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Optical Parapets and Electrical Conductivity of Ni $_X$ Co$_{1-X}$ O$_2$ Nanomaterials in Different Molar

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Abstract: *Nickel Oxide doped by Cobalt Oxide (Ni $_X$ Co$_{1-X}$ O$_2$) at different molar (0.1, 0.3, 0.5, 0.7and 0.9) Nanomaterial made by sol gel method. Optical properties were investigated for Ni $_X$ Co$_{1-X}$ O$_2$ Nanomaterials that made by using UV-VS min 1240 spectrophotometer. The absorption of Ni $_X$ Co$_{1-X}$ O$_2$ Nanomaterials samples are rapid increase at wavelengths 574nm corresponding photon energy 2.16 eV by molar increase , the value of absorption coefficient (α) equal 0.416x10^3 cm^{-1} for NiCoO$_4$m Molar0.9 m Molar sample in the visible region574 nm but for NiCoO$_4$0.1 m Molar sample equal 0.316x10^3 cm^{-1} at the same wavelength , this means that the transition must corresponding to un direct electronic transition, the value of (Eg) of NiCoO$_4$0.9 m Molar sample obtained was 1.7595 eV while for other sample NiCoO$_4$0.1 m Molar sample obtained was 1.7713 eV .The high magnitude of optical conductivity (11.47x10^{11} sec^{-1}) confirms the presence of very high photo-response of Ni $_X$ Co$_{1-X}$ O$_2$ Nanomaterials samples.*

Keywords: *Nickel Oxide, Cobalt Oxide different molar, optical properties, UV-VS min 1240 spectrophotometer and Optical Conductivity.*

Introduction

Recently, Nickel Oxide NiO has been investigated as a type of important inorganic material [1]. The NiO is a crucial material that can be grown and used in a wide range of applications, such as solar cell[2], capacitor[3], and rechargeable lithiumion batteries[4]. In addition, NiO nanoparticles have attracted and great attention because of their potential applications and their specific physical and chemical properties1.The structure, calcination temperature [1, 5] and pH value [1,6] of the solution must be controlled to produce pure NiO nanoparticles. These parameters affect the size1,5, distribution1 and morphology1 of the particles. The specific physical and chemical properties of pure NiO can be determined if pure NiO is produced. Sol-gel is a suitable method to synthesize NiO nanoparticles because it exhibits homogeneoeus mixing7, better crystallinity [7], uniform particle distribution, and smaller particle size [7]. Cobalt oxide-based materials are suitable candidates for the construction of solid-state sensors [8], heterogeneous catalysts,[9] electrochromic devices [9], and solar energy absorbers.[10]. To our knowledge, there are few reports about the production of cobalt oxide nano- tubes. The major example that we are aware of is the cobalt oxide nanofibers prepared by Martin and coworkers using the sol-gel method combined with a membrane-based synthesis.

This work aims to synthesize Nickel Oxide doping by Cobalt oxide (Ni $_X$ Co$_{1-X}$ O$_2$) nanoparticles through sol-gel method. Several characterizations were conducted to ensure the quality of the synthesized (Ni $_X$ Co$_{1-X}$ O$_2$) nanoparticles. Characterizations for Optical properties as like (absorbance , transmission, reflection , absorption coefficient ,extinction coefficient ,refractive index ,optical energy band gap and optical and electrical conductivity).

Material & Method

Nickel (II) nitrate hexahydrate [Ni $(NO_3)_2 \cdot 6H_2O$, Merck] was dissolved in 20 ml of isopropanol alcohol [$(CH_3)_2CHOH$, Merck] and 20 ml of polyethylene glycol [H (OCH_2CH_2)nOH), Merck]. The solutions were stirred with a magnetic stirrer for 24 hours until chemically dissolved. Ammonium hydroxide (NH_4OH, Merck) was added until solutions reached pH 11. Triton X-100 [$C1_4H_{22}O$ (C_2H_4O)n, Sigma Aldrich] was added to avoid particle agglomeration. Then cobalt nitrate was dissolved in 20 ml of isopropanol alcohol stirred with magnetic stirrer for 24 hours to , Ammonium hydroxide (NH_4OH) was added until solution reached pH 11,and Triton X-100 [$Cl_4H_{22}O(C_2H_4O)$ was added to .Max the tow solvents by rat Ni $_X$ Co$_{1-X}$ O$_2$, and the mix solutions were gradually heated at 80 °C until gel was formed. The gel was dried at 200 °C and then ground. The Optical properties as like (absorbance , transmission, reflection , absorption coefficient ,extinction coefficient ,refractive index ,optical energy band gap and optical and electrical conductivity) of Ni $_X$ Co$_{1-X}$ O$_2$ sample were measured as a function of wavelength by UV-visible spectroscopy.

