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Synthesis and Characterization of some metals (Sn, Ni, Zn and Co) doped with CdO Nanoparticles by Co-Precipitation method for super capacitor applications

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Abstract
In this present investigation, a set of pure and some metals doped Cadmium oxide nanoparticles were synthesized by the way of co-precipitation method. The precursor materials used in this current work were cadmium nitrate, tin (II) chloride, nickel acetate, zinc acetate dihydrate and cobalt (II) chloride has been make uses of a precursor materials. The as-synthesized nanopowders were characterized by XRD, FTIR, UV-Vis and SEM analysis. The X-Ray Diffraction patterns revealed a polycrystalline having the characteristic peaks are well matched with the phase purity of cubic structure. Scanning Electron Microscope exhibit surface morphology, Fourier Transform Infrared spectrum has affirmed the presence of the functional groups present in the pure and metals doped cadmium oxide nanoparticles. The room temperature photoluminescence (PL) and Ultra Violet-Vis near Infra measurement studies were carried out to optical properties and band gap of the materials. The band gaps of the materials were observed to be 2.47 eV for pure CdO, 2.32 eV for metals doped CdO which were appraise from Tauc's plot. The average particle diameter of CdO nanoparticles was measured in the nanometer range using a dynamic light scattering (DLS) particle size analyzer. The magnetic properties to express vibrating sample magnetometer studies (VSM). The uppermost electrochemical capacitance implementation is using Cyclic Voltammetry analysis, which indicates capable electrode materials for electrochemical super capacitor applications.

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Keywords: Cadmium oxide, XRD, SEM, Optical band gap, Particle diameter, Cyclic Voltammetry, Super capacitor and VSM

1. Introduction

Nowadays many researchers focused, transition metal oxide nanoparticles, such as cadmium oxide (CdO), nickel oxide (NiO), vanadium pentoxide (V_2O_5), manganese oxide (MnO_2), rutherium oxide (RuO_2) and cobalt oxide (Co_2O_3) have been study as electrochemical and electrode materials for supercapacitors [1]. The electrochemical supercapacitor has become one of the most optimistic energy storage devices in the recent times, due to its large power density, longer cycle life contrasted, high-energy density and faster recharge capacity with the commercial batteries purpose [2]. In this present work researcher have interest in the synthesis of low cost transparent conducting oxide (TCOs) for cadmium oxide (CdO) nanoparticles [3]. CdO, have been broadly considered due to their electrochemical and optical properties. Cadmium oxide is one of such material which has excellent structural and optoelectronic properties [4]. Among these metal oxide nanoparticles, CdO is one of the important non-stoichiometric degenerate group II and VI n-type of semiconductor materials having sodium chloride (NaCl) rock - salt cubic crystal structure with face centered cubic type (fcc) and lattice constant (a) = 0.469 nm, it is n-type with alternating Cd and O atoms located at lattice scale [5-6]. Moreover cadmium oxide nanoparticles there are two types of band gap it has a narrower direct

band gap of 2.20 eV to 2.50 eV and an indirect band gap of 1.36 eV to 1.98 eV [7-8].

This low band gap energy makes its electrical conductivity will be high because of conductivity values 103 ohm^{-1} cm^{-1} and also carrier mobility high (142 cm^2/Vs). The several structures of CdO in nanoscale have been revealed such as nanoparticles [9], thin films, nanoneedles, nanotubes [10], nanowires [11]. A great deal of attention is focused on cadmium oxide nanoparticles; they have been used in gas sensors, optoelectronic device, solar cells, transparent electrodes [12-15], phototransistors, photovoltaic cells [16]. Additionally, CdO due to its used in cadmium salts, phosphors, catalyst ceramic glazes and has been a major ingredient for paint pigments and electroplating baths [17-18]. Cadmium oxide is one of the bright semiconducting oxide materials with the electrical resistivity of 10^{-2}-$10^{-4}\Omega cm$ [19-20]. In addition, it has a corresponding absorption wavelength is 500nm [21]. Nowadays, there are numerous techniques to prepare these materials such as hydrothermal/solvothermal method [22], microemulsion [23], sonochemical [24], thermal evaporation [25], sputtering, sol-gel method [26], vapor transport [27], spray pyrolysis [28] and thermal decomposition [29]. It has been revealed that the chemical and physical properties of cadmium oxide (CdO) nanoparticles are comparable to its stoichiometry as well as particle size, diameter and shape, which, in turn, depend on its preparation conditions and preparation methods [30-35].Though several methods have been employed but utilized of co-precipitation method, which has commonly been used for growth of other CdO chalcogenide, is limited in case of cadmium oxide nanoparticles. Among these methods in the present work we have opted for utilized co-precipitation technique for synthesis of Cadmium oxide nanoparticles. Moreover, no results and report is available in the literature on metals (Sn, Ni, Zn and Co) doping into CdO so researchers curiosity and focused in this work. In this case, CdO nanoparticles, both undoped and doped with metals (Sn, Ni, Zn and Co) were synthesized through a co-precipitation method. It is crucial to strike a balance between the amount and rate of addition of Cadmium Nitrate and Sodium Hydroxide during the synthesis of the required CdO nanoparticles. To create metals-doped CdO nanoparticles, metals (Sn, Ni, Zn and Co) was combined with pure CdO. After synthesis, the nanoparticles' structural, functional, morphological, optical and electrochemical properties were investigated using a wide range of techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), ultraviolet-visible spectroscopy (UV-Vis), fluorescence spectroscopy (PL), dynamic light scattering (DLS) and Cyclic Voltammetry analysis (CV). In this research, pure and metals (Sn, Ni, Zn and Co)-doped CdO nanoparticles were made using a low cost and easy chemical co-precipitation approach so that their electrochemical performance could be tested toward the end goal of building a cheap but significant super capacitor. Doping metals (Sn, Ni, Zn and Co) with CdO nanoparticles has led to yet another breakthrough in the creation of diamagnetic behavior at room temperature using vibrating sample magnetometer (VSM). Therefore, with proper device manufacturing, various technological applications using Cadmium oxide nanoparticles would be higher-level in the future.

2. Materials and methods

2.1. Raw materials

Cadmium nitrate [$Cd(NO_3)_2.4H_2O$; 99.99%], tin (II) chloride dihydrate [$SnCl_2.2H_2O$; 99.99%], nickel acetate [$C_4H_6NiO_4$; 99.99%], zinc acetate dihydrate [$Zn(CH_3COO)_2{\cdot}2H_2O$;99.99%], cobalt (II) chloride [$CoCl_2.6H_2O$; 99.99%] and Sodium hydroxide pellets [NaOH] chemicals used in this study were of analytical reagent grade purchased from Sigma- Aldrich company, without any further prification. Ethanol and distilled water were used as a solvent for sample preparation.

