Dielectric, Magneto-Dielectric and Optical properties of Carbon/Graphene Quantum Dots modified $ZnFe_2O_4$ manifesting photovoltaic applications

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(under the guidance of)

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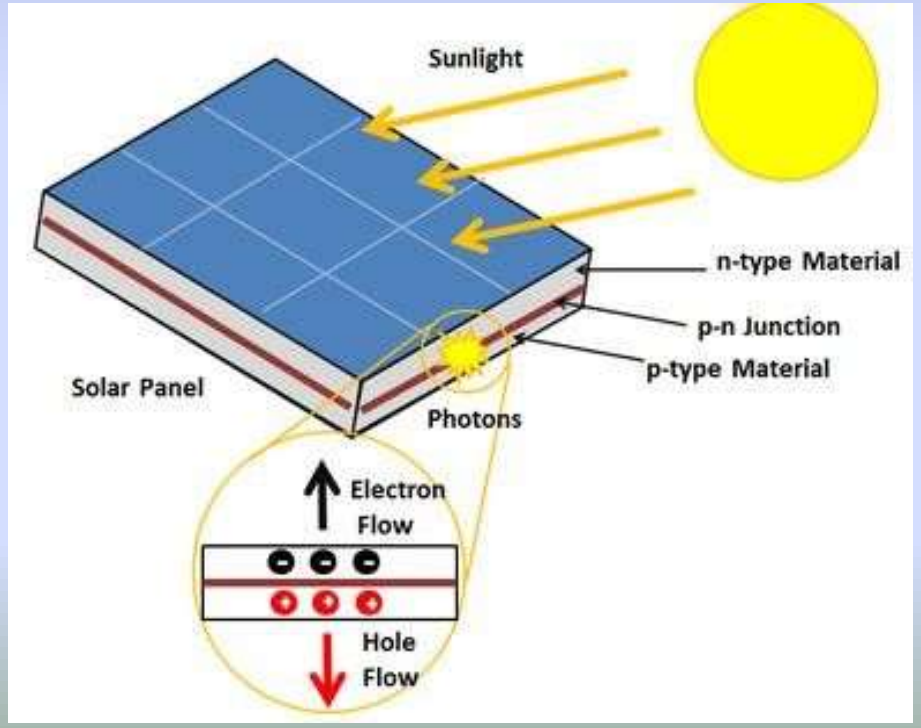
Topics to discuss

- **Introduction**
- **Experimental details**
  - **Synthesis**
  - **Results and discussions**
    - **Characterization**
- **Conclusion**

INTRODUCTION

What is Photovoltaic

Photovoltaic is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current is produced that can be used as electricity.



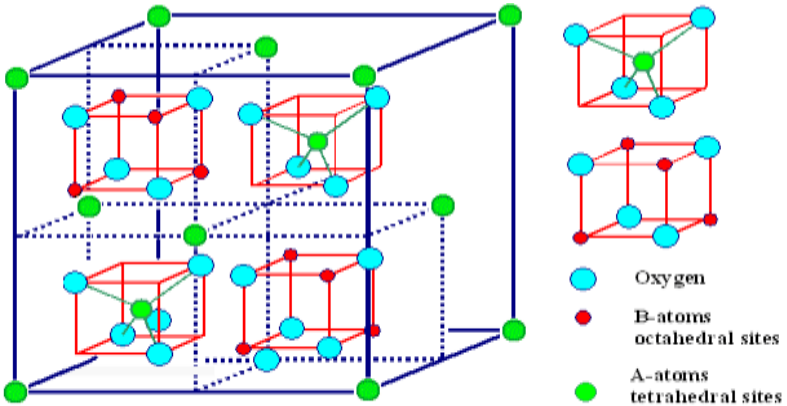
Role of nanomaterials in photovoltaic

- Excellent structural, electrical, magnetic properties
- In the family of magnetic material, ferrites nanoparticles are predominant material

[source: energy education]

Spinel Zinc Ferrites

A spinel ferrite is a complex oxide crystal structure with a face-centered cubic core and a unit formula of AFe_2O_4 . AFe_2O_4 unit consists of 32 closely packed oxygen atoms with A^{2+} and Fe^{3+} usually occupying 8 tetrahedral and 16 octahedral sites, respectively.

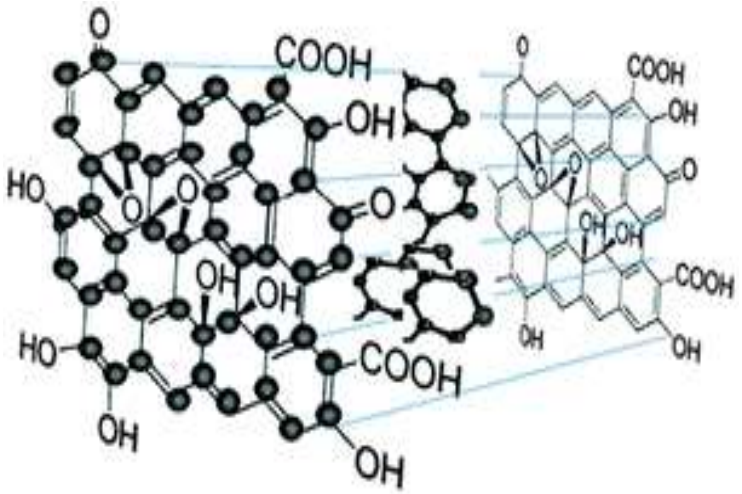


AB_2O_4 **spinel** The red cubes are also contained in the back half of the unit cell

