IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, July 2026
Impact Factor: 8.2

Synthesis of ZnO Nanoparticles and their Applications in Dye Degradation

Neha Desai[1], Lokare Amar[2], Korake Suraj[3], Mokale Rohan[4]
Department of Chemistry, K. B. P. Mahavidyalaya, Pandharpur (M.S.) India[1-4]
nehadesai323@gmail.com[1]

Abstract: *In the present investigation we have synthesized ZnO nanoparticles by sol gel method.The synthesized nanopartilces are characterized by UV-vis, XRD, SEM and EDS for the optical, structural, morphological compositional properties. The XRD pattern confirms wurtzite crystal structure with the confirmation of nanocrystalline material formation. The SEM pattern reveals the formation of nanograins. The compositionl analysis confirms the presence of zinc and oxygen in stiochiometric composition. All these results reveals that ZnO is a better candidate for the photocatalytic degradation of the dye.*

Keywords: ZnO, nanograins, dye degradation

I. INTRODUCTION

Zinc oxide is an inorganic compound with the formula ZnO. It appears as white powder and is nearly used as an additive in numerous materials and products including ceramics, glass, cement, rubber(for Eg: car tyres), selants, pigments Zinc oxide is well known transition metal oxide(TMO). ZnO is water insoluble and soluble in dilute acid and bases. Several metal oxide nanoparticles are produced with possible future applications. Among them zinc oxide is consider to be one of the best exploited at nanoparticles dimension. The wide band gap and large excitonic binding energy have made zinc oxide important both for scientific and industrial application. ZnO is a wide band gap semiconductor with a direct band gap of approximately 3.37 eV and a high exciton binding energy of 60 meV at room temperature. It commonly crystallizes in the hexagonal wurtzite structure which provides excellent thermal and chemical stability making it suitable for numerous scientific and industrial applications.

ZnO nanoparticles can be synthesized using physical, chemical and green methods. Common synthesis techniques includes sol gel, precipitation, hydrothermal, chemical vapour deposition and plant mediated green synthesis. The morphology and size of nanoparticles such as nanospheres, nanorods, nanoflowers can be controlled by various synthesis conditions.

Owing to the remarkable UV absorption, photocatalytic activity, antimicrobial properties, biocompatibility and semiconducting behavior ZnO nanoparticles have attracted significant attention in diverse fields. They are widely used in photocatalysis, dye sensitized solar cells , gas sensors , drug delivery, antimicrobial coatings, cosmetics, sunscreens, waste water treatment and environmental remediation. Their low toxicity , abundance and cost effectiveness further enhance their potential for sustainable technological and biomedical applications.

II. SYNTHESIS OF ZNO NANOPARTICLES BY SOL-GEL METHOD:

- ***Chemicals:***

I. Zinc acetate – 4.4 gm
II. Ethanol - 50ml
III. NaOH - 100%

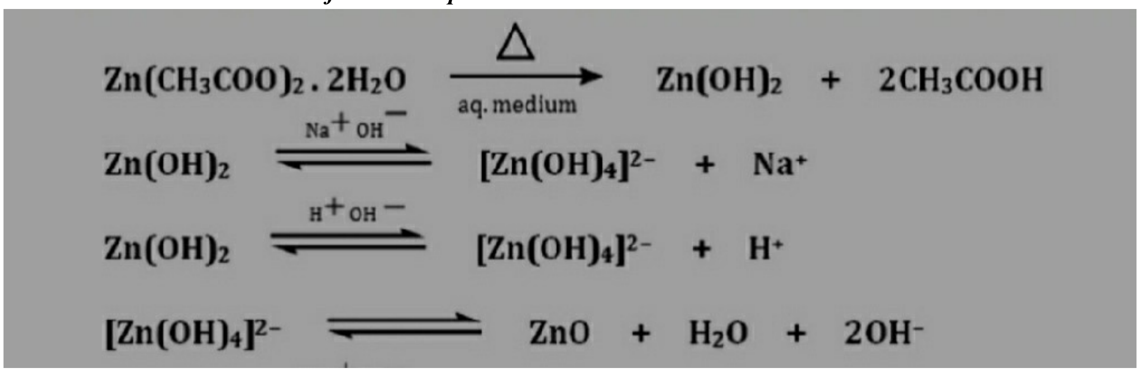
All the chemicals used are of ***AR grade*** chemicals.