2.2. Synthesis of pure and metals doped CdO nanoparticles

Cadmium oxide and metals doped cadmium oxide nanoparticles were accurately synthesized by co-precipitation process using the above mentioned chemicals. Two types of sample are synthesized in this article that's pure cadmium oxide and metals doped cadmium oxide nanaparticles. The technique for the growth of Cadmium oxide nanoparticles from Cadmium nitrate tetra-hydrate was used as precursor and transition metals was employed such as a tin (II) chloride, nickel acetate, zinc acetate dihydrate and cobalt (II) chloride sources. In the preparation of CdO nanoparticles from Cadmium nitrate ($Cd(NO_3)_2.4H_2O$) and sodium hydroxide pellets (or) pearls (NaOH) components co-precipitation process that's 6.169g of $Cd(NO_3)_2.4H_2O$ was dissolved in 50ml of distilled water in a beaker. The PH of the solution was maintained at around 11 to 12 by adding 3.600g of sodium hydroxide (NaOH) was dissolved in 100ml of distilled water were mixed by drop wise under vigorous magnetic stirring to from a clear white precipitate of cadmium hydroxide and sodium nitrate was formed. In the preparation of metals doped CdO nanopowder were synthesized by chemical co-precipitation method. The starting materials were the same as utilized in undoped cadmium oxide. Just before adding the precipitating agent, the measurement quantity of doping metals was added to the solution in terms of 0.3 mol% concentration and the reaction was carried out under the same temperature conditions. The resultant precipitate was filtered applying 70^{o}c of air oven and then washed alternately with de-ionized water and ethanol for several times to remove un-reacted or impurities materials. The precipitate of pure and metals doped CdO was dried in hot air oven at 150^{o}c for 3h and cadmium oxide was harvested in the nano size. The final pure and metals doped CdO powder was obtained used for the muffle furnace stable at 550^{o}c then the collect the sample grain agate mortar. The final pure and metals doped CdO powder was then obtained and used for the further different characterization. Fig.1**.** Schematic illustration of the synthesis of pure CdO and metals doped CdO nanoparticles by co-precipitation process.

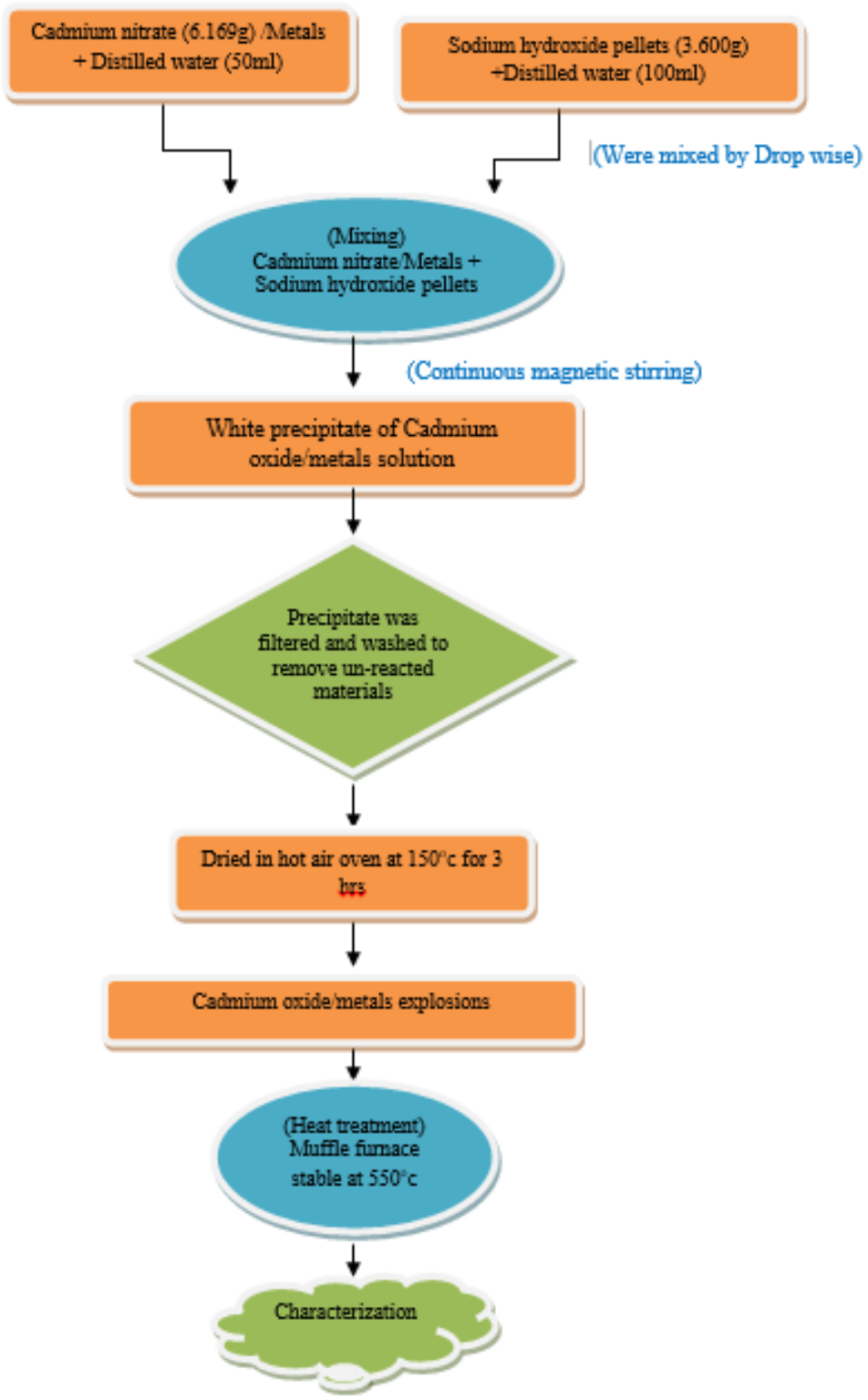

Fig 1: Schematic illustration of the synthesis of pure CdO and metals doped CdO nanoparticles by co-precipitation process.

