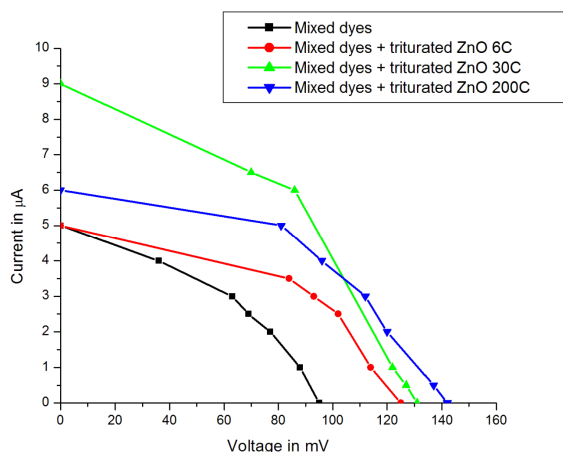


Fig.6. Current versus voltage characteristic curves for mixed Azure C, Rose bengal and triturerated zinc oxide of potency 6C, 30C and 200C

The energy conversion efficiency of the cell using three different potencies 6C, 30C and 200C of the medicine with same concentration of the two dyes (0.5×10^{-5} M) in all cases are 0.39%, 0.43% and 0.35% respectively. The efficiency is only 0.15% for the mixed dye under similar conditions. (Table 1) (Bandyopadhyay *et al.*, 2016)

Table 1. The characteristics of electrochemical cell using mixed Azure C, Rose bengal and triturerated ZnO of potency 6C, 30C and 200C

Sample used	Peak value of photovoltage (mV)	Short circuit current (μ A)	One Cycle duration (minutes)	Fill factor (FF)	Energy conversion efficiency (%)
Only mixed dye	95	5	310	0.38	0.15
Mixed dye+ZnO 6C	150	6	248	0.52	0.39
Mixed dye+ZnO 30C	134	9.5	375	0.40	0.43
Mixed dye+ZnO 200C	152	6	255	0.50	0.35

In order to understand how triturerated ZnO tuned the photoelectric properties of the dye molecules, the absorption spectra of the mixed dye in presence of triturerated zinc oxide at different potencies had been studied (Figure 7). Azure C and Rose bengal have their characteristic bands at 545 nm and 610 nm respectively. With addition of the triturerated ZnO, the characteristic peaks of the dye remain unchanged but absorbance increased.

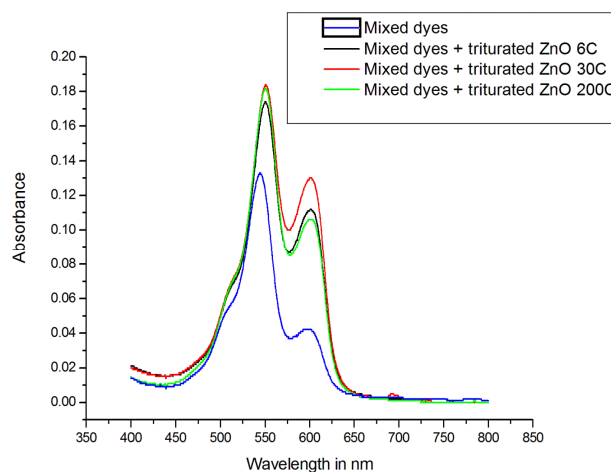


Fig.7. Absorption spectra of mixed Azure C, Rose bengal and triturerated zinc oxide system with concentration of mixed dyes solution 0.85μ M and triturerated zinc oxide of potency 6C, 30C and 200C