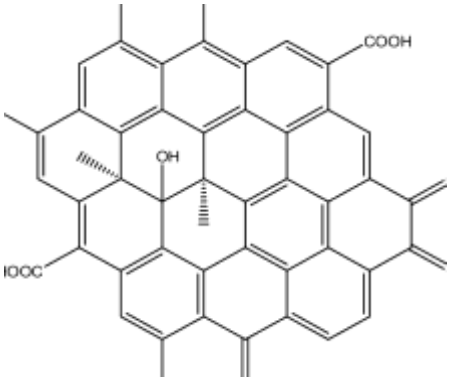
Quantum Dots

Quantum dots (QDs), also known as "artificial atoms", are material with diameters in the range of 1-10 nm.

Carbon Quantum Dots

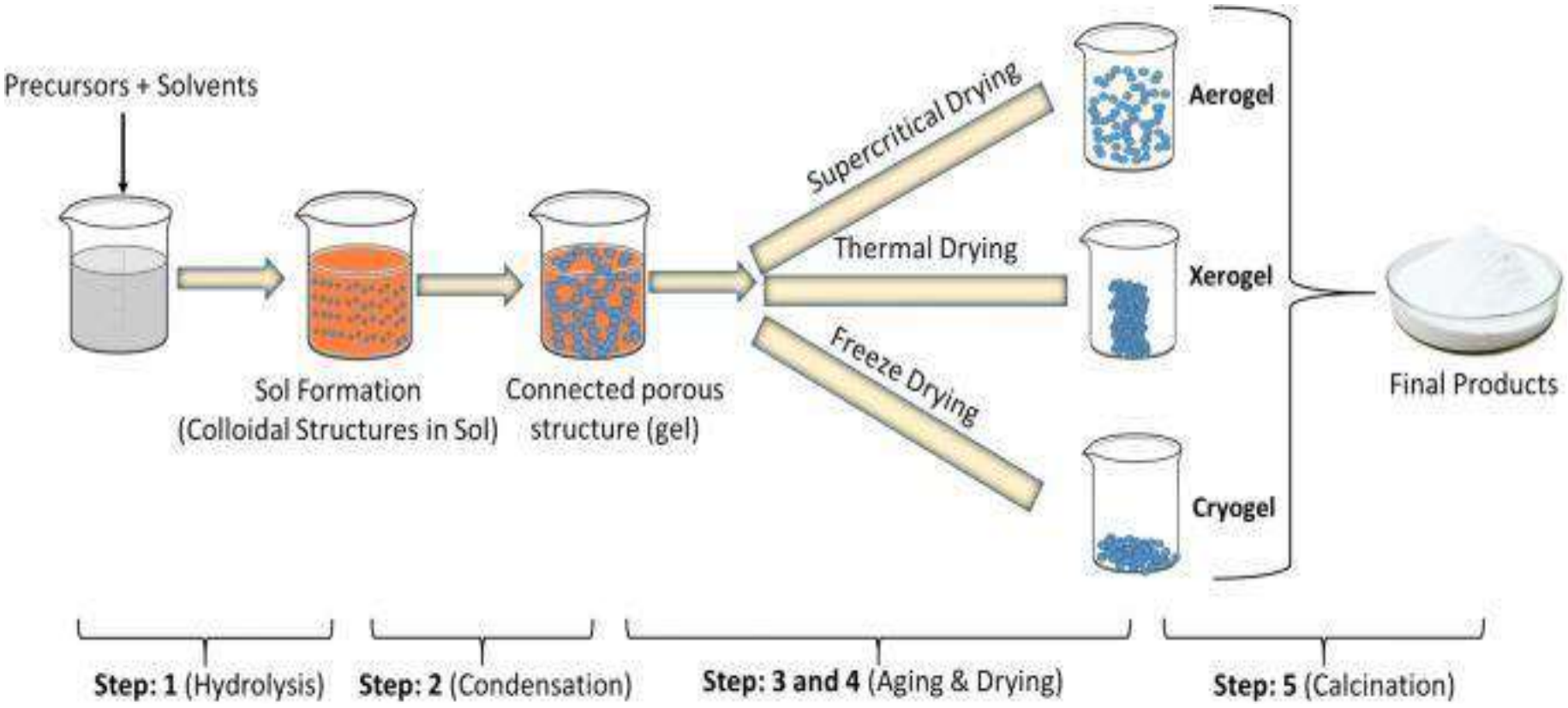


Graphene Quantum Dots



[Source: researchgate.net]