2.3. Material Characterization

The following characteristics of pure CdO and metals doped CdO nanoparticles are uncovered by analysis of the characterizations: The powder X-ray diffraction (XRD) patterns were recorded on a Rigaku Multiflex instrument for 2θ values from 10.01−74.99° using nickel-filtered CuKα (0.154060 nm) and radiation source and a scintillation counter detector and measurement temperature [°C] 25. Infra-red spectra were measured using a thermal Nicolet 6700 FT-IR spectrophotometer, Model Spectrum Two FT-IR Spectrometer (Perkin Elmer). Measurements were achieved by pelletizing the samples with KBr in the mid-infrared region at an accelerating voltage of 200 V. For optical studies, an optical absorption UV-spectrums was recorded using UV-Vis spectrophotometer (Model-Perkin Elmer Lambda 35). The microstructure images of the samples were acquired on a HITACHI-S300N field emission scanning electron microscopy (SEM). The particle size analyzer instrument can measure (Dilution method) the particle size of pure and metals doped samples suspended in liquids in the range of 0.1 nm to 12.3 µm with sample suspension concentration from 0.00001% to 40% and a sensitivity for

molecular weight to as low as 250 Da. A Flexible STAT MC evaluated electro-chemical applications at frequencies between 1 Hz and 1 MHz, using a powder sample cell, under conditions where the voltage was higher than predicted by the Nernst equation. The fluorescence spectrum (PL) was recorded using a Perkin-Elmer LS-55 spectrophotometer. A Lakeshore 7410 vibrating sample magnetometer (VSM) was used to calculate the magnetic characterization.

3. Results and Discussion

3.1. Powder X-ray diffraction analysis

The powder X-ray diffraction pattern of pure and metals doped cadmium oxide nanoparticles were shown in Fig.2. The X-ray diffraction patterns were recorded from 10º to 80º. It exhibited there are three strong diffraction prominent peaks at (33.201º, 38.231º, 55.343º) which are equal with planes (111), (200), (220) and other prominent peaks assigned for the (311) and (222) planes, respectively. The resulted X-ray diffraction patterns of the undoped and metal doped cadmium oxide nanoparticles were compared with the standard data - JCPDS card no. (05-0640).The prominent peaks were matched well except for very few impurity phases. Also the acquired peaks are consistent with a cubic crystalline structure. The sharp prominent peaks express that the sample is thoroughly crystallite structure. Overall, the intensity of the prominent peaks is found to moderately increase with metals doping, which indicates that the crystallite nature of the particle size will be decreased. The crystalline structure of the pure and metals doped CdO powder can be calculated from the X-ray diffraction peak angle and intensity analysis using the Debye-Scherer's equation:

$$D = \frac{k\lambda}{\beta \cos \theta} \quad (1)$$

Where D is the crystalline size of the particle in nm, k is known as the Scherer's constant the value of k = 0.94, λ is the X-ray radiation wavelength (for Cu–kα radiation wavelength) the value of λ = 1.54178 Å, β is the full width at half maximum (FWHM) of the X-ray diffraction peak and Θ is the Bragg's diffraction peak angle [36].

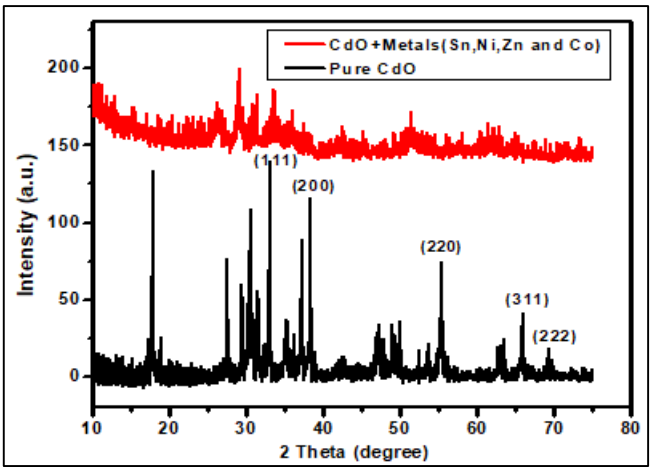

Fig 2: Powder XRD pattern of pure CdO and Metals doped CdO nanoparticles

The X-ray diffraction density has been calculated using the lattice parameters equation:

$$D_{th} = z\frac{M}{NxV} \quad (2)$$

Where D_{th} is the X-ray diffraction density, z is the number of such chemical units in one unit cell of the crystal, V is the volume of the crystalline unit cell as determine by XRD, M (in atomic weight units) is the mass of atomic ensemble constituting one unit of the chemical formula and N is the Avagadro's number. The average crystallite size of the undoped and metals doped CdO nanoparticles were found to be around 33.59 nm for pure CdO and 31.23 nm for metals doped CdO nanoparticles. The crystallite parameters obtained on undoped and metals doped CdO nanoparticles are displayed in Table. 1. The crystalline characteristics were indicating to be uniform in all the samples. It is clear from Table 1 that the crystalline size is changed systematically for a smooth increase of metals concentration.

Table 1: Average crystalline size, average d- Spacing, unit cell parameters, density of the undoped CdO and some metals doped CdO nanoparticles

Sample name	Average Crystalline size (nm)	Average d-Spacing (Å)	Unit cell parameters [a] (Å)	Density [D_{th}] (g/cm^3)
CdO	33.59	1.6734	4.425	1.3740
CdO + Metals (Sn, Ni, Zn and Co)	31.23	1.7910	4.476	1.3325

3.2. Scanning electron microscopy analysis

The surface morphology of undoped CdO and metals doped CdO nanoparticles was carried-out by Scanning Electron Microscopy (SEM) analysis are indicated in Figure 3(a) and (c) shows the micrographs of pure CdO and Figure 3(b) and (d) shows the metals doped CdO nanoparticles. SEM has a large depth of field which allows more of a sample to be in focus at one time. Also has much higher resolution, so closely spaced samples can be magnified at much higher levels. Scanning electron microscopy (SEM) images were used to confirm the structure characterization, which was then evaluated at a higher magnification using the micrographs. From the figure it is visible that all the images show smooth and composed of crowded cluster spherical shaped and rod nanostructures appearing different range for pure and metals doped CdO nanoparticles. We found that the average nanocluster size, as confirmed by SEM analysis, is 41.31 nm for pure cadmium oxide and 47.29 nm for metals doped cadmium oxide nanoparticles. In these scanning electron microscopy (SEM) images, we can see that the dopants are located between the crystal atoms, which cause the grain size to be larger than that of pure CdO nanoparticles. Scherer's formula applied to X-ray diffraction data yields a confirmed of 33.59 nm [37] for pure CdO nanoparticles and 31.23 nm for metals doped CdO nanoparticles as the average grain size. According to XRD analysis, the crystallite grain size was therefore very close to the value calculated from the SEM surface micrographs. The morphology image pure CdO in 3µm range and 5µm range shows that nanoparticles are clear cut of spherical rod shape.

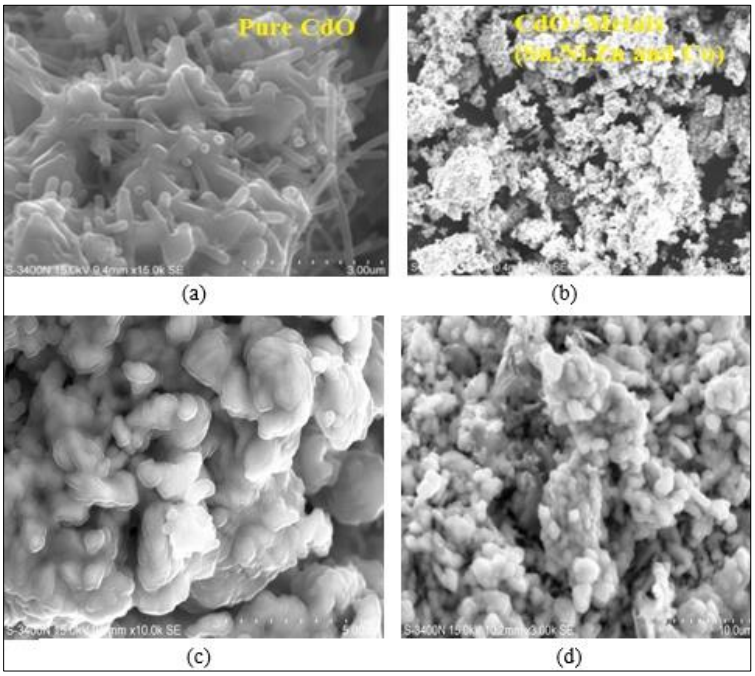

Fig 3: SEM images obtained on (a) and (c) pure CdO, (b) and (d) Metals (Sn,Ni,Zn and Co) doped CdO nanoparticles.

And image in 100µm range and 10µm range metals doping CdO shows that large crowded cluster spherical shaped nanostructures was found. The circumstance of large and more size particles should be ascribed to be the collection or overlapping of some small particles. So finally, it can be noted from the images that a particular orientation can be the explanation behind the collection of the nanoparticles into spherical rod shape will be formed. These structures like reduced particle size and increased large amount of boundary surface.

3.3. Fourier transforms infrared spectroscopy analysis

The showing of functional group can be carried out by Fourier transform infrared spectrum analysis. The absorption bands that appeared evidently belong to the organic functional groups of the synthesized nanopowders. Figure 4(a) and (b) shows the Fourier transform infrared spectral analysis of pure and metals doped CdO nanoparticles. The absorption bands at 3584.0 and 3456.1 cm-1 can be attributed to the asymmetrical and symmetrical stretching vibration bands of H_2O molecules, respectively. The observed vibration mode at 2925 and 838.9cm-1 can be assigned to the C-H asymmetrical and symmetrical stretching vibrations, respectively. The peak centered at 2426.3 cm-1 belongs to the absorption of CO_2 molecule from the air at the time of sample preparation. The specified weak peak at 1639.3 cm-1 and broad peak at 1383.6 cm-1 are assigned to C=O and C–O stretching vibrations of the carbonyl groups, respectively. Peaks below 1000 cm-1 is useful in understanding most of the metal oxide bonding. In this sense, the strong narrow absorption bands at 2426.3 cm-1 and weak peak at 685.5 cm-1 represents the Cd–O phase [38]. It is interesting to note that incorporation of metals (Sn, Ni, Zn and Co) atom reduces the broadness of the region between 1639.3 and 1271.3 cm-1, which implies that metals doping limits the vibration of carbonyl groups. Likewise, metals doping also reduces the absorption peak at 2426.3 cm-1. Therefore, the FTIR spectra confirmed the presence of Cd, Sn, Ni, Zn, Co and O atoms in the prepared samples.

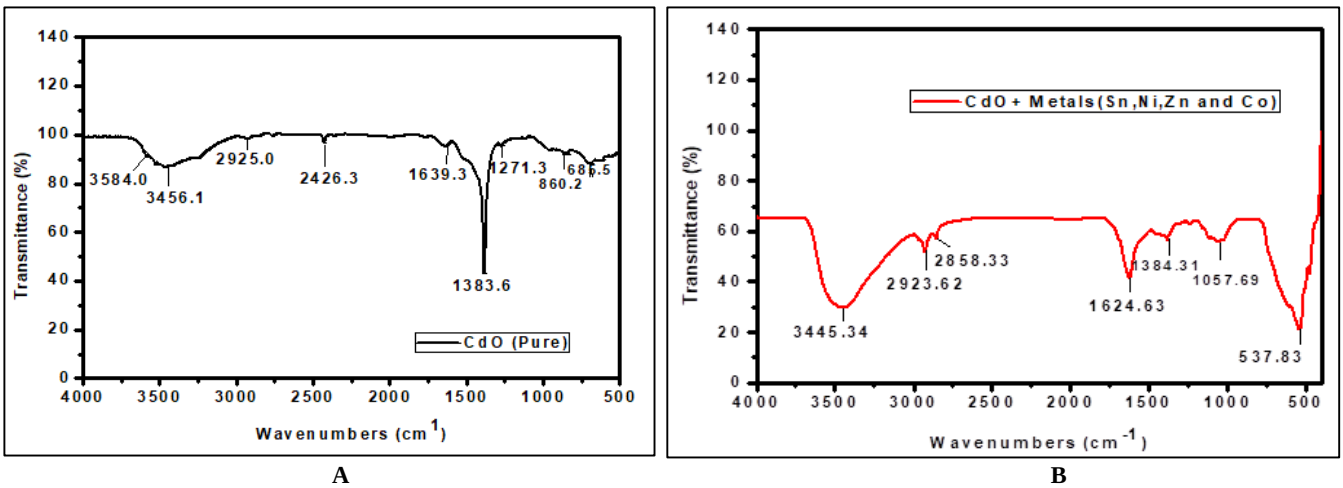

Fig.4. Depicts FT-IR spectrum of synthesized nanoparticles. (a) Pure CdO and (b) Metals (Sn, Ni, Zn and Co) doped CdO nanoparticles.