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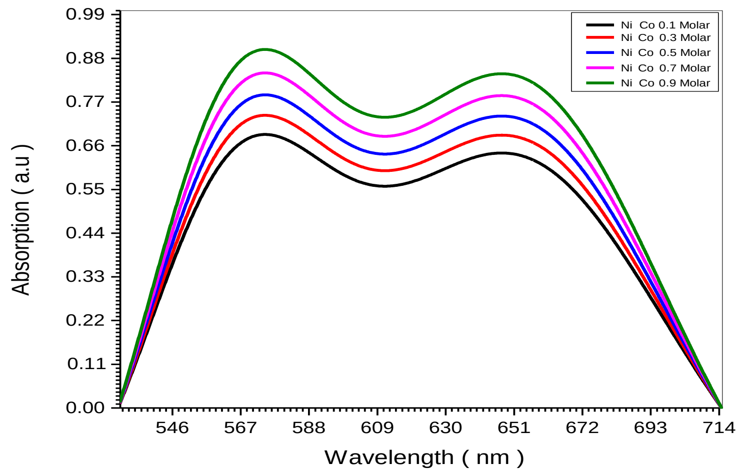
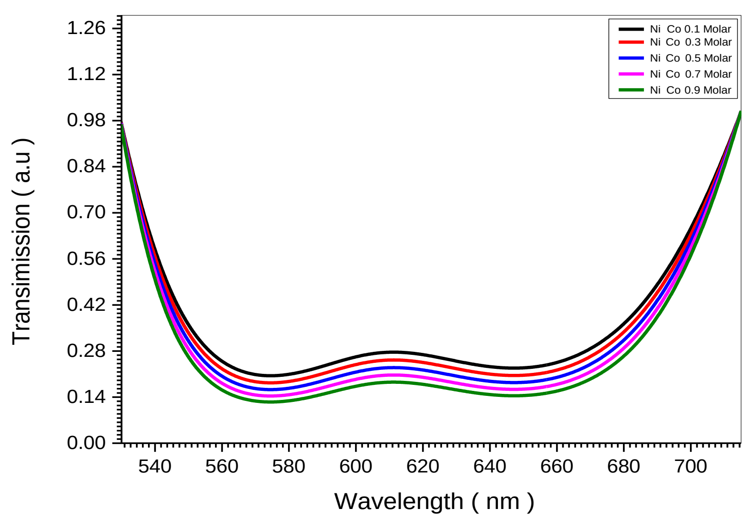
Results and Discussion

After made Ni $_X$ Co_{1-X} O_2 Nanomaterials by sol gel method in different molar (0.1, 0.3, 0.5, 0.7 and 0.9) used UV-VS min 1240 spectrophotometer to study the Optical properties (absorbance, transmission, reflection, absorption coefficient, extinction coefficient, refractive index, optical energy band gap and optical and electrical conductivity) as showing in the results blow.



Fig(1) relation between absorbance and wavelengths of five Ni $_X$ Co_{1-X} O_2 samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar



Fig(2) relation between transisimission and wavelengths of five Ni $_X$ Co_{1-X} O_2