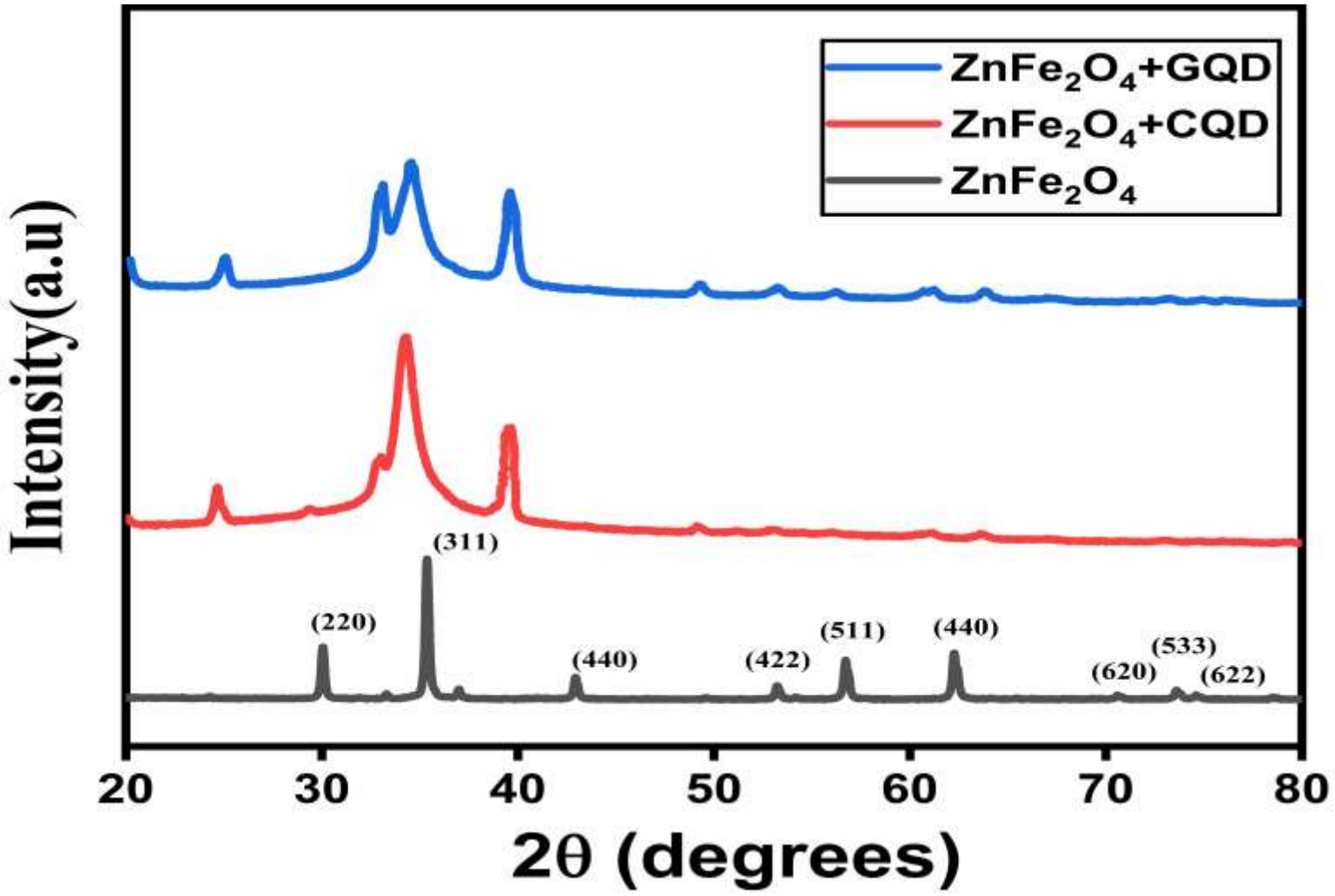
Synthesis by Sol-gel method



[Source: Nanomaterial by Sol-Gel Method: Synthesis and Application", *Advances in Materials Science and Engineering*, vol. 2021]