- ***Procedure***:
  - Wash all apparatus with chromic acid and dry all apparatus.

DOI: 10.48175/IJARSCT-37748

- Take 4.4 gm zinc acetate in beaker.
- Add 50 ml Ethanol in it.
- Place the beaker on magnetic stirrer and stir it for 1 hr at 60^0c.
- When solutions pH is 3 then add NaOH dropwise upto pH become 8.
- Precipitate will be form,filter it on suction pump and dry it well.
- Annealing it on 240 ^{0}c for 1 hr.
- ZnO nanoparticles white powder is form.

: Growth & Reaction mechanism of ZnO nanoparticles:



In a typical synthesis Zinc acetate is used as precursor of ZnOinitially on reaction of Zinc acetate with water molecule forms Zinc hydroxide on aniline water molecule is removed and Zinc oxide ZnO is formed. In this process the initially seed nucleiis form and number of seed nuclei come together to form multi nuclei.

This multi nuclei center fevers the growth of ZnO nano-grains. In this way by controlling the chemical composition of a reaction we have obtain nano-grains of ZnO. The synthesis ZnO powder is further characterized by optical(UV-visible), Structural(XRD), Morphology(SEM

UV- visible spectrophotometer

One of the most promising methods to determine the band gap of a material is optical absorption study. The operating principle of UV- visible spectrophotometer is Beer-Lamberts law. The Beers-Lamberts law is the linear relationship between the absorbance and concentration of absorbing species. The general Beer-Lamberts law is usually written as,

$$A=\alpha \times b \times c$$

Where A is measured absorbance, α- is the absorption coefficient, b- is the path length and c- is the sample concentration. The size of nanoparticle plays an important role.Change in the size of material changes the entire properties of nanomaterials.

The size evolution of semiconducting nanomaterial becomes very essential to explore the property of material, UV-Visible absorption spectroscopy is widely being used technique to examine the optical property of nanosized particle.

The absorption spectra of ZnO nanoparticle shown in fig 3.2.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, July 2026
Impact Factor: 8.2

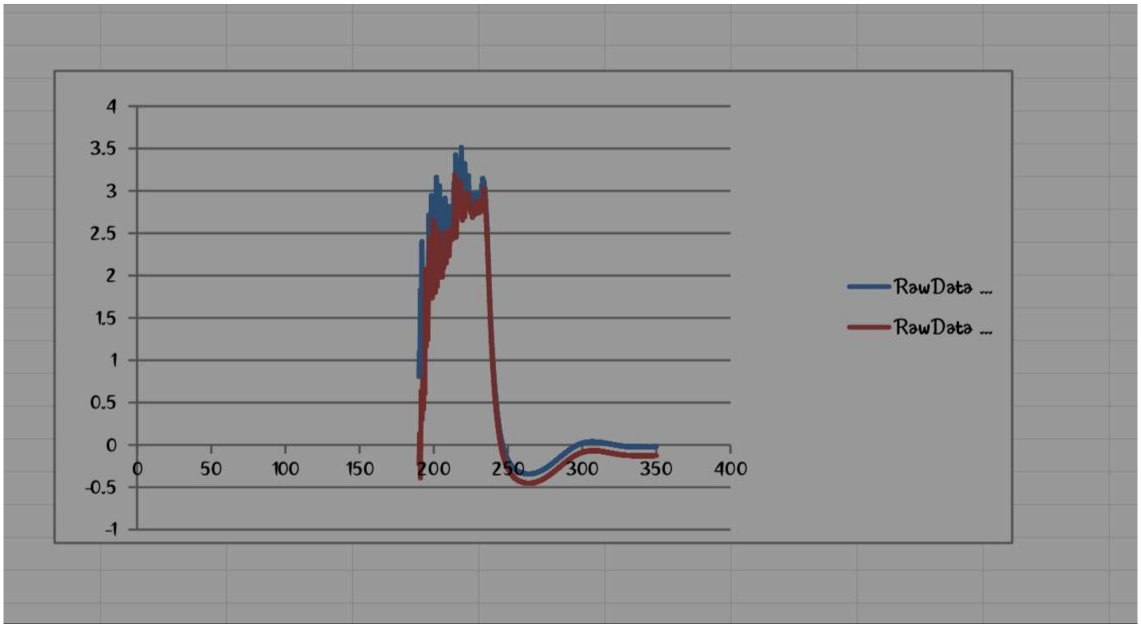


Fig 3.2: Optical absorbance spectra of ZnO nanoparticles

ZnO is UV-sensitive material, is shows maximum absorption the at 240nm.