Our experimental results on photovoltage generation using triturerated ZnO show presence of nanoparticles (Fig. 1), of almost spherical shape and particle sizes within 5-7 nm (Nandy, 2015; Bandyopadhyay *et al.*, 2010). Due to adsorption of dye molecule on the surface of triturerated ZnO nanoparticles, the absorption efficiency of the dye molecule increased. There is also a high possibility of forming exciplex between these two dyes at excited state which could not participate in the process of conversion of solar energy. Addition of triturerated ZnO also plays a vital role here. As the dyes got adsorbed on the surface of these nanoparticles, they

could participate now actively in conversion process and the problem of spectral loss was reduced by better exploitation of the incident photon. The increase in efficiency of triturerated ZnO at 30C from that of 6C can be explained from the fact that with increasing potency the particle size decreases, leading to increased surface to volume ratio (Kar *et al.*, 2015). However at 200C, the concentration of nanoparticle is too low to participate in conversion process resulting in lower efficiency than those at 6C and 30C. Our study of photovoltage generation in a dye-sensitized photo-electrochemical cell using Azure C, Rose bengal and triturerated ZnO at three different potencies shows that with addition of triturerated zinc oxide in mixed solution of Azure C and Rose bengal system, magnitude of photovoltage, storage duration and energy conversion efficiency get enhanced significantly and has maximum value at 30C potency. Spectral studies reveal that with addition of the nanoparticle, the characteristics of the dye solution remains unchanged while only overall optical density of the system increases indicating that there is no chemical reaction between the dyes and the triturerated zinc oxide nanoparticle.

B) Improvisation of electrical properties of PVDF-HFP: use of homeopathic medicines, novel metallic nanoparticles

Poly(vinylidene fluoride) (PVDF) and its copolymers like poly(vinylidene fluoride-hexa-fluoropropylene (PVDF-HFP) are in great demand for their versatile and unique properties like flexibility, low processing temperature, low dielectric constant, high dielectric breakdown field etc., making them potential candidate for a broad range of applications in electronic industry such as dielectric filler for condensers (Martins *et al.*, 2012; Martins *et al.*, 2013). In order to improve the capacitive performance of the polymer material, incorporation of metal nanoparticles in the polymer matrix has received great attention. The uniform and homogeneous distribution of the nanoparticles allows good interaction between them and the polymer matrix material and enhances the electrical properties of the host material. (Nalwa, 1995) In this endeavour, a great deal of effort had been devoted to develop PVDF-HFP composites by incorporating different metallic nanoparticles within the matrix. The effective dielectric permittivity of these metal nanoparticle doped polymer composite are higher than that of the host polymer matrix. They also show enhancement of conductivity and decrement of tangent loss making them potential candidates as good capacitors and electric energy storage devices (Li *et al.*, 2011; Thakur *et al.*, 2015; Dang *et al.*, 2007; He *et al.*, 2009; Thakur *et al.*, 2014; Paul *et al.*, 2016). Here we have chosen two homeopathic medicines Cuprum metallicum (triturerated copper) and Cobaltum metallicum (triturerated cobalt), two very novel and unique metallic fillers, which are nontoxic, inexpensive and are easily available. As homeopathic medicines, they affect the membrane permeability and their nanoparticle aspect has been proved experimentally (Nandy *et al.*, 2011; Kar *et al.*, 2015). These novel nanoparticles were incorporated in the polymer PVDF-HFP in dimethyl-sulfoxide solution and films were prepared by simple solution casting technique. These nanocomposites of PVDF-HFP/triturerated Cu (CuPC) and PVDF/triturerated Co (CoPC) were studied by FTIR, FESEM and dielectric analysis (Paul *et al.*, 2016). The presence of α and β phases, formation of spherulites, enhancement of dielectric constant and conductivity of the nanocomposite films were observed by changing the potency of triturerated Co and triturerated Cu and the observed values were compared with that of the pure PVDF-

HFP film. The presence of α - and β - phases and spherulitic crystal structure of PVDF-HFP of these nanocomposite films have been detected by Fourier Transform Infrared Spectroscopy (FTIR) study (Fig.8). The transition of phase between α and β is activated by the incorporation of metallic nanoparticles in the polymer matrix. This provides the nanocomposites higher mobile charge carriers which participate in the interfacial polarization.