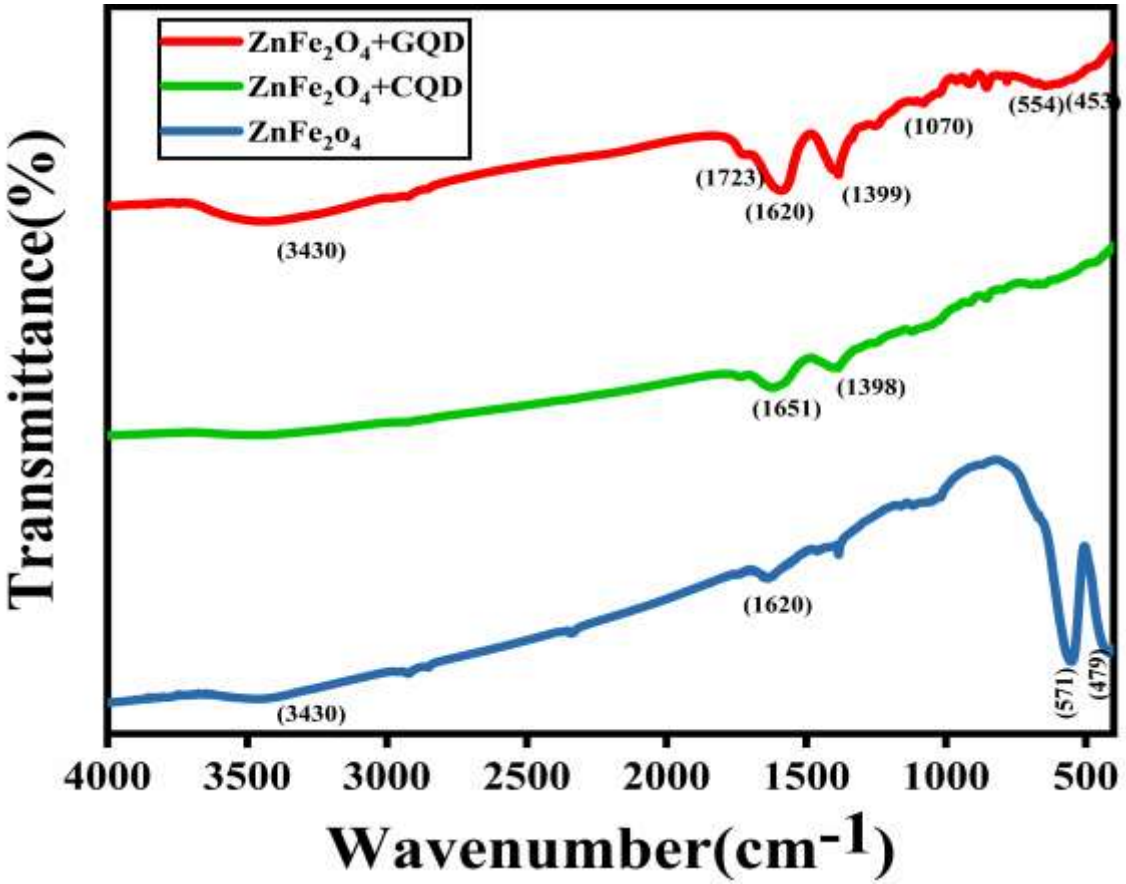
Results and Discussions

Structural Analysis



Comparison of XRD pattern of pure $ZnFe_2O_4$ and $ZnFe_2O_4$ doped with CQD and GQD

FT-IR analysis



- 3430 cm^{-1} and 1620 cm^{-1} O-H bonds.
- 571 and 479 cm^{-1}, Zn-O and the Fe-O
- 1620 cm^{-1} shows to the bending vibration of –OH
- peaks at 1723 cm^{-1}, 1399 cm^{-1} and 1070 cm^{-1} , C=O stretching vibrations of COOH groups, the stretching vibration of C-O (carboxyl)and the stretching vibration of C-O (alkoxy), respectively
- C-H and C-O bands in 1000–1700 cm^{-1}

FT-IR spectra of $ZnFe_2O_4$, $ZnFe_2O_4$-CQD and $ZnFe_2O_4$-GQD

Dielectric characterization

- **Dielectric constant (ε)**
- property of an electrical insulator which is equal to the ratio of the capacitance of a capacitor filled with the given electrical insulator to the capacitance of an identical capacitor in a vacuum without the dielectric material.

- **Dielectric loss (tan δ)**
- Dielectric loss quantifies a dielectric material's inherent dissipation of electromagnetic energy. In other words it is the loss of energy that goes into heating a dielectric material in a varying electric field.

- **Electrical conductivity(σ)**
- Electrical conductivity is an intrinsic property that quantifies how strongly a given material allows the flow of electric current.

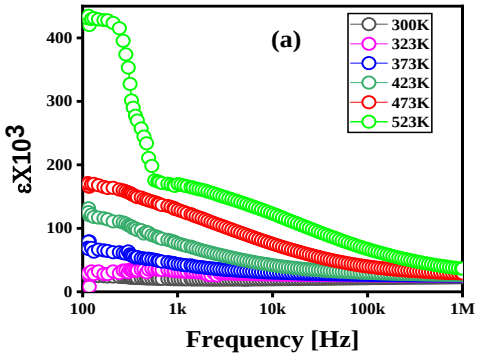
- **Magneto Dielctric effect (MD)**
- Magneto dielectric (MD) effect is the variation in the dielectric permittivity of a material under an applied magnetic field

- **Magneto Dielectric loss (ML)**
- Magnetic losses generically refer to the various energy dissipation mechanisms taking place when a magnetic material is subjected to varying external field

