Synthesis of Zinc Vanadium Oxide (ZnV_2O_6) nanoparticles for Photocatalytic Degradation of Methylene blue dye

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Abstract

Zinc Vanadium Oxide Nanoparticles were synthesized by varying temperature through solution combustion method using zinc nitrate and ammonium meta vanadate as raw materials and urea as fuel. For the photocatalytic degradation of methylene blue dye due to its high toxicity effect in water resources. Most of the chemicals involved in the preparation of methylene blue dye produces toxic gases after their use in the industries. The potential of Zinc Vanadium Oxide which acts as photo catalyst was investigated by degrading methylene blue dye by photocatalytic activity. To degrade such harmful chemicals released in the water resources Zinc Vanadium Oxide nanoparticles plays a crucial role on photocatalytic degradation process. In this study, we discussed about the Zinc Vanