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### Preparation and studying Structural and Electrical properties of nano $\text{Co}_3\text{O}_4$

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#### ABSTRACT

In this study (Cobalt oxide) nano powder prepared using sol-gel method with a crystallite size 22 nm By testing XRD and by matching with card (JCPDS) files No.( 00-042-1467). Electrical and dielectric properties like (Dielectric constant, resistivity, electrical conductivity) are studied by LCR meter with frequency range from (50 Hz) to (5 MHz ). It was noted that the resistivity and dielectric constant was decreasing while electrical conductivity increased with increased frequency .

#### Introduction

Nanotechnology is science of the production, industry, and used of sub-atomic materials to synthesis new materials and processes [1]. A year ago nanoparticles of noble metals oxides have been the subject of concentrated research because of their optical, electronic, mechanical, and magnetic properties [2].

Nanomaterials have been extensively studied for fundamental scientific and technological interests in reaching new categories of materials with unprecedented properties and applications [3-5]. The  $\text{Co}_3\text{O}_4$  is important material used in electrochromic films, gas sensors, battery cathodes and magnetic catalysts and heterogeneous [6,7].  $\text{Co}_3\text{O}_4$  nanoparticles were manufactured in various ways such as sol-gel, polymerization [8-9]

$\text{Co}_3\text{O}_4$  is a semiconductor type p important anti-viral magnetic with excellent properties such as gas sensing, electrochemical properties, and has been widely studied for applications in solid sensors, electromechanical devices as well as lithium batteries [10-12]. Thus tremendous efforts have been directed in recent years to manufacture and investigate the properties of the  $\text{Co}_3\text{O}_4$  nanostructures.

Among the many methods developed for the formation of micro-powders of metal oxides, the method of metallic organic precursor precursors has been considered one of the most appropriate methods, because it only avoids complex tools and processes

and extreme preparation and also provides good control over the purity, composition, homogeneity, phase and microscopic structure of the resulting products [13]

$\text{Co}_3\text{O}_4$  nanotubes were prepared by decomposition of carbon dioxide, while semi-spherical nanoparticles with an average volume of about (15-25) nm were manufactured by bis (2-hydroxyacetophenato) (cobalt II) [14]. The study suggests that primers can be very important to synthesize nano materials in different sizes and shapes, For the main interest at present in the development of organic or inorganic compounds for the preparation of nanoparticles. Using a composite can be useful And opened a new way to prepare nanomaterials to control the size and distribution of nanostructures.

#### Experimental details

cobalt nitrate (25gm) was dissolved in (25 ml) of deionized water at (24°C) in a beaker and then placed on a magnetic stirrer . Urea (10gm) was added to the solution. The solution was filtered to remove any insoluble impurities .The solution was heated at (100°C) for (1hrs) to produce transparent gel The gel of ( $\text{Co}_3\text{O}_4$ ) was heated at (250°C) for (1hrs) to produce a powder of ( $\text{Co}_3\text{O}_4$ ) with particle size 22 nano by using Debye-Scherrer formula, then the powder designed as a mold of pellet in diameter (1cm) and thickness (5mm) .

## Result and discussion

### X – ray diffraction

X-ray test is very important characterization it used in materials science. XRD is an easy method to compute the size and state the shape of the unit cell for any compound. The results of X-ray diffraction show that the material prepared at (250°C) is cobalt oxide after comparison with international card (JCPDS) files No.(00-042-1467) by matching with the planes (111), (220), (311), (222), (400), (422), (511), (440), (531), (622). the XRD of  $\text{Co}_3\text{O}_4$  prepared at (250°C) is shown in fig (1).

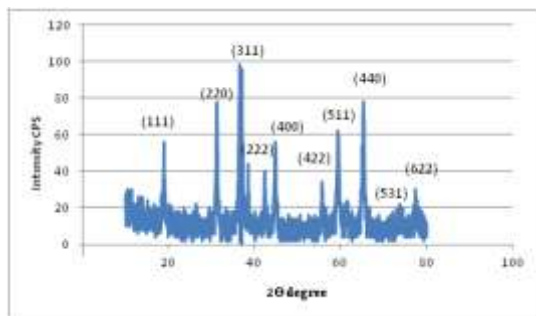


Fig. 1: XRD of nano  $\text{Co}_3\text{O}_4$

The crystallite size of Cobalt Oxide was calculated using the Debye -Sherrer equation using the the angle of highest peak and taking the width of middle the highest peak , as the equation (1)

$$D = K \lambda / \beta \cos(\theta) \quad \dots\dots\dots(1)$$

Where :  $D$  is the crystal size

$\lambda$  is wave length of Cu =  $1.54059 \text{ \AA}$

$K$  is constant =0.9

$2\theta$  is the angle of highest peak = $36.8$

$\beta$  is width of middle the highest peak in radian .

And by apply this information in the Debye – sherrer equation show the crystal size is 22 nm .