3.5. UV-Visible Analysis

The absorption spectra of the pure CdO and metals doped CdO nanoparticles were studied to scrutinize the optical properties. Figure 5(a) and (b) shows the UV–Vis absorption spectra of the prepared samples. The samples indicate absorption bands values below 450 nm as shown in the figure. The absorption spectrum of the pure CdO nanoparticles exhibits an excitonic absorption edge at 421 nm. The absorption peak of the metals doped CdO nanoparticles were shifted to 425 nm. The samples exhibit absorption bands of the pure and metals doped cadmium oxide nanoparticles indicates a blue shift which is due to the quantum confinement of created nanoparticles. This optical appearance shows that these nanoparticles indicate quantum size effect. The related band gap energy (*Eg*) for two samples has been calculated using the following equation.

$$E_g = \frac{hc}{\lambda_{max}} \quad (3)$$

Where, *h* is Planck's constant the value of (6.63 x 10^{-34} Js), c is the velocity of light the value of (3 x 10^{8} m/s), and λ_{max} is the excitonic absorption edge. The Fig. 6 shows the related band gap energy calculated to be pure CdO 2.47 eV and metals (Sn, Ni, Zn and Co) doped CdO 2.32 eV. Finally, UV–Vis analysis reveals that metals doping causes decrease in band gap energy of CdO nanoparticles. This decrease band gap energy makes its electrical conductivity will be high.

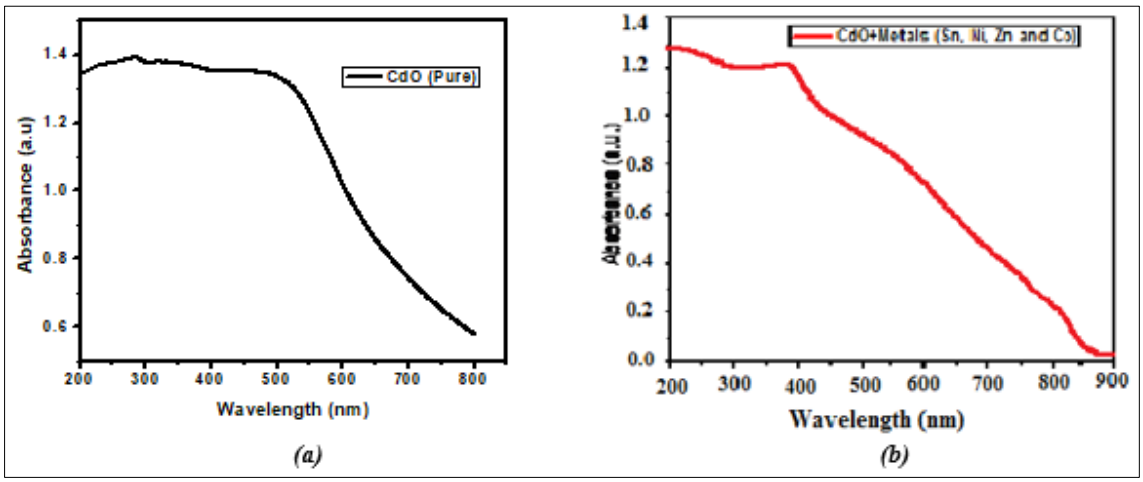

Fig 5: (a) and (b) UV-visible absorption spectra of pure CdO, and Metals doped CdO nanoparticles

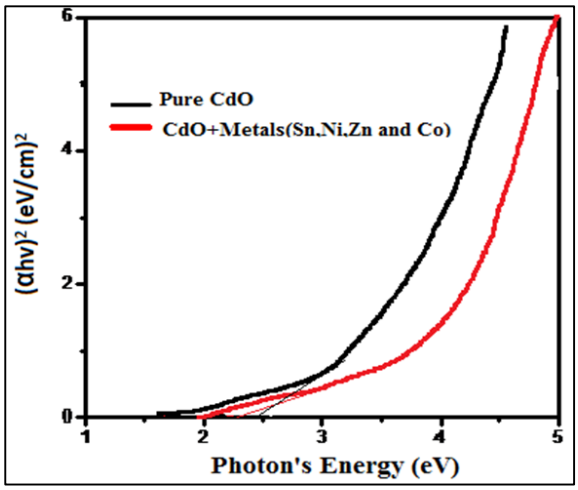

Fig 6: Optical band gap energy of pure CdO and metals doped CdO nanoparticles

3.6. Photoluminescence spectral analysis

Figure 7(a) and (b) shows the visible-light-measured photoluminescence spectra of pure CdO and metals doped CdO nanoparticles the wavelength range of 200 nm to 800 nm. CdO and metals doped CdO nanoparticles had excitation wavelengths (λ_{exi}) of 320 nm and 340 nm, respectively, providing more photonic energy to atoms in the valence band. Immediately, the photoluminescence emissions occurred at distinct wavelengths (λ_{emi}) due to the special nanomaterial combinations of the electrons from the conduction band and holes from the valence band. These spectra study two emission bands for the un-doped sample and three emission bands for the doping sample. The undoped cadmium oxide nanoparticles emit a one sharp and maximum violet light at 433 nm (photon energy of 3.26 eV) and a one weak green light at 566 nm (photon energy of 3.48 eV) as shown in the figure 7(a). Metals doped cadmium oxide nanoparticles emit a one weak red light colored fluorescence when illuminated with a wavelength of 686.51 nm (photon energy of 1.98 eV), whereas those two sharp and maximum wavelengths of doping materials exhibits 417.98 nm (photon energy of 3.1 eV) and 480.96 nm (photon energy of 2.75 eV) produce a more intense violet light and blue light respectively, as shown in the figure 7(b). It has been resulted that bulk CdO haven't show luminescence emission [39]. But we recorded weak luminescence behavior for un-doped CdO nanoparticles; it may be due to particles size effect. The metals doped CdO increases, the intensity of sharp bands violet emission also increases. It is the truth that the added one by one metal ion samples decrease the number of defect sites which results in increase in intensity of the emission.

3.7. Particle Size Analysis

Figure 8 (a) and (b) show that the diameter vs. intensity distribution of particle size analysis characterization using the nanoplus Dilution method. The particle size analyzer is used to characterize the size distribution of particles in a given pure CdO and metal doped CdO nanoparticles. There are different methods employed to measure particle size. Some particle size analyzer methods can be used for a wide range of samples and some other particle size analyzer methods can be used for specific applications. The nanoplus particle size Dilution methods can be utilized to average the diameter of

the particles. The Dilution method instrument can measure the particle size of pure CdO and metal (Sn, Ni, Zn and Co) doped CdO nanoparticles suspended.

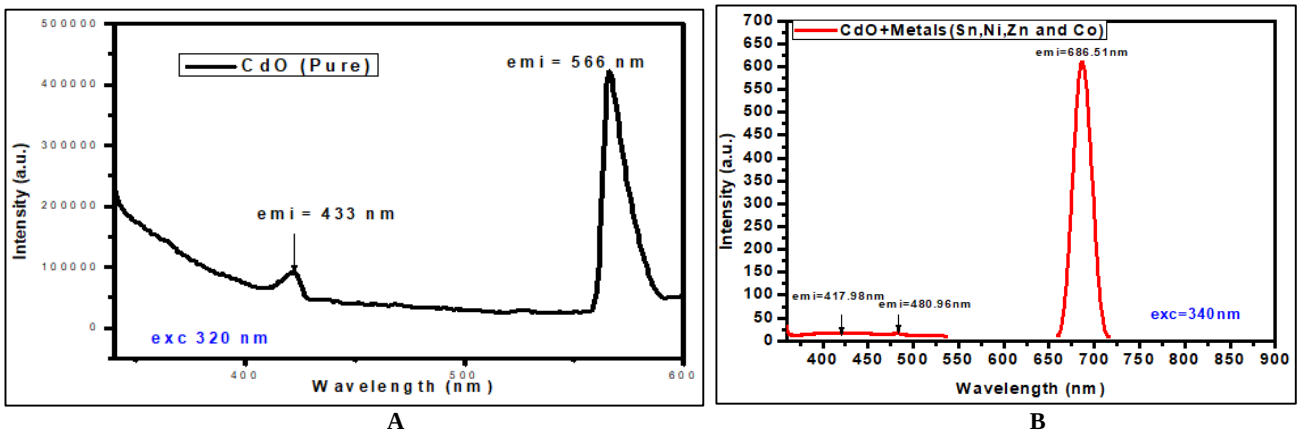

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Fig.7 (a) PL spectra of pure CdO nanoparticles (b) PL spectra of metals (Sn, Ni, Zn and Co) doped CdO nanoparticles.

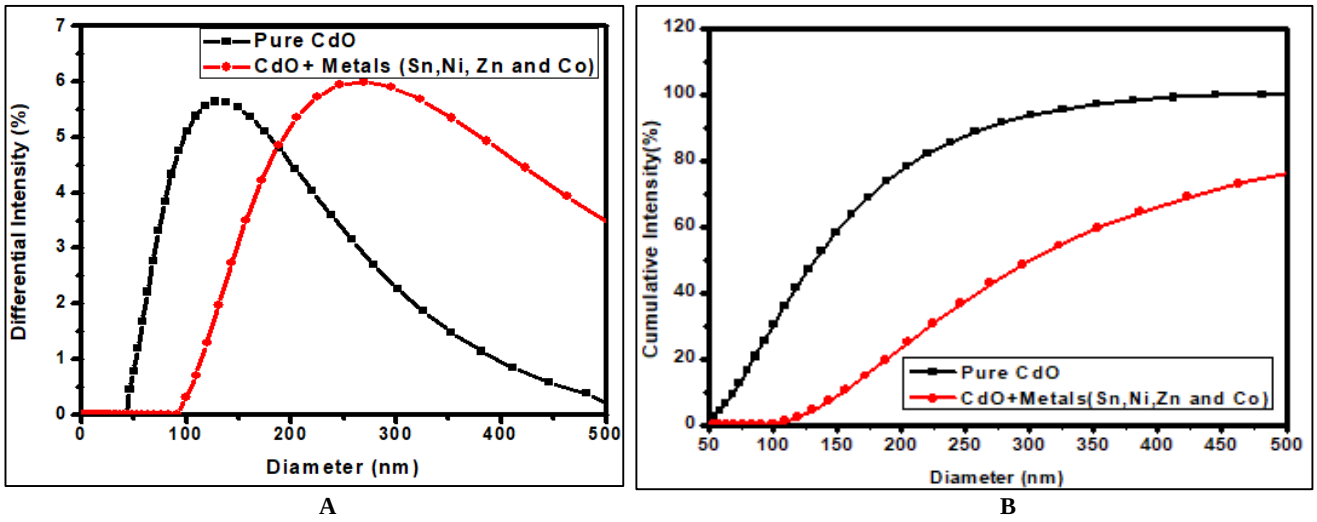

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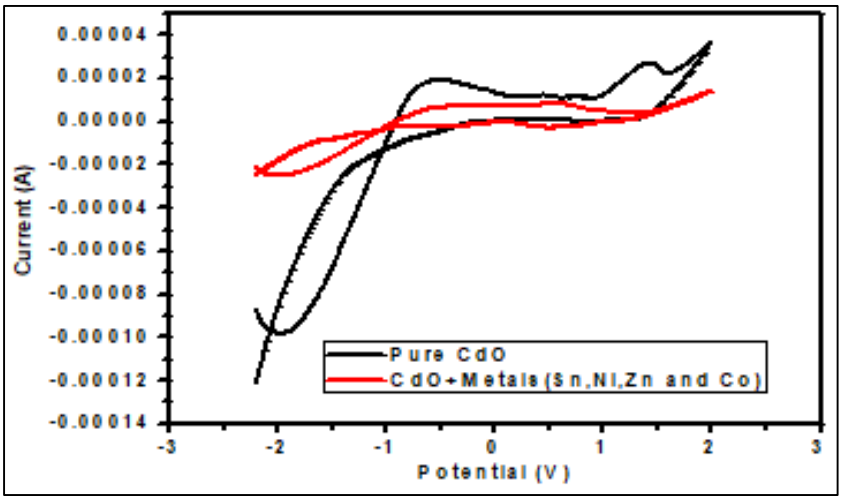
Fig 8: (a) and (b) Diameter vs. Intensity Distribution of pure CdO and metals doped CdO nanoparticles

In liquids in the range of 0.1 nm to 12.3µm with sample suspension concentrations from 0.00001% to 40% may be measured for their average diameter using this technique. In this present investigation, the average diameter of pure CdO nanoparticles was calculated to be 149.7 nm, while the average diameter of metals doped CdO nanoparticles was calculated to be 126.5 nm by means of a percentage of different intensity. Otherwise, if we convert the percentage of cumulative intensity into a particle size, we find that pure CdO nanoparticles have an average diameter of 120.4 nm, whereas metal doped CdO nanoparticles are 106.9 nm. Accordingly, we found that the particle diameters of the metals doped CdO nanoparticles were smaller than those of the pure CdO.