FTIR analysis

Fourier Transform Infrared Spectroscopy (FTIR) study of these nanocomposite films in the selected range of 400–1,100 cm^{-1} detected presence of α - and β - phases Fig.8(a). The FTIR spectra of CuPC and CoPC nanocomposite film show characteristic absorbance bands at 484, 606 and 878 cm^{-1} corresponding to the α -phase and around 510 and 840 cm^{-1} corresponding to the β -phase. The spectra indicate that there is no phase shift or chemical interaction between the metal nanoparticles and the polymer film, but the intensity of α - and β -phases change with the concentration of doping material. We observe in Fig.8(b) that with increase in potency, the β -phase peaks have grown significantly compared to those of PVDF-HFP. Using Beer-Lambert law, which relates absorbance with concentration of the absorbing species, the fraction of β - phase, F_{β} , present in the (crystalline regions of) films was calculated using the formula,

$$F(\beta) = \frac{A_{\beta}}{1.26A_{\alpha} + A_{\beta}}$$

where, A_{α} and A_{β} are the absorption fractions of α and β -phases at 484 cm^{-1} and at 840 cm^{-1} respectively. Undoped PVDF had 53 % β -phase that increased with the addition of the different potency of the nanoparticles. The enhancement in β -phase was maximum (82.04 %) for TCu nanoparticles at 200C potency among all the composites. All composite film showed a constant increasing trend with increase in potency.

FESEM analysis

Fig. 9(a)-(f) show the morphology and microstructure of all composite films doped with TCu and TCo nanoparticles of 6C, 30C and 200C potencies respectively. Fig. 9(a) and (d) is the evidence of large number of densely packed agglomerated particles embedded in the polymer matrix whereas Figs. 9(b), (c), (e) and (f) show that the particles are more scattered, well separated and also homogeneously distributed maintaining an intermolecular distance.

Dielectric Measurements

The variations of dielectric constant of all CuPC and CoPC film with frequency are shown in Fig.10(a) and (b) respectively. Throughout the whole frequency range, dielectric constant has substantially higher value in case of all CuPC and CoPC films compared to the pure polymer film. As there are two different conducting media present here (e.g. PVDF-HFP and TCu or TCo), this enhancement may be explained by MWS (Maxwell-Wagner-Sillars) interfacial polarization effect which appears in heterogeneous medium consisting of different phases with different permittivity and conductivity due to accumulation of the charges at the interfaces (Gayen *et al.*, 2017). The interfacial polarization is associated with the entrapment or accumulation of free charges generated in the cores at the interfaces between the cores and the matrix.

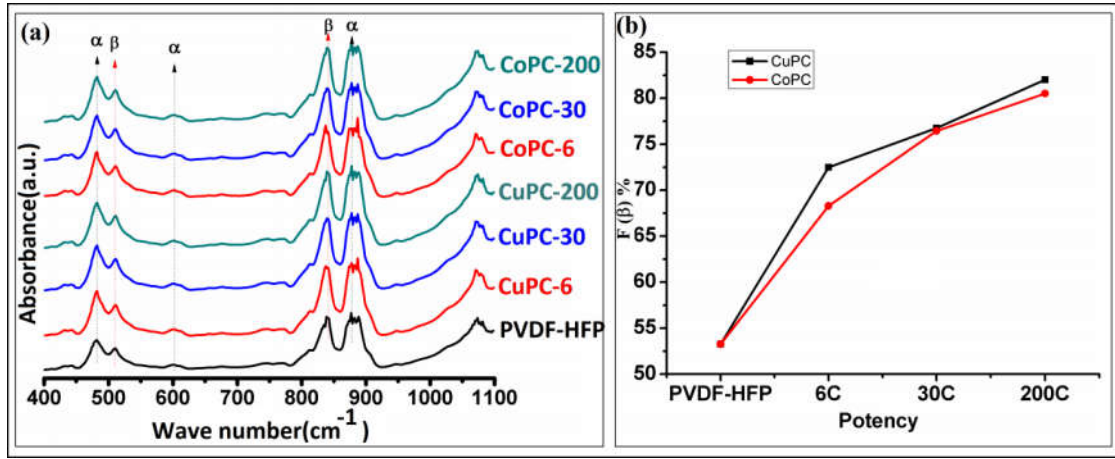


Fig.8. (a) Fourier transform infrared spectra of CuPC and CoPC for all potency (b) Increase of F(β)% with increase in potency