### Electrical properties of $\text{Co}_3\text{O}_4$

#### The dielectric constant of (cobalt oxide)

The dielectric constant was determined by LCR meter for a wide range of frequency reaches  $5 \times 10^6 \text{ Hz}$  and it is high at low frequencies and it decrease with increasing of frequency as shown in the figure (2).

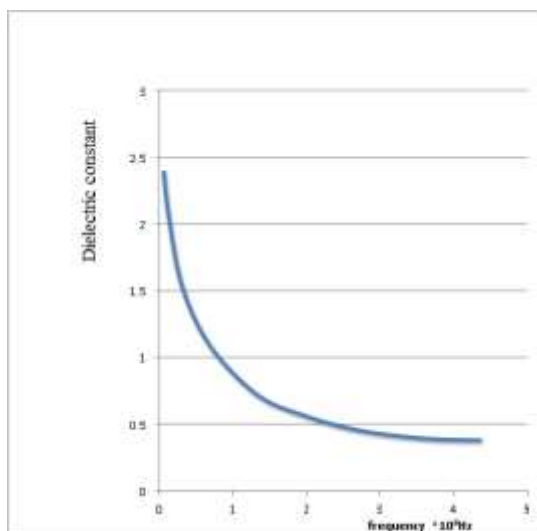


Fig. 2: variation of dielectric constant with frequency

the dielectric constant is high and later decreases with increasing frequency. because there are different polarization in four types (ionic, electronic, dipolar and space charge), but in high frequency some of polarization contributions relax out, result in the lowering of dielectric constant[8] .

### Electrical conductivity

The conductivity ( $\sigma$ ) of the sample is computed from LCR meter The conductivity is taken for a wide range of frequency .the electrical conductivity is increased with increases frequency ,it is because of increase in mobility of electron and this leads to increase in electrical conductivity[8] and shown in Figure (3).

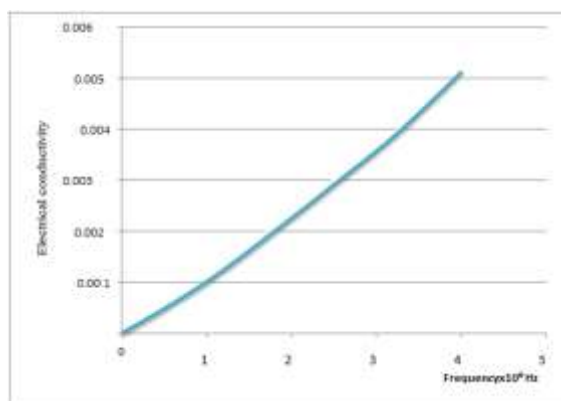


Fig. 3: The variation of electrical conductivity with frequency

### Electrical resistivity

The electrical resistivity of the sample is very high at low frequency and decrease gradually with increasing the frequency and it taken for a wide range of frequency as shown in the figure (4).

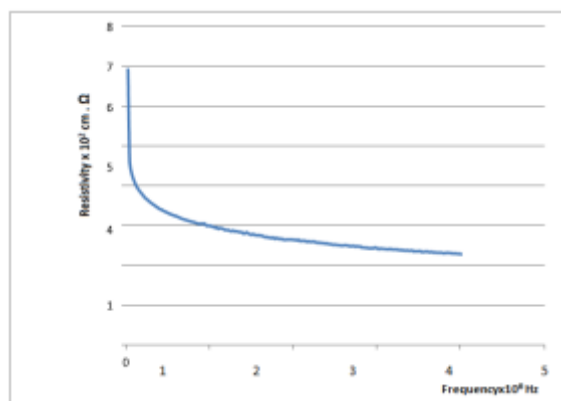


Fig. 4: The variation of electrical resistivity with frequency

## Conclusions

- 1- Sol–gel is a good and cheap method for preparation (cobalt oxide) with nano size particle.
- 2- The dielectric constant and electrical resistivity of cobalt oxide decreases with the increase of frequency, While The electrical conductivity increases with the increases of frequency.

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## تحضير ودراسة الخصائص التركيبية و الكهربائية لمادة اوكسيد الكوبلت النانوية

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## المخلص

لقد تم في هذا البحث تحضير مادة اوكسيد الكوبلت بطريقة (سول – جل ) وبالحجم 22 نانو , حيث تم الفحص بجهاز حيود الاشعة السينية و بعد المطابقة مع البطاقة الدولية الخاصة بالمادة والمرقمة (00-042-1467). ايضا تمت دراسة الخواص الكهربائية (ثابت العزل، المقاومة ، التوصيلية الكهربائية) بجهاز LCR-meter وللترددات بالمدى من (50 هيرتز – 5 ميكا هيرتز)، وقد لوحظ ان ثابت العزل والمقاومية يتناقصان بينما تزداد التوصيلية بزيادة التردد.