3.8. Electro chemical Analysis

The electrochemical characterization measurement of the synthesized nanoparticles was carried out by using Cyclic Voltammetry (CV) experiment. Fig. 9 indicates the electrochemical measurement of the pure CdO and metals doped CdO nanoparticles. Cyclic Voltammeter plot of pure CdO and metals doped CdO nanoparticles in a potential (V) range from -3.0 V to 3.0 V at scan rate value of from 10 mV/s as shown in the figure 9 (a). The pure cadmium oxide nanoparticles more conductive materials and encourages the charge transfer and conduction from the reactions. Contrarily, the Cyclic Voltammetry of pure CdO was indicates a narrow rectangle, manifest prove the appearance of the electrochemical performance and a small amount of capacitance. Furthermore, the increase in current values with the increase of scan rate in the Cyclic Voltammetry plot exhibit that the material is a highly accomplished supercapacitor. Figure 9 (a) shows that 10 mV/s single scan rate of pure CdO and metals doped CdO nanoparticles. The different scan rate (10 mV/s, 20 mV/s, 30 mV/s, 50 mV/s, 60 mV/s, 80 mV/s and 100 mV/s) values of pure and doping curves indicates fig. 9 (b) and (c). All the curves indicates not rectangular shapes but quasi - rectangular type of shape and are symmetrical in nature, which shows the perfect supercapacitor characteristics of pure CdO and metals doped CdO nanoparticles [40]. The redox probe reaction's electron transfer resistance (Rct) is indicates by the reaction's semi-circular diameter. The electrochemical Impedance measurement was investigated by the Nyquist plot (Zim vs Zre) of pure and doping materials. Fig.10 (a) and (b) shows, in the high-frequency domain, the charge-transfer resistance of redox reactions (Rct) caused by the diffusion of electrolyte with pure and metals doped CdO nanoparticles. In pure cadmium oxide, the Rct value is 7380.12 Ω, but in metals (Sn, Ni, Zn and Co) doped cadmium oxide; it is 43656.61 Ω, as

seen by the Nyquist plot as shown in the figure. The Hence, the magnificent electrochemical activity of the pure CdO and metals doped CdO nanoparticles. Such dramatic shifts happened because the probe redox electron transport was sped up at the metals doped CdO surface. However, because of their higher-level electrochemical activity, CdO and metals doped CdO may be used as electrodes in a high performance energy storage super capacitor.



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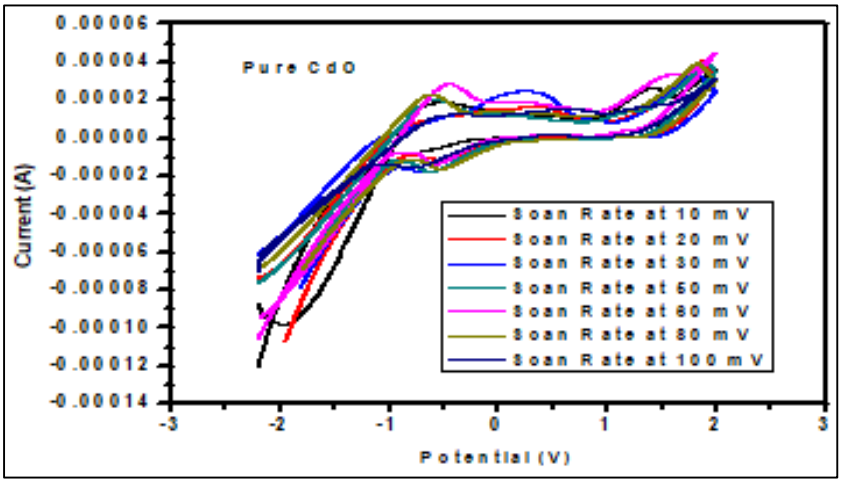

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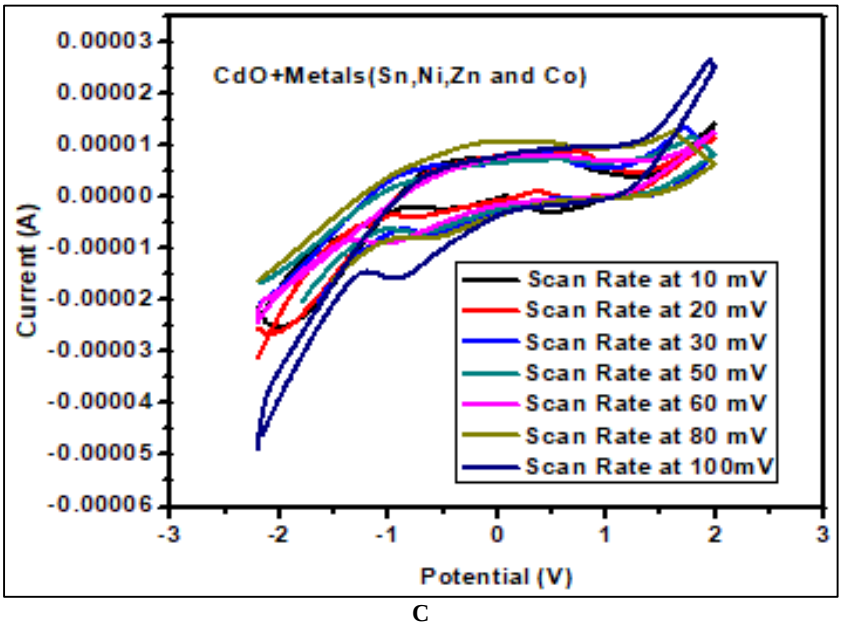

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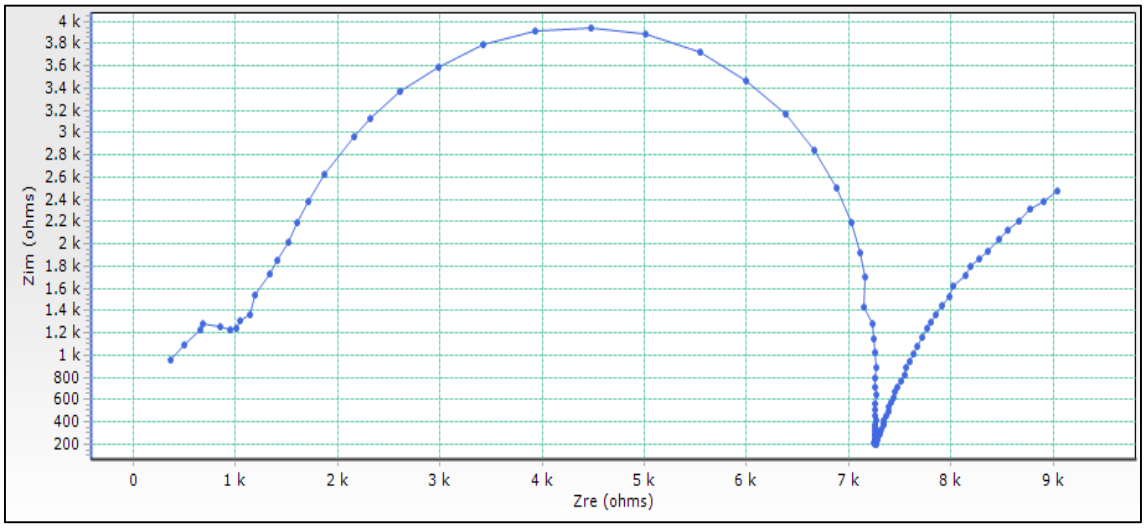
Fig 9: CV properties of selected samples. (a) CV Curve of pure CdO and metals doped CdO nanoparticles. (b) Different CV scan rate of pure CdO nanoparticles. (c) Different CV scan rate of metals (Sn, Ni, Zn, and Co) doped CdO nanoparticles