X-Ray Diffraction technique (XRD):

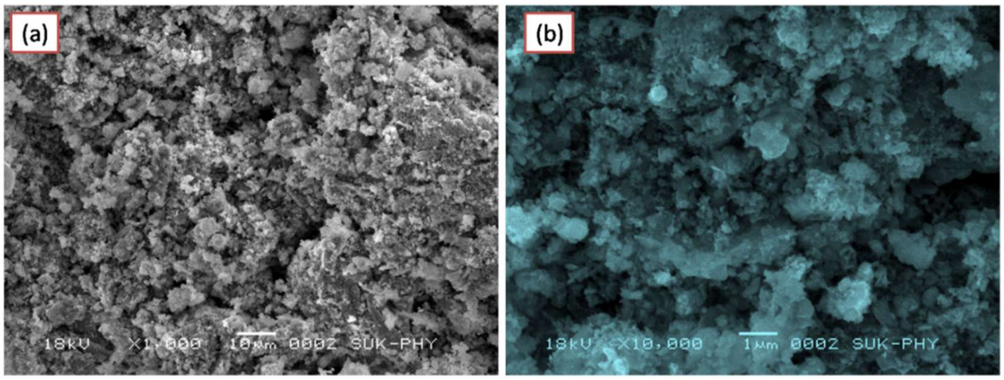
Fig 3.3. represent X-Ray diffraction pattern of ZnO nanoparticle. A definite line broadening of the XRD peaks indicates that the prepared material consists of particles in nanoscale peak intensity, position and width, full-width at half maximum (FHWM) data. The diffraction peaks located at 31.84^0, 34.52^0, 36.33^0, 47.63^0, 56.71^0, 62.96^0, 68.96^0, 68.13^0 and 69.18^0 have been keenly indexed as hexagonal wurtzite phase at ZnO [28, 29] with lattice constant a=b=0. 324nm and c=0.521nm (JPCDS card number: 36-1451) [30], and further it alsoconfirms that synthesized nanoparticles was free of impurities as it does not contain any characterization XRD peak other than ZnO peak. The synthesized ZnO nanoparticle diameter was calculated using Debye-Scherrer formula.

$$D = \frac{0.89\lambda}{\beta cos\theta}$$

Where, 0.89 is Scherrer's constant
λ is wavelength of X-ray
θ is Bragg's diffraction angle
β is full width at half maximum (FWHM) of the diffraction peak corresponding to plane. The average particles size of the sample was found to be 16.21nm which is derived from the FWHM of more intense peak corresponding to 101plane located at 36.33^0 using Scherrer's formula.