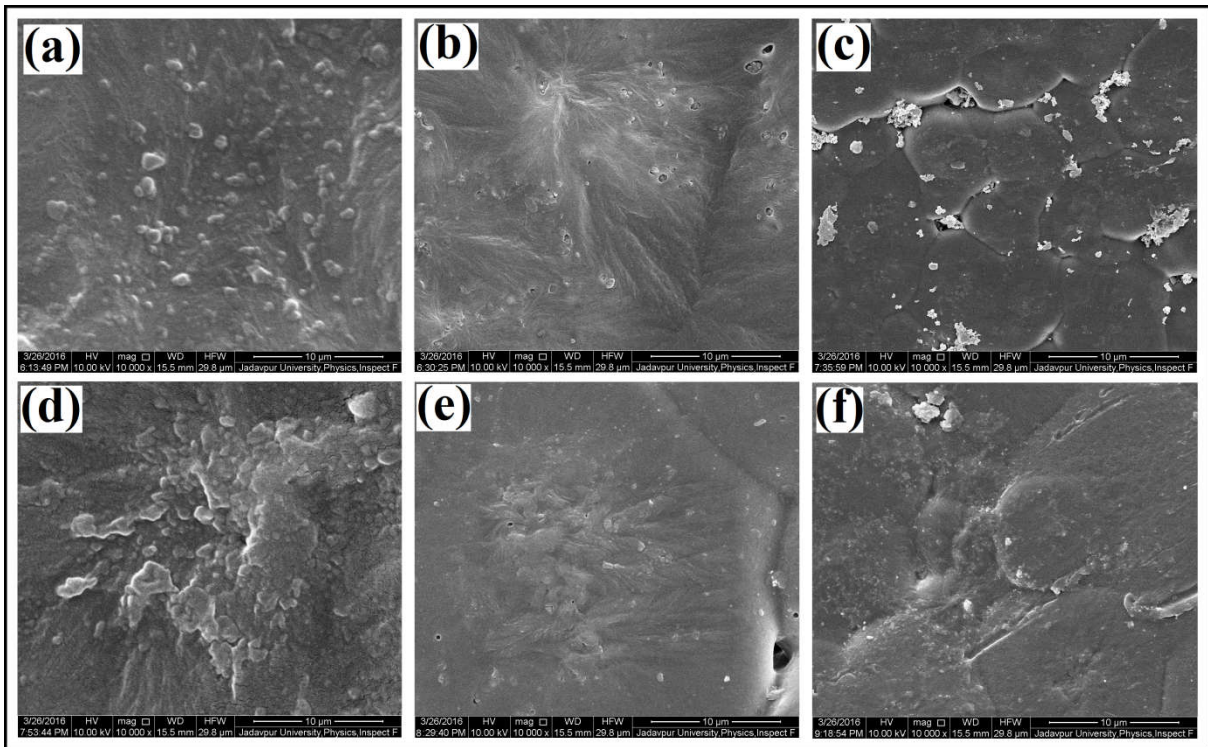


Fig.9. Field-emission scanning electron micrograph (FESEM) of (a) CuPC-6, (b) CuPC-30, (c) CuPC-200, (d) CoPC-6, (e) CoPC-30 and (f) CoPC-200 films

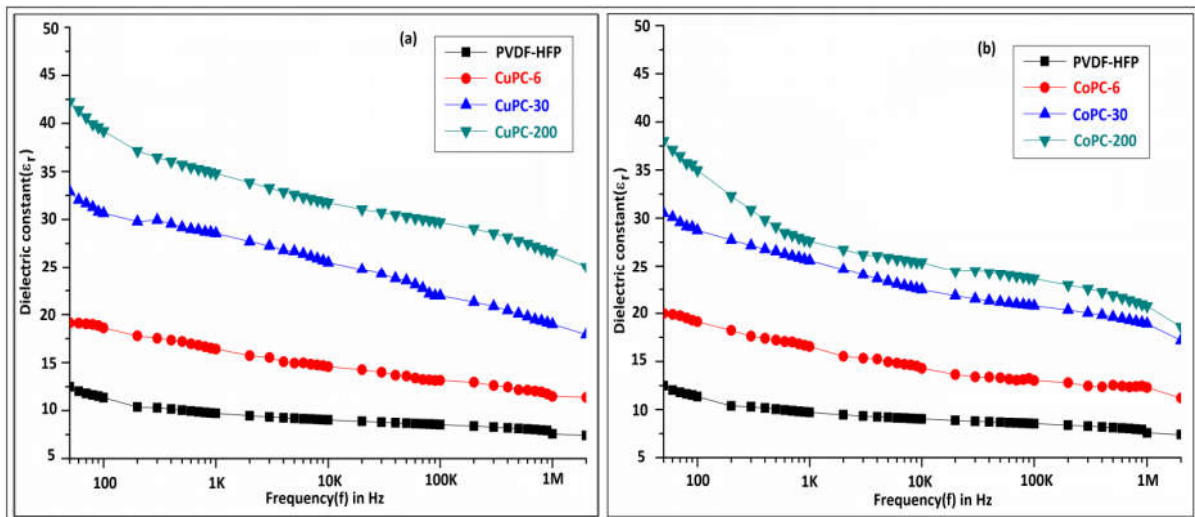


Fig.10. Frequency dependent dielectric constant (ϵ_r) of (a) CuPC and (b) CoPC for all potency

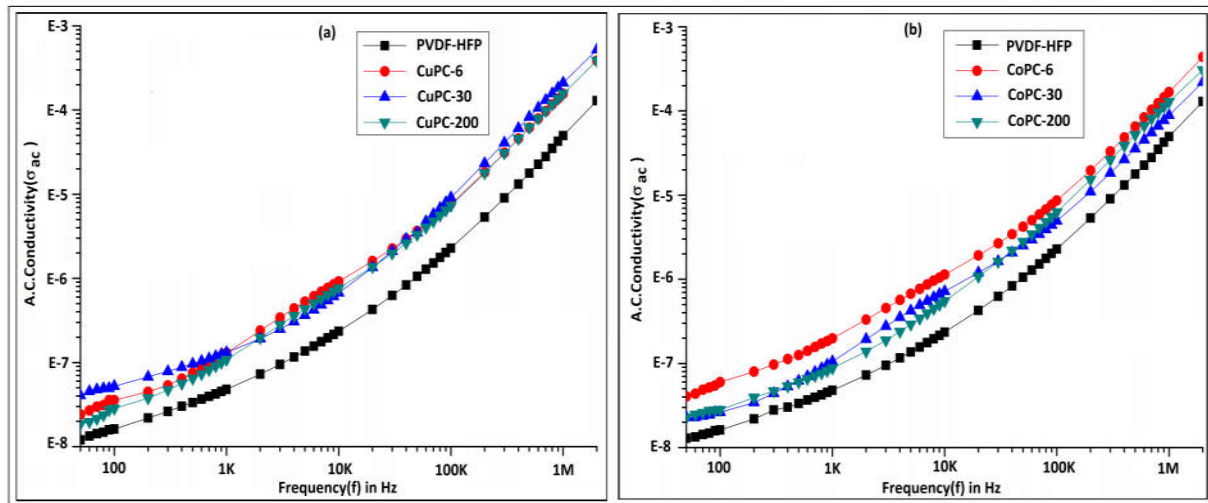


Fig.11. Frequency dependent ac conductivity (σ_{ac}) of (a) CuPC and (b) CoPC for all potency

At lower frequency the easy orientation of dipoles as well as MWS interfacial polarization contribute this (\sim) 4 times enhancement. As the frequency is increased further, dipole response is restricted and the dielectric constant has a saturation tendency. In this case, the internal individual dipoles contribute to the dielectric constant which is ideally the electronic polarisation effect (Rogti and Ferhat, 2014).

A.C. Conductivity

The variation of ac conductivity with frequency for all CuPC and CoPC film is shown in Fig.11(a) and (b) respectively. It shows ac conductivity increases exponentially with frequency for both the nanocomposite films. At higher frequency range, rapid increase of conductivity with increasing frequency is referred to electronic polarization effect. This increase in conductivity with frequency also arises due to the presence of free ions in the polymer matrix that may increase the mobility of the ions which finds an easy path to move and hence increase the electrical conductivity. The value of ac conductivity is higher for all nanocomposite films than the pure polymer film. For lower potencies of these films, the particles are in bulk form and agglomerated which is embedded in the polymer matrix. So the interfacial area per unit volume decreases while the interparticle distance decreases. This decreases the average polarization associated with the particles resulting in the further decrement of dielectric constant and ac conductivity as well as increment of tangent loss. This phenomenon is also clearly observed from their microstructures (Fig. 9).