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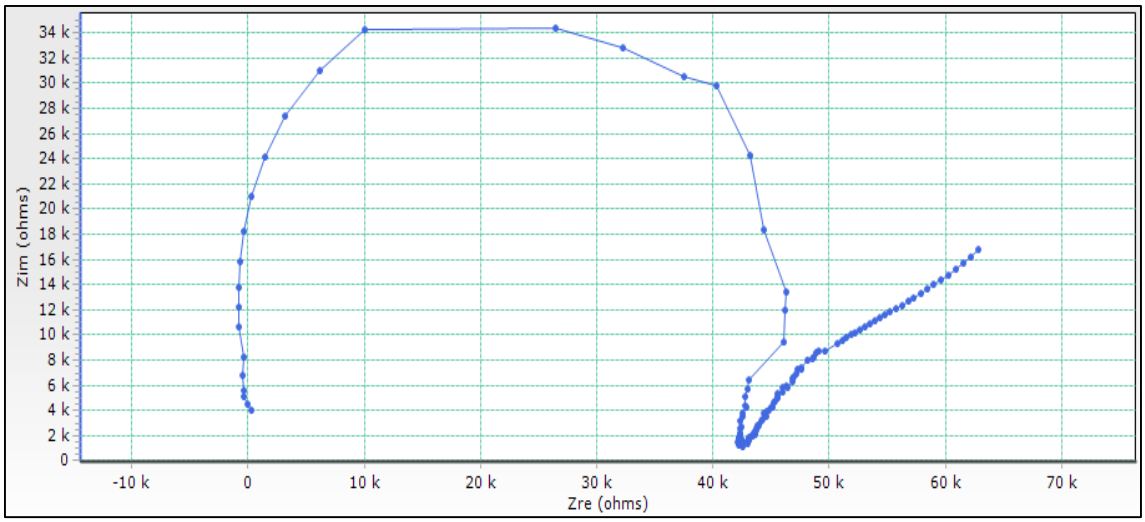

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Fig 10: (a) and (b) Z_{im} vs. Z_{re} Plot of pure CdO and metals doped CdO nanoparticles

3.9. Magnetic Studies

Figure 11 shows the magnetic hysteresis (M-H) loops at room temperature for the pure and some metal doped (Sn, Ni, Zn and Co) CdO nanoparticles (0.8M% for pure material and 0.3M% for doped material) using vibrating sample magnetometer (VSM). The demonstrated that magnetizations loop of pure and doping materials was recorded in the range of ± 15000 G at room temperature. The magnetic field versus magnetization curve both pure and doping materials shows that the composite is diamagnetic behaviour and also little amount of change. The diamagnetism behaviour has been attributed to the fact that d-electrons are completely paired. The resultant magnetic properties depend on synthetic methodologies, concentration, and site occupation, size of quantum dots, or cluster, and shape of the host materials [41, 42]. Furthermore, the magnetic behaviour of the prepared samples depends on the magnitude of the transition metal ion with the electronic levels. Finally, synthesize these types of materials from which we can find promising to better magnetic activities.

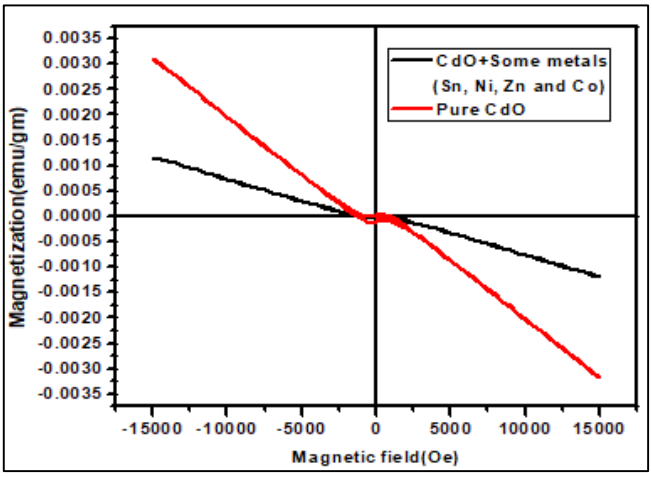

Fig. 11: Magnetic hysteresis loop of the Pure (0.8M) CdO and metals (0.3M) doped CdO Nanoparticles and Vibrating Sample magnetometer a reaction temperature of room

4. Conclusion

The synthesis, characterization and electrochemical super capacitor activities of undoped and some metals doped CdO nanoparticles were discussed in this work through a co-precipitation process. The synthesized samples were analyzed numerous characterization approach such as XRD, SEM, FTIR, UV-vis spectral analysis, PL, particle size analysis and Cyclic Voltammetry analysis. The X-Ray Diffraction analysis patterns shows that metals doped CdO increases crystallite size and also revealed a polycrystalline having the characteristic peaks are well matched with the phase purity of cubic structure. The Scanning electron microscope investigation disclosed the sample exhibited a spherical rod shape for the pure sample and a large crowded cluster spherical shape for the doping sample, and also crystalline and average grain size of the particles were determined from XRD patterns. FTIR spectra, analysis observed the Cd-O stretching vibration bond formation and the other functional groups have been confirmed. The optical band gap of pure and doping samples was found to be 2.47 eV and 2.32 eV respectively. The band gap of CdO is much greater than that of some metals doping by analyzing UV-vis spectrum. The photoluminescence spectrum study decides that the samples are enhanced in the intensity of the violet emission. The particle size analysis calculated that the average diameter of cadmium oxide particles was 149.7 nm and 126.5 nm for pure and doped CdO, respectively, whereas the average diameter was 120.4 nm and 106.9 nm for all two combinations, respectively, when analyzed using the percentage of cumulative intensity of dilution method. The Cyclic Voltammetry analysis was performed on pure and doped CdO electrodes to probe capacitive behavior for electrochemical studies and also, the super capacitor character was confirmed by a Nyquist plot showing Rct values of 7380.12 Ω for CdO and 43656.61 Ω for some metals-doped CdO. VSM data reveals diamagnetic behavior in pure and doping materials at room temperature. Therefore, based on the study presented here, it is concluded and discussed here that it can be used to fabricate some low-cost nanomaterial's and may be possible for electrochemical super capacitor applications.

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