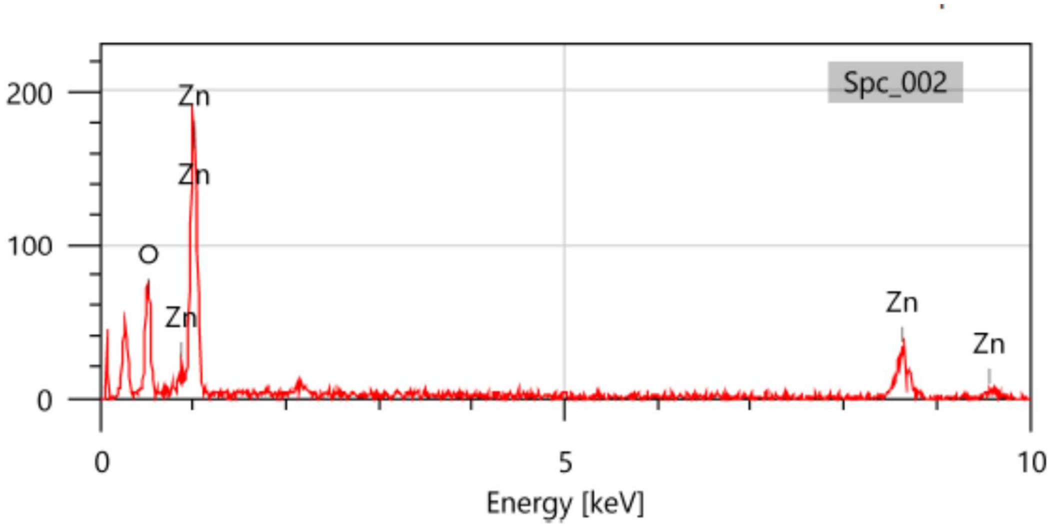
III. MORPHOLOGY

The surface morphology of ZnO nanoparticles were studied by using SEM and resultance.Figure 3.3 represent the SEM pictures of ZnO nanoparticles at different magnification.These pictures confirm the formation of ZnO nanoparticle. These pictures substantiate that the approximate***grannulars, non-porous morphology is obtained and the SEM shows that uniform,well adherent and crack free nano particles are formed.*** This nano grannuler morphology is highly beneficial for photocatalyst,from the picture it also can be seen that the size of nanoparticles is less than 10um which was goodagreement in particles size (8.32nm).



Compositional analysis:-

In order to confirm the composition of the synthesized ZnO nanomaterials, EDS analysis is carried out. The EDS data confirms the presence of Zinc and oxygen. The zinc and oxygen observed percentage is in good agreement with the standard data. Further peaks due to impurity are not observed. This confirms the formation of ZnO nanopartilces.



Element	Line	Mass%	Atom%
O	K	30.96±1.53	64.70±3.20
Zn	K	69.04±4.43	35.30±2.27
Total		100.00	100.00
Spc_002			Fitting ratio 0.3986

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, July 2026
Impact Factor: 8.2

IV. DYE DEGRADATION

Dye degradation is a process in which the large dye molecules are broken down chemically into smaller molecules. The resulting products are water, carbon dioxide, and mineral byproducts that give the original dye color. The color of the material becomes permanent.

Synthetic dyes are found in a wide range of product such as clothes, leather, accessories and furniture. These dyes are commonly used every day. However, a side effect of their widespread use is that upto12% of these dyes are wasted during the dying process and about 20% of this wastage enters the environment (mainly into waste water supply)

Photocatalysis is define as initiation of chemical reaction under the action of ultraviolet, visible or infrared radiation in the presence of a substance the photo catalyst that absorb light and in involved in the chemical transformation of reaction pollutants.

The concept of photo catalysis was discovered by Honda and Fujishima in 1972.

Dye degradation by ZnO nanoparticles:

- ***Chemicals:***

I. Methylene red
II. ZnO nanoparticles
III. Distilled water

- ***Procedure:***
  - Take 40 mg methyl red in beaker and dissolved in 100ml dist. Water.
  - Then pipette out 5.0ml methyl red solution and dissolve 100ml by using dist. Water in beaker.
  - Then our 20ppm methyl red solution will be prepared.
  - Measure the maximum wavelength of this solution on UV-spectrophotometer.
  - After that add pinch of ZnO nanoparticles in 20ppm methyl red solution. Stir it for 1hr in magnetic stirrer.
  - Place this solution in UV chamber for 1 hr. then measure maximum wavelength.
  - Repeat this procedure every15 min and measure wavelength on UV-spectrophotometer.

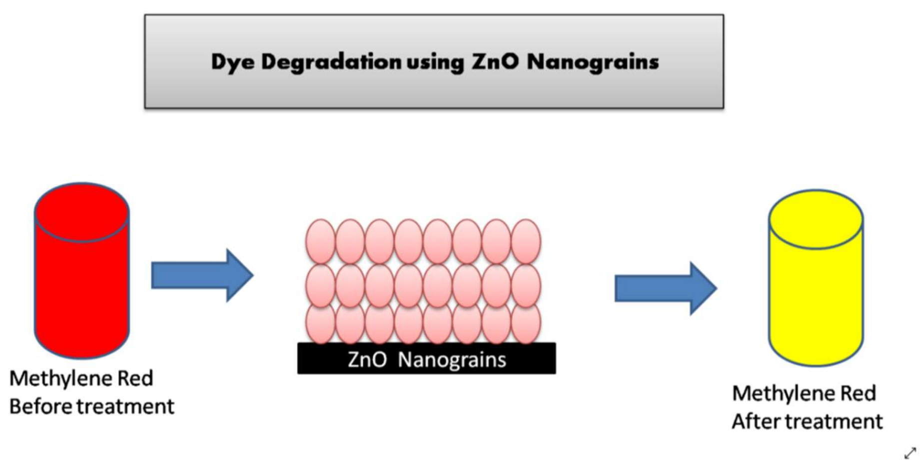


Fig.4.1.1: Dye degradation by using ZnO nanograins

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, July 2026
Impact Factor: 8.2

Fig:4.1.2: Methylene red dye degradation by ZnO nanoparticles.