We conclude that incorporation of homeopathic nano particles in PVDF-HFP leads to

- Gradual increase in electroactive β -phase compared to PVDF-HFP (Fig.8).
- As the potency of the medicine increased, better interaction observed on polymer matrix and thereby found homogeneously distributed particles.(Fig.9)
- The dielectric constant of all nanocomposites decrease with increase in frequency for all concentrations of metal nanoparticles (Fig.10). This value is higher for higher dilutions and highest for CuPC-200 HNPs concentration. (Fig.10).

- The AC conductivity increases with frequency for all nanocomposite films due to the presence of mobile metal ions in the polymer composites (Fig.11).

We have shown that the incorporation leads to strong interfacial interaction between the HNPs and the polymer resulting in enhanced dielectric constant of the thin films. The observed variation of the dielectric properties of the thin films depends on the surface, size and extent of agglomeration of the HNPs in the polymer matrix. Thus, pure polymer film which has comparatively low dielectric constant can be modified into materials with enhanced dielectric constant by making a composite with triturated metal nanoparticles, which are nontoxic, eco-friendly and easily available in the nano form. As a dielectric material, these nanocomposite films can then be a promising candidate for the fabrication of high charge-storing multilayer capacitors and can be of great use in electronic industry. From these experiments we conclude that homeopathic medicines as nanoparticles can enhance candidate for the fabrication of high charge- storing multilayer capacitors and can be of great use in electronic industry.

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REFERENCES

- Bandyopadhyay P, Chakraborty S, Basu R, Das S, Bhar DS, Manchanda RK, Khurana AK, Nayak D, Nandy P. 2016. Efficiency of a dye-sensitized photoelectrochemical device using thionine and triturated zinc oxide at different potency. *Energy Sources, Part- A: Recov, Utilization and Environ effects*, 32(13) 1833-1839.
- Bandyopadhyay P, Nandy P, Basu R, Bhar DS, Das, 2010. Effect of dilution on thermovoltage generation using homeopathic nanomedicine *Zincum oxydatum*. *Int J, Innovative Res in Sci and Eng.*, 3:226-230