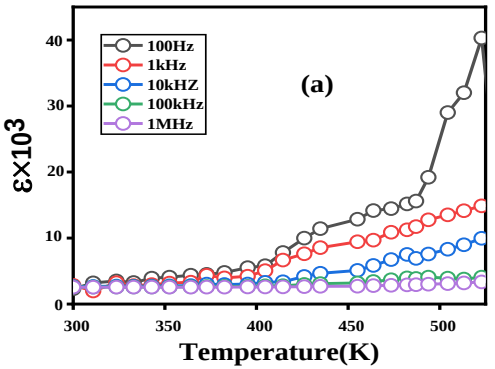
Dielectric constant

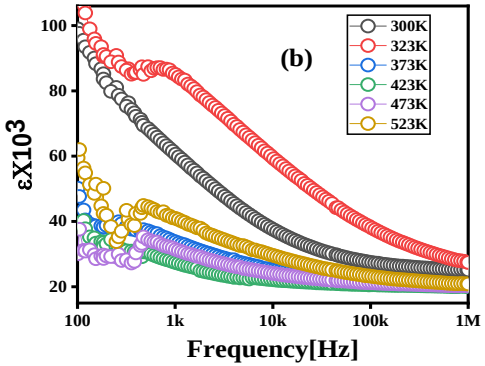
Ɛ vs Frequency

Ɛ vs Temperature

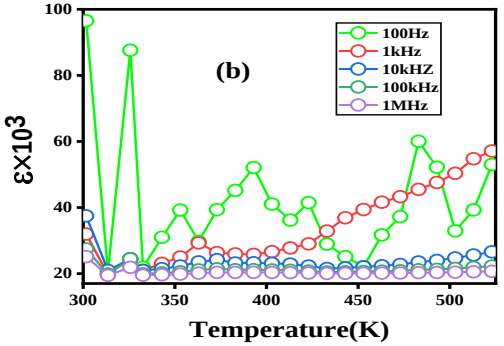


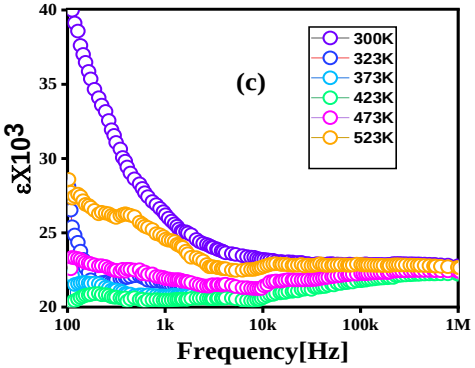
← $ZnFe_2O_4$ →



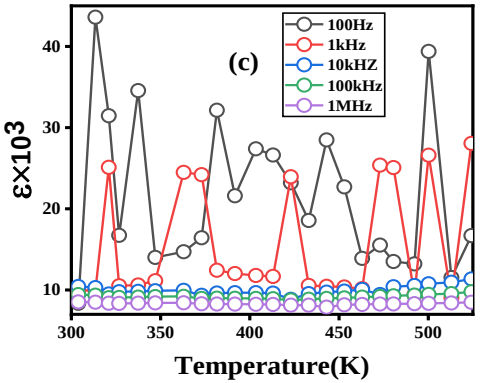


← $ZnFe_2O_4$-CQD →





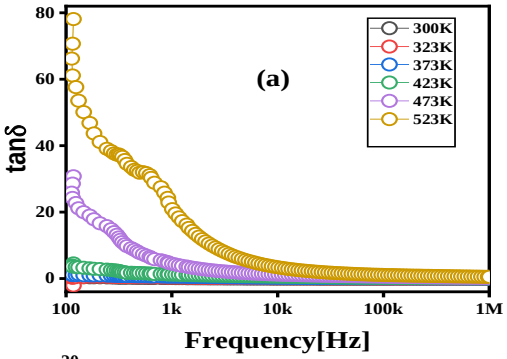
← $ZnFe_2O_4$-GQD →



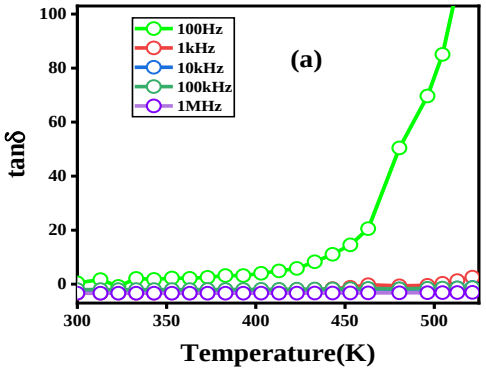
Tangent loss

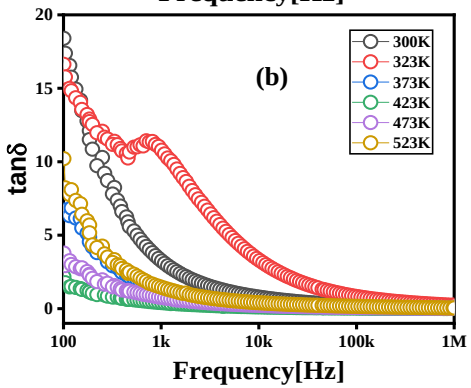
tan δ vs Frequency

tan δ vs Temperature

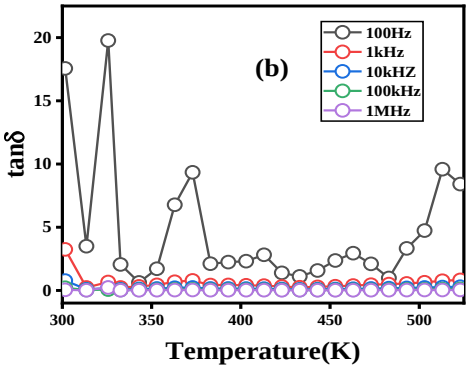


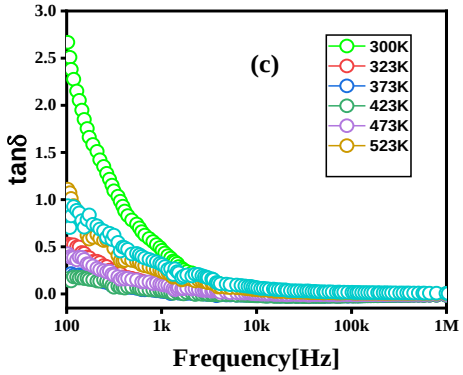
← $ZnFe_2O_4$ →



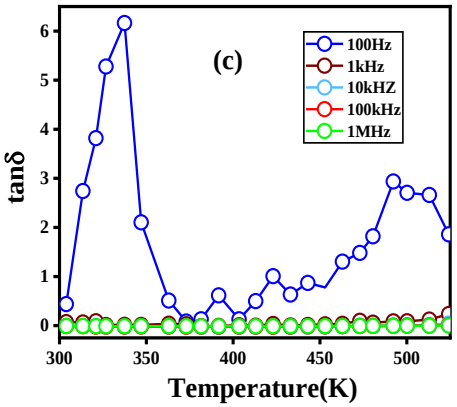


← $ZnFe_2O_4$-CQD →





← $ZnFe_2O_4$-GQD →



Electrical conductivity

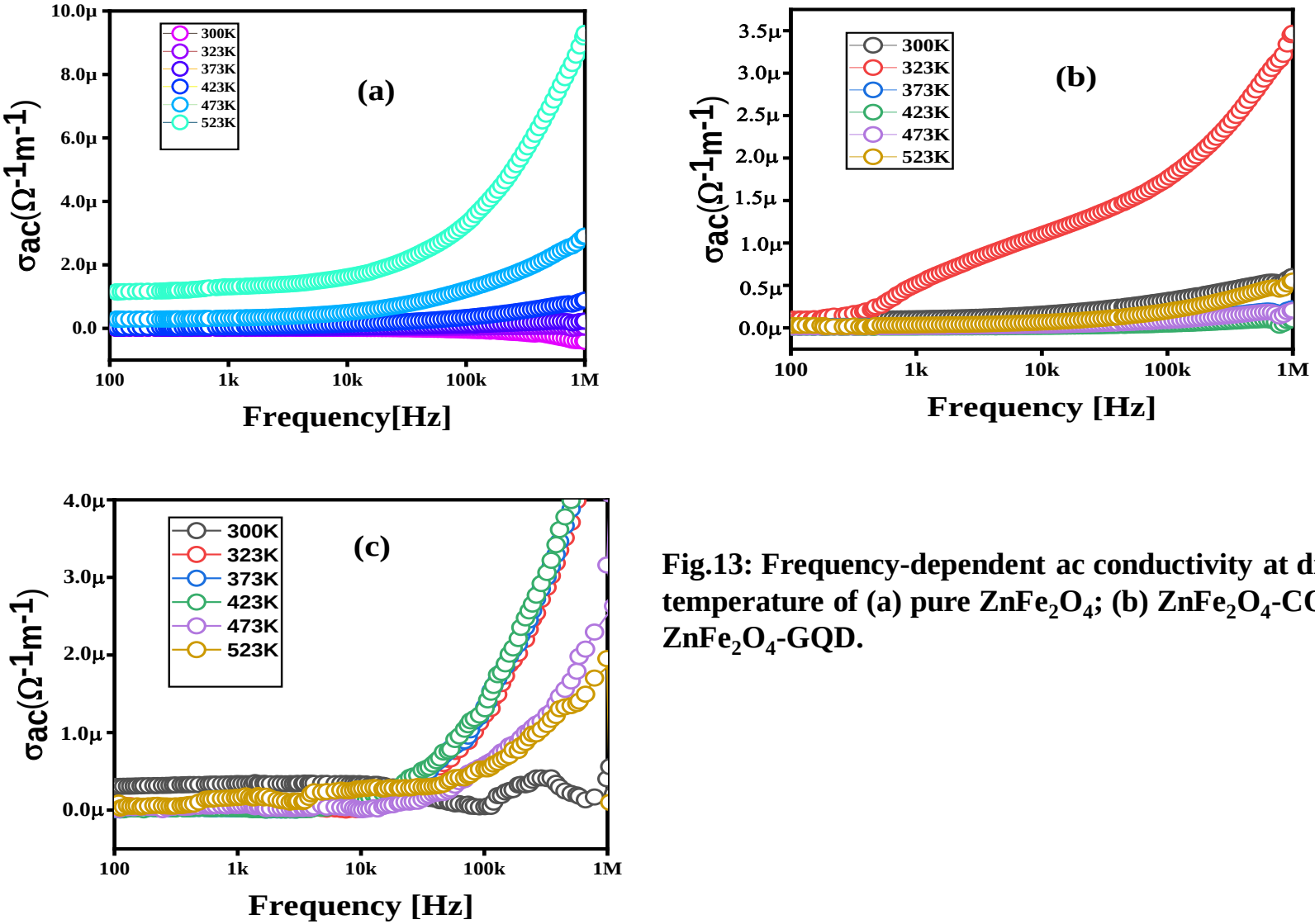


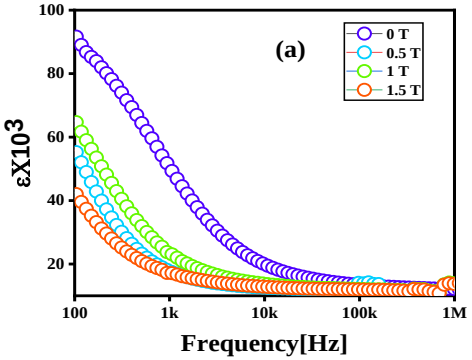
Fig.13: Frequency-dependent ac conductivity at different temperature of (a) pure $ZnFe_2O_4$; (b) $ZnFe_2O_4$-CQD (c) $ZnFe_2O_4$-GQD.

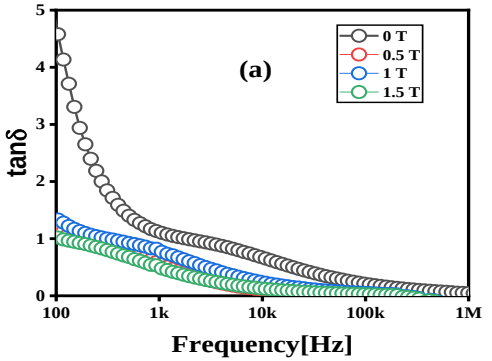
Magneto-dielectric study

ε vs Frequency

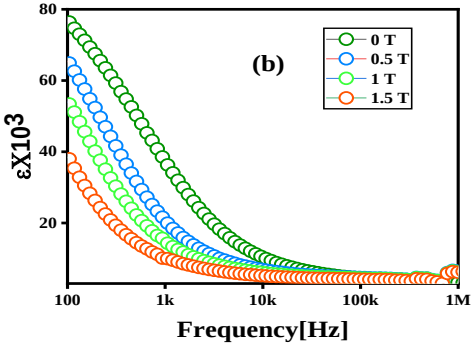
tan δ vs Frequency

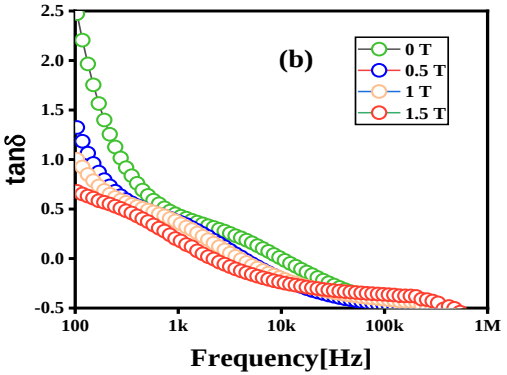
← $ZnFe_2O_4$ →



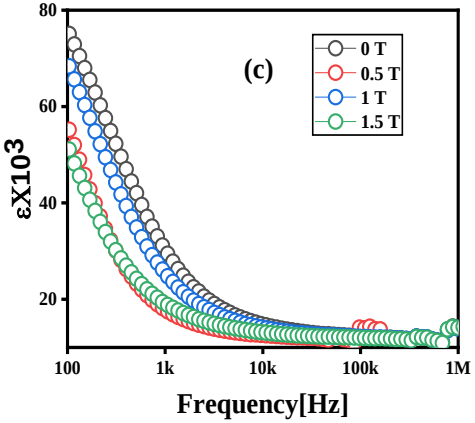


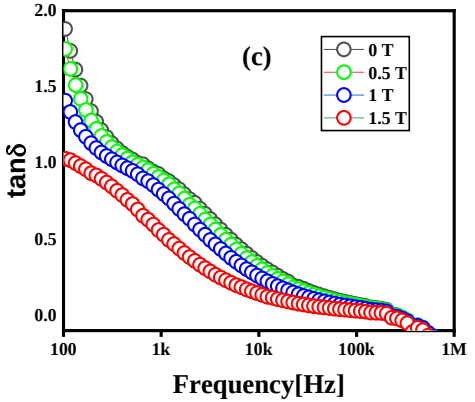
← $ZnFe_2O_4$-CQD →





← $ZnFe_2O_4$-GQD →





UV-Vis. Spectroscopy study

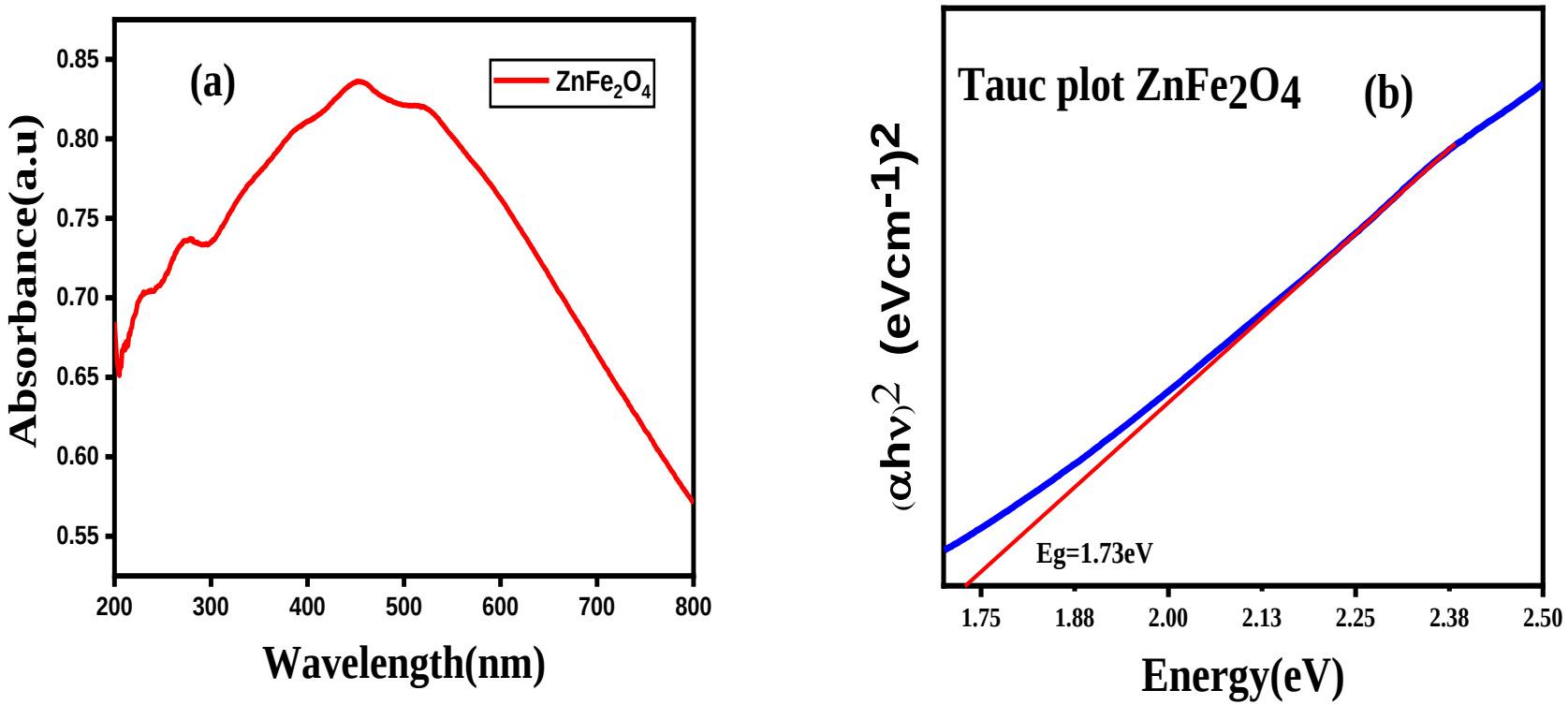


Fig.: 16(a) Absorption spectra of $ZnFe_2O_4$ (b) Tauc Plot of $ZnFe_2O_4$

CONCLUSION

- $ZnFe_2O_4$, $ZnFe_2O_4$-CQD and $ZnFe_2O_4$-GQD nanocomposites were prepared via sol gel method.
- The structural investigation confirms the cubic spinel structure with space group Fd3m.
- The FT-IR analysis showed the presence of different absorption bands in the samples.
- The frequency and temperature dependence of dielectric permittivity and tangent loss for the samples were investigated.
- Electrical conductivity analysis done helped to investigate the impact of frequency on the compound's electrical properties as well as ion hopping dynamic.
- The existence of the magneto-dielectric effect of samples was analyzed by applying an external static magnetic field and by measuring the dielectric permittivity (ε) and tangent losses (tan δ) vs. frequency dependences.
- Dielectric permittivity (ε) and tangent loss for all samples decreases with the applied magnetic field, thus indicating negative magneto-dielectric effect.
- The optical properties recorded by UV-Visible spectroscopy showed absorption band at 452.25 nm showing that $ZnFe_2O_4$ nanocomposites are optically active.
- Band gap calculated was found to be 1.73 eV.

Thank you…….