Graph:

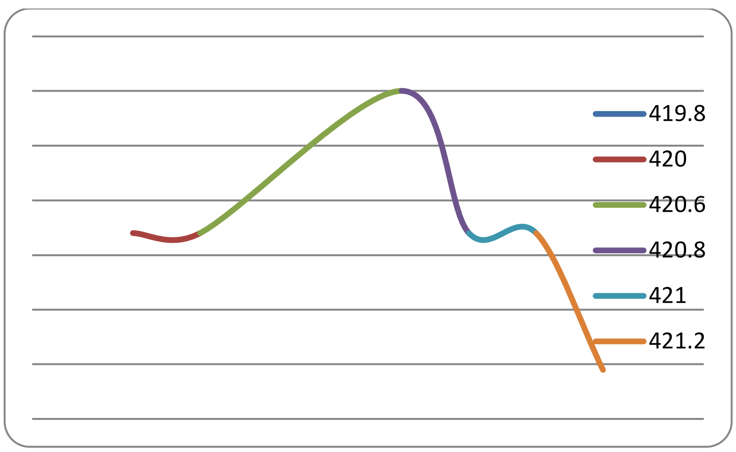


Fig :4.1.3: Wavelength of Methylene red before treatment of ZnO nanoparticles.

Methylene red solution shows maximum wavelength at **420.6nm** without treatment of ZnO nanoparticles.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, July 2026
Impact Factor: 8.2

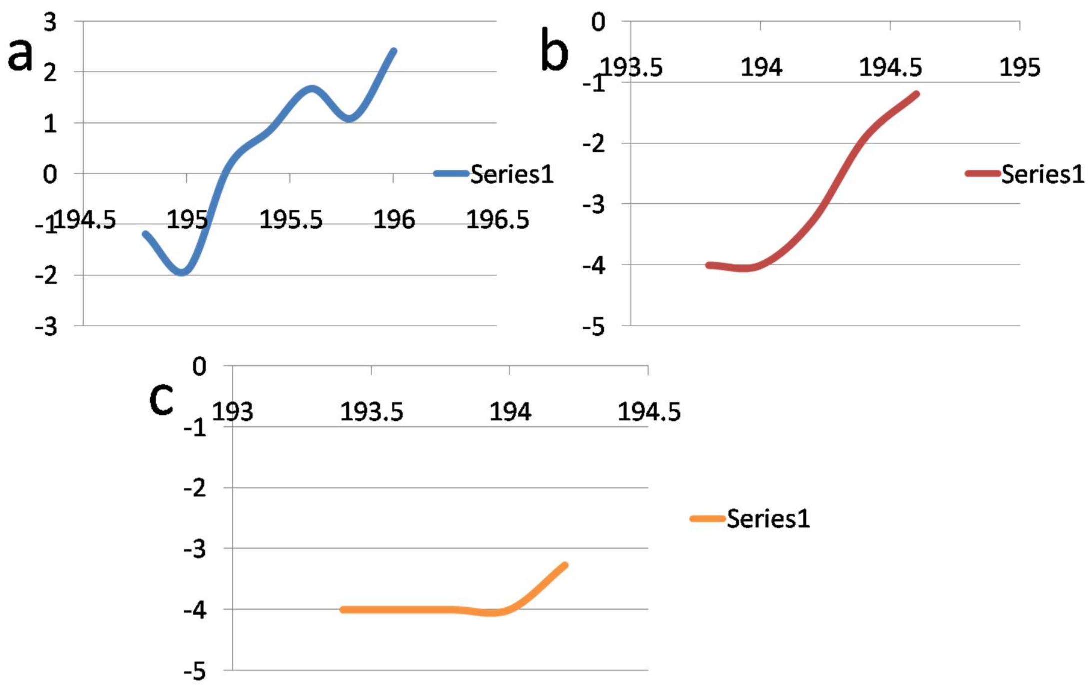


Fig :4.1.4: Wavelength of Methylene red After treatment ZnO nanoparticles.