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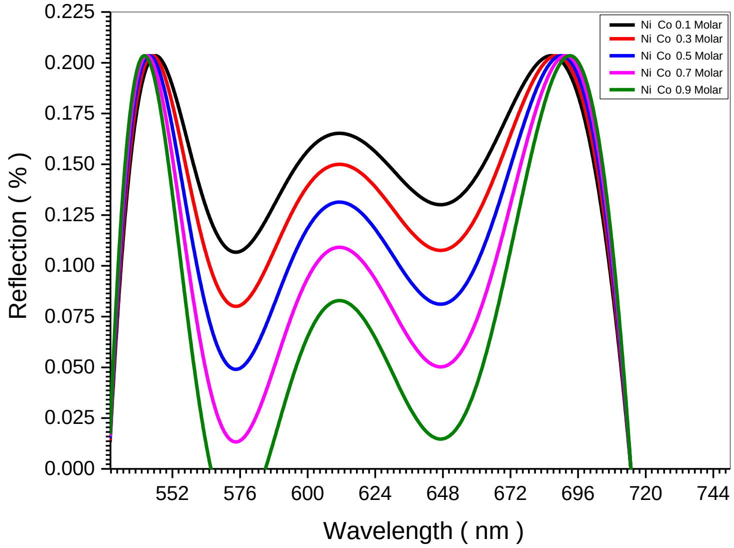
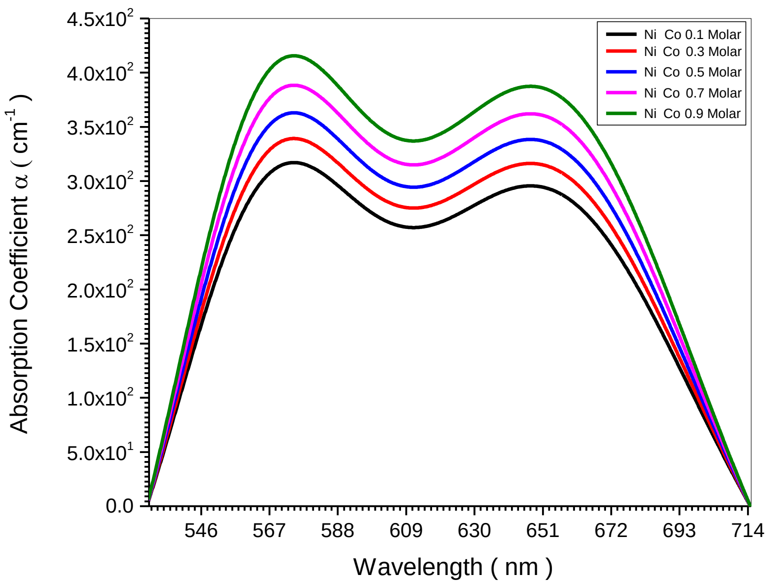
samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar



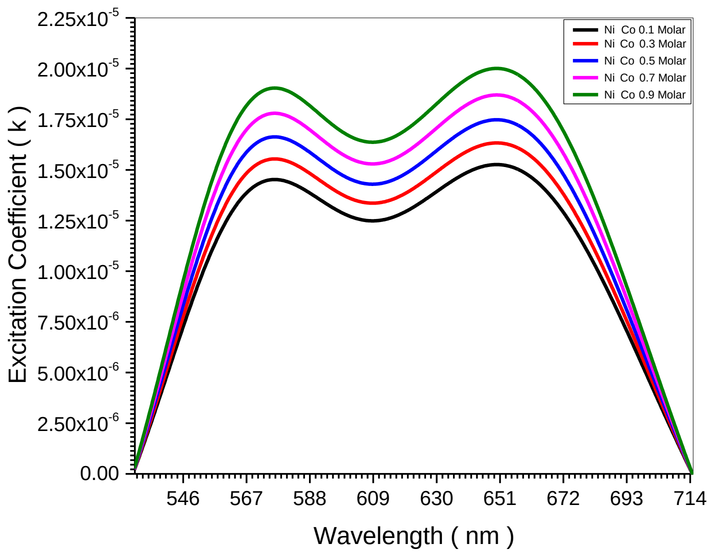
Fig(3) relation between reflection and wavelengths of five Ni $_X$ Co_{1-X} O_2

samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar

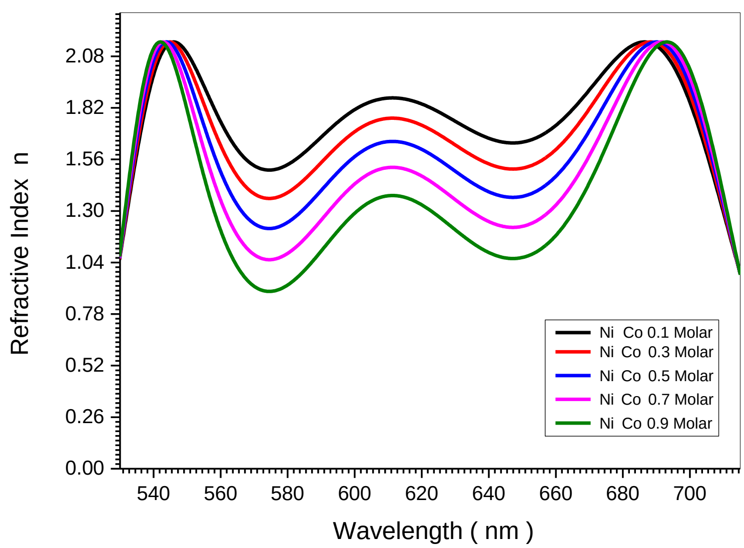


Fig(4) relation between absorption coefficient and wavelengths of five Ni $_X$ Co_{1-X} O_2

samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar



Fig(5) relation between exctintion coefficient and wavelengths of five Ni $_X$ Co_{1-X} O_2 samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar



Fig(6) relation between refractive index and wavelengths of five Ni $_X$ Co_{1-X} O_2 samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar

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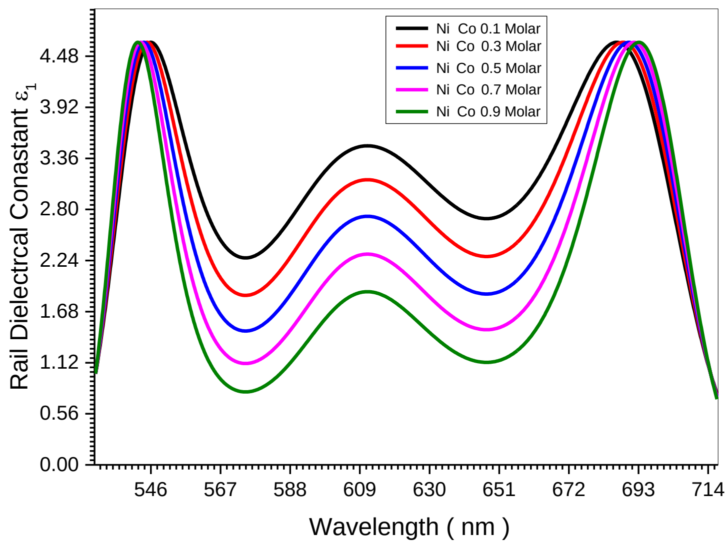
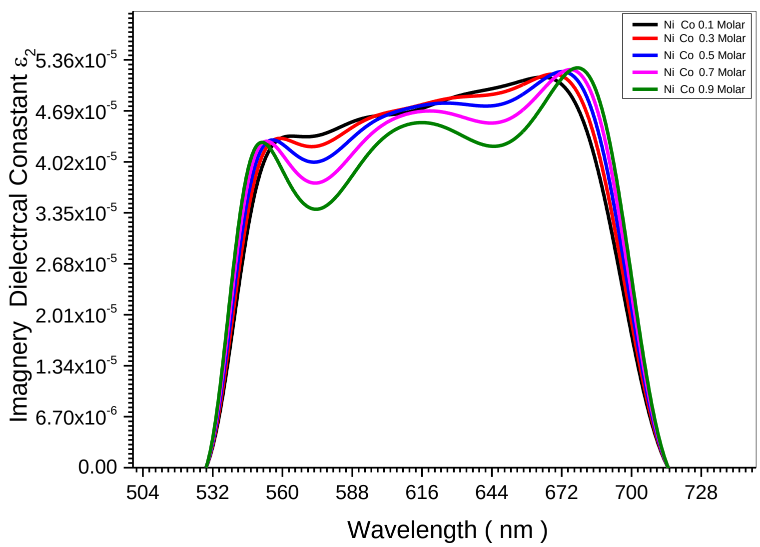
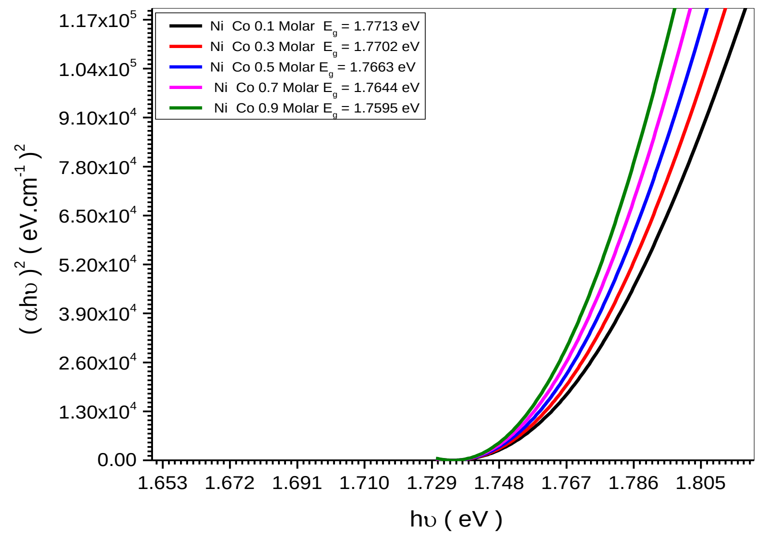


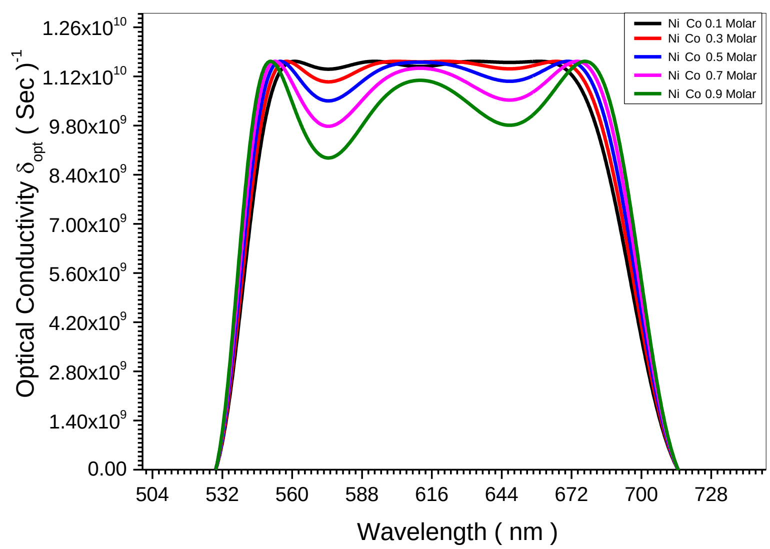
Fig(7) relation between rail dielectrical conastant and wavelengths of five Ni $_X$ Co_{1-X} O_2 samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar



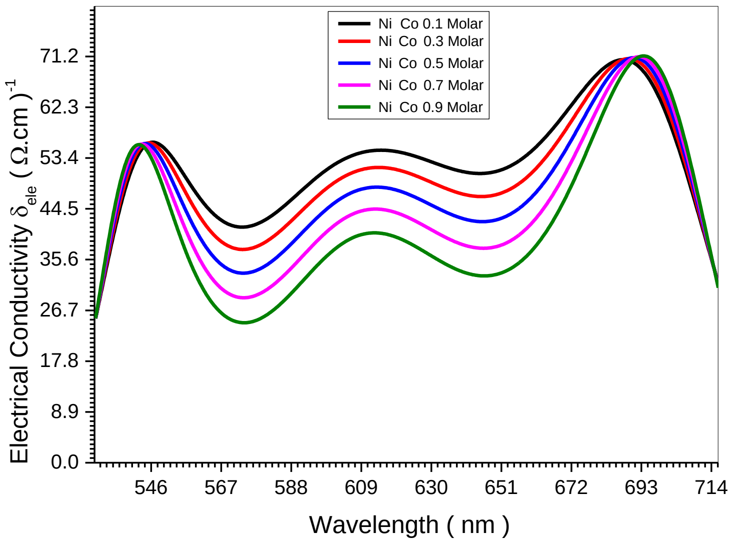
Fig(8) relation between imaganery dielectrical conastant and wavelengths of five Ni $_X$ Co_{1-X} O_2 samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar



Fig(9) optical energy band gap of five $Ni_X Co_{1-X} O_2$ samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar



Fig(10) relation between optical conductivity and wavelengths of five $Ni_X Co_{1-X} O_2$ samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar



Fig(11) relation between electrical conductivity and wavelengths of five Ni $_X$ Co_{1-X} O_2 samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar

Discussion Optical Results of (Ni $_X$ Co_{1-X} $O_{2)}$ samples

The absorbance we found the behavior of curves is the same for five Ni $_X$ Co_{1-X} O_2 samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarstudied using UV-VS min 1240 spectrophotometer. Show all results of absorbance in fig (1). In fig. (1) shows the relation between absorbance and wavelengths for five samples of Ni $_X$ Co_{1-X} $O_{2,}$ the rapid increase of the a absorption at wavelengths 574nm crosponding photon energy 2.16 eV by molar increase. Transission we found the behavior of curves is the same for five samples of five Ni $_X$ Co_{1-X} O_2 **samples** (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar that showing in fig (2). In fig. (2) shows the relation between transission and wavelengths for five Ni $_X$ Co_{1-X} O_2 samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molar, the efficet of molar on the transission was increase molar decrease transission value . Reflection with five samples of five Ni $_X$ Co_{1-X} O_2 samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar that showing in fig (3). In fig. (3) shows that the reflection for five samples of $NiCoO_4$ was maximal value in tow area the first one in-ranged (540 to 610) nm the second (620 to 700) nm in this tow point the samples become mirrors. The efficet of molar on the refelection was increase doping the transission in red sheft in first point and plue sheft in the second point . The absorption coefficient (α) of the five prepared sample by Ni $_X$ Co_{1-X} O_2 in different molar (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarwere found from the following relation $\alpha = \frac{2.303xA}{t}$ where (A) is the absorbance and (t) is the optical legth in the samples[11] . In fig (4) shows the plot of (α) with wavelength (λ) of five Ni $_X$ Co_{1-X} O_2 samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molar, which obtained that the value of $\alpha = 0.416x10^3$ cm^{-1} for $NiCoO_4$m Molar0.9 m Molar sample in the visiable region574 nm but for Ni $_X$ Co_{1-X} O_2 0.1 m Molar sample equal $0.316x10^3$ cm^{-1} at the same wavelength , this means that the transition must corresponding to un direct electronic transition, and the properties of this state are important since they are responsible for electrical conduction. Also, fig.(4) shows that the value of (α) for the five samples of five Ni $_X$ Co_{1-X} O_2 samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarincrease while molar increased . Extinction coefficient (K) was calculated using the related $k = \frac{\alpha\lambda}{4\pi}$ [11]. The variation at the (K) values as a function of (λ) are shown in fig. (5) for five Ni $_X$ Co_{1-X} O_2 samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarand it is observed that the spectrum shape of (K) as the same shape of (α). The Extinction coefficient (K) for five $NiCoO_4$ samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarin fig.(5) obtained the value of (K) at the 574 nm wavelength was depend on the samples treatment method , where the value of (K) at 574 nm for Ni $_X$ Co_{1-X} O_2 0.9 mMolar sample equal $1.9x10^{-5}$ while for other sample Ni $_X$ Co_{1-X} O_2 0.1 mMolar at the some wavelength equal $1.44x10^{-5}$ .The effects of Cobalt molar on Ni $_X$ Co_{1-X} O_2 samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarsamples was increased the molar increased Extinction coefficient (k).The optical energy gap (Eg) has been calculated by the relation $(\alpha h\upsilon)^2 = C(h\upsilon - Eg)$ where (C) is constant[11] . By plotting $(\alpha h\upsilon)^2$ vs photon energy (hυ) as shown in fig.(6) for the five Ni $_X$ Co_{1-X} O_2 samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarsamples . And by extrapolating the straight thin portion of the curve to intercept the energy axis , the value of the energy gap has been calculated .In fig (6) the value of (Eg) of Ni $_X$ Co$_{1-X}$ O$_2$ 0.9 m Molarsample obtained was 1.7595 eV while for other sample Ni $_X$ Co$_{1-X}$ O$_2$ 0.1 m Molarsample obtained was 1.7713 eV.The value of(Eg) was decreased from 1.7713 eV to 1.7595 eV. The decreasing of (Eg) related to increased of molar on the samples. It was observed that the different e molar for five $NiCoO_4$ samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarsamples confirmed the reason for the band gap shifts . The refractive index (n) is the relative between speed of light in vacuum to its speed in material which does not absorb this light. The value of n was calculated from the equation $n = [\left(\frac{(1+R)}{(1-R)}\right)^2 - (1 + k^2)]^{\frac{1}{2}} + \frac{(1+R)}{(1-R)}$ Where (R) is the reflectivity[11,12] . The variation of (n) vs (λ) for five samples was treetetment by Ni $_X$ Co$_{1-X}$ O$_2$ samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarsamples is shown in fig.(7). Fig (7) Show that relationsheep of five Ni $_X$ Co$_{1-X}$ O$_2$ samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarsamples refractive index (n) spectra,which shows that the maximum value of (n) is 2.146 for all samples at tow area the first one in ranged (540 to 550) nm the second (584 to 594) nm, the first point was agreement with blue sheft , and the second point and read shefte by increase for molar . Also we can show that the value of (n) begin to decrease befor 540 nm and after 700 nm of region spectrum . The Real Dielectric Constant (ε_1) as showing in fig(8) shows the variation of the realdielectric constant (ε_1) with wavelengthof five samples prepared by five Ni $_X$ Co$_{1-X}$ O$_2$ samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarsamples form, which calculatedfrom the relation $\varepsilon_1 = n^2 - k^2$ [11,12] .Where the real the dielectric (ε_1) is the normal dielectric constant . From fig (8) the variation of (ε_1) is follow the refractive index, where at tow area the first one in ranged (540 to 550) nm the second (584 to 594) nm for all samples of Ni $_X$ Co$_{1-X}$ O$_2$ samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molardifferent molar , where theabsorption of the samples at these wavelength is small, but the polarizationwas increase. The maximum value of (ε1) equal to 4.64at at tow area the first one in-ranged (540 to 550) nm the second (584 to 594) nm equal 4.66. The effect of treetetment by molar (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molaron the (ε1) was red sheft on the first point and plue shefte on the second point by increase for molar . The imaginary dielectric constant (ε_2) vs (λ) was shown in fig(9) this value calculated from the relation $\varepsilon_2 = 2nK$ [11,12] , (ε_2) represent the absorption associated with free carriers.As shown in fig(9) the shape of (ε_2)is the same as (ε_1), this means that the refractive index was dominated in these behavior . The maximum values of (ε_2) are different according to the tratment operation , so the maximum value of (ε1) equal to 4.64 at at tow area the first one in ranged (540 to 550) and equal 4.66 in the second point (584 to 594) nm. But for the imaginary dielectric constant (ε_2) of five Ni $_X$ Co$_{1-X}$ O$_2$ samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molar samples but (ε_2) for this sample equal ($42.9x10^{-4}$) for first point and ($52.8x10^{-4}$) for the second point,these behavior may by related to the different absorption mechanism forfree carriers. The optical conductivity is a measure of frequency response of material when irradiated with light which is determined using the following relation, $\delta_{opt} = \frac{\alpha n c}{4\pi}$ Where (c) is the light velocity[13]. The electrical conductivity can be estimated using the following relation $\delta_{ele} = \frac{2\lambda\delta_{opt}}{\alpha}$ [13]. The high magnitude of optical conductivity ($11.47x10^{11}$ sec^{-1}) confirms the presence of very high photo-response of the five samples prepared forfive Ni $_X$ Co$_{1-X}$ O$_2$ (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarsamples . The increased of optical conductivity at high photonenergies is due to the high absorbance of five Ni $_X$ Co$_{1-X}$ O$_2$ (0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molarsamples formand may be due to electron excitation by photon energy as it is shown in Figs (10) and (11) .

Conclusion

The (Ni $_X$ Co$_{1-X}$ O$_2$) nanoparticles were successfully synthesized through the sol-gel method. The refractive index maximum value is 2.146 for all Ni $_X$ Co$_{1-X}$ O$_2$ samples at tow area the first one in-ranged (540 to 550) nm the second (584 to 594) nm. The value of Optical energy band gap (Eg) for Ni $_X$ Co$_{1-X}$ O$_2$ samples was decreased from 1.7713 eV to 1.7595 eV. The decreasing of (Eg) related to increase of molar on the samples. It was observed that the different e molar for five Ni $_X$ Co$_{1-X}$ O$_2$ samples (0.1, 0.3, 0.5, 0.7 and 0.9) m Molar samples confirmed the reason for the band gap shifts.

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