- Bandyopadhyay, P., R. Basu, S. Das, DS Bhar, R. Manchanda, P. Nandy. Enhancement of quantum efficiency of a dye sensitized electrochemical cell by using triturated zinc oxide mixed with two organic dyes, azure c and rose bengal. *International Journal of High Dilution Research* (In press)
- Bhandary S, Das S, Basu R, Bhattacharyya S, Nandy P. 2011. Effect of *Aconitum napelles* on liposomal microviscosity. *Int J Emerg Technol Sci Eng.*, 3:1-5.
- Chikramane PS, Kalita D, Suresh AK, Kane SG, Bellare JR. 2012. Why extreme dilutions reach non-zero asymptotes: A nanoparticulate hypothesis based on froth flotation. *Langmuir*, 28: 15864-75.
- Chikramane PS, Suresh AK, Bellare JR, Kane SG. 2010. Extreme homeopathic dilutions retain starting materials: A nanoparticulate perspective. *Homeopathy*, 99: 231-42.
- Dang, Z. M., L. Wang and Y. Yin, 2007. 'Giant dielectric permittivities in functionalized carbon-nanotube/electroactive-polymer nanocomposites', *Adv.Mater.*, 19, 852-857.
- Gayen, A. L., B. K. Paul, D. Roy, P. Bandyopadhyay, R. Basu, S. Das, D. S. Bhar, R.K. Manchanda, A.K. Khurana, D. Nayak, P. Nandy, 2017. "Improvisation of electrical properties of PVDF-HFP: use of novel metallic nanoparticles" (Communicated)
- Ghosh S, Chakraborty M, Das S, Basu R, Nandy P. 2014. Effect of different potencies of nanomedicine *Cuprum metallicum* on membrane fluidity – A biophysical study. *Am J Homeopath Med.*, 107: 161-9.
- He F., S. Lau, H. L. Chan and J. Fan, 2009. 'High dielectric permittivity and low percolation threshold in nanocomposites based on poly (vinylidene fluoride) and exfoliated graphite nanoplates', *Adv. Mater.*, 21, 710-715.
- Kamat PV. 2007. Meeting the Clean Energy Demand: Nanostructure Architectures for Solar Energy Conversion. *J Phys Chem.*, C 111:2834-2860
- Kar S, Bandyopadhyay P, Chakraborty S, Chakrabarty M, Ghosh S, Basu S, Das S, Manchanda RK, Khurana AK, Nayak D, Nandy P. 2015. Derivation of an empirical relation between the size of the nanoparticle and the potency of homeopathic medicines, *Intl. J. High Dilution Res.*, 14(4), pp. 2-7
- Li, Y., X. Huang, Z. Hu, P. Jiang, S. Li and T. Tanaka, 2011. 'Large dielectric constant and high thermal conductivity in poly(vinylidene fluoride)/ barium titanate/silicon carbide three- phase nanocomposites', *Appl. Mater. Interfaces*, 3, 4396-4403.
- Martins, P., A. C. Lopes and S. Lanceros-Mendez, 2013. 'Electroactive phases of poly (vinylidene fluoride): determination, processing and applications, *Prog. Polym. Sci.*, 39, 683-706.
- Martins, P., C. M. Costa, M. Benelmekki, G. Botelho and S. 2012. Lanceros-Mendez: 'On the origin of the electroactive poly(vinylidene fluoride) β -phase nucleation by ferrite nanoparticles via surface electrostatic interactions', *Cryst. Eng. Comm.*, 14, 2807-2811.
- Nalwa, H. S. 1995. 'Ferroelectric polymers: chemistry, physics, and applications'; New York, Marcel Dekker.
- Nandy P, Bhandary S, Das S, Basu R, Bhattacharya S. 2011. Nanoparticles and membrane anisotropy. *Homeopathy*, 100: 194.
- Nandy P. 2015. A review of basic research on homeopathy from a physicists's point of view *Indian J. Research in Homeopathy*, 9(3) : 141-151
- Paul, B. K., S. Das, R. Basu, D. S. Bhar, R. K. Manchanda, A. K. Khurana, D. Nayak, P. Nandy, 2016. 'Effect of dilution of Ferrum metallicum and zincum oxidatum, homeopathic nanomedicines on the dielectric properties of poly(PVDF-HFP) film', *Int. J. High Dilution Res.*, 15, (1), 10-17
- Paul, B. K., S. Kar, P. Bandyopadhyay, R. Basu, S. Das, D. S. Bhar, R. K. Manchanda, A. K. Khurana, D. Nayak and P. Nandy, 2016. 'Significant enhancement of dielectric and conducting properties of electroactive polymer polyvinylidene fluoride films: an innovative use of Ferrum metallicum at different concentrations', *Indian J. Res. Homeopath.*, 10, (1), 52-57.
- Rogti, F. and M. Ferhat, 2014. 'Maxwell-Wagner polarization and interfacial charge at the multi-layers of thermoplastic polymers', *J. Electrostat.*, 72,1, 91-97.
- Thakur, P., A. Kool, B. Bagchi, S. Das and P. Nandy, 2014. 'Enhancement of β phase crystallization and dielectric behavior of kaolinite/halloysite modified poly (vinylidene fluoride) thin films', *Appl. Clay. Sci.*, 99, 149-159
- Thakur, P., A. Kool, B. Bagchi, S. Das and P. Nandy, 2015. 'Effect of in situ synthesized Fe_2O_3 and Co_3O_4 nanoparticles on electroactive β phase crystallization and dielectric properties of poly(vinylidene fluoride) thin films', *Phys. Chem. Chem. Phys.*, 17, 1368-1378.
- Upadhyay RP. and Nayak C. 2011. Homeopathy emerging as nanomedicine. *Int J High Dilution Res.*, 10: 299-310.