Graph (a) shows wavelength of methylene red solution after treatment of ZnO nanoparticles at **0 min is 195.6nm.**
Graph *(b)* shows wavelength of methylene red solution after treatment of ZnO nanoparticles at**15 min is 194.6nm.**
Graph (c) shows wavelength of methylene red solution after treatment of ZnO nanoparticles at**30 min is 193nm.**

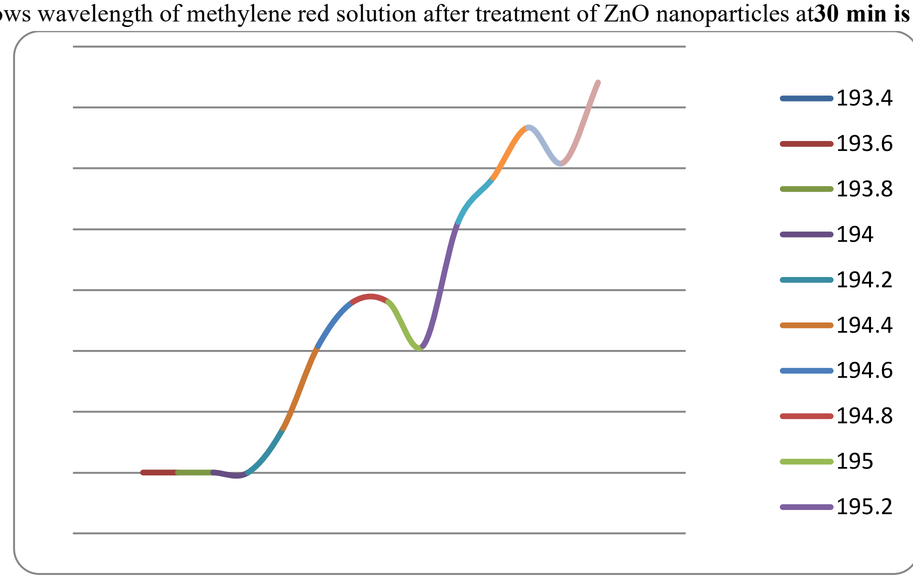


Fig:4.1.5:Wavelength ofMethylene red After treatment ZnO nanoparticles.

All graph's result shows that methylene red dye is degraded by using ZnO nanoparticles in presence of UV radiation.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, July 2026
Impact Factor: 8.2

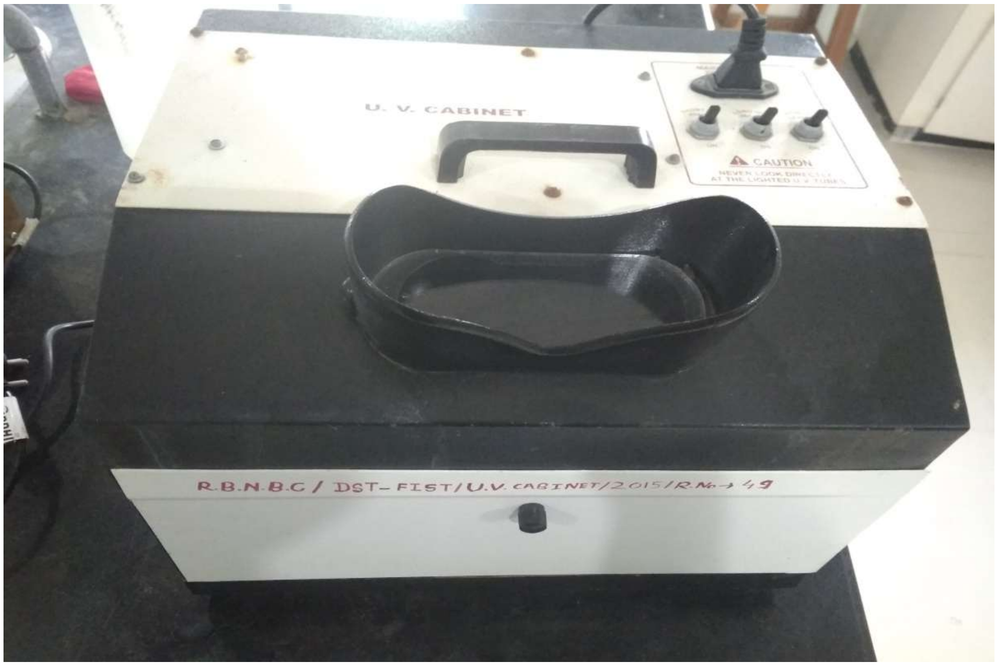


Fig: 4.1.6: UV- Chamber

V. RESULT:

I.	Methylene red before reading	420.6nm	
II.	Methylene red after ZnO addition reading	Time	Wavelength
		0 min	195.6nm
		15 min	194.6nm
		30 min	193.0nm

VI. CONCLUSIONS

ZnO was synthesized by 2 methods.

1. Optical study shows band gap in UV region.
2. XRD pattern confirm the synthesize of nanocrystalline ZnO.
3. SEM shows nanogranular morphology.
4. ZnO is UV sensitive nanoparticle and it is better candidate for photocatalysis.
5. ZnO nanoparticles are used for dye degradation.
6. ZnO nanoparticles are applicable for industrial waste water. By using ZnO nanoparticles we can change reduce the turbidity and hardness of water.
7. The pH of a water changes from acid to neutral.

All these results conclude that ZnO nanoparticles are having better performance for industrial water effluent and photocatalysis.

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 6, Issue 2, July 2026

Impact Factor: 8.2

REFERENCES

1. 1.Kavitha, K. S. *et al*. Plants as green source towards synthesis of nanoparticles. *Int. Res. J. Biol. Sci.* **2**, 66–76 (2013).
2. Malik, P., Shankar, R., Malik, V., Sharma, N. & Mukherjee, T.K. Green chemistry based benign routes for nanoparticle synthesis. *J. Nanopart*.
3. Makarov, V. V. *et al*. "Green" nanotechnologies: synthesis of metal nanoparticles using plants. *Acta Naturae* **6**, 35–44 (2014)
4. Biswas, B., Rogers, K., Mclaughlin, F., Daniels, D. & Yadav, A. Antimicrobial activities of leaf extracts of Guava (*Psidium guajava* L.) on two Gram-negative and Gram-positive bacteria. *Int. J. Microbiol*.
5. Ahmed, S., Ahmad, M., Swami, B. L. & Ikram, S. A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise. *J. Adv. Res.* **7**, 17–28 (2016).
6. Ramesh, P., Rajendran, A. & Sundaram, M. Green synthesis of zinc oxide nanoparticles using flower extract *Cassia Auriculata*. *J. Nanoscience. Nanotechnol.* **2**, 41–45 (2014).
7. 7.Benhebal, H.; Chaib, M.; Salomon, T.; Geens, J.; Leonard, A.; Lambert, S.D.; Crine, M.; Heinrichs, B. Alex. Eng. J. 2013, 52, 517–523.
8. 8.Yildirim, Ö.A.; Durucan, C. *J. Alloy. Compd.* 2010, 506, 944–949.
9. 9.Kang, H.K.; Leem, J.; Yoona, S.Y.; Sung, H.J. Nanoscale., 2014, 6, 2840-2846.
10. 10.Chandross, E.A.; Miller, R.D. *Chem. Rev*., 1999, *99*, 1641-1642.
11. Djalali, R.; Samson, J.; Matsui, H. *J. Am. Chem. Soc*., 2004, *126*, 7935-7939.
12. Wang ZL (2004) Zinc oxide nanostructures: growth, properties and applications. J Phys Condens Matter. 16:R829–R858
13. Tienes BM, Perkins RJ, Shoemaker RK, Dukovic G (2013) Layered phosphonates in colloidal synthesis of anisotropic ZnO nanocrystals. Chem Mater. 25:4321–4329
14. Goh EG, Xu X, McCormick PG (2014) Effect of particle size on the UV absorbance of zinc oxide nanoparticles. Scripta Mater. 78:49–52
15. Fan ZY, Lu JG (2005) Zinc oxide nanostructures: synthesis and properties. J NanosciNanotechno. 5:1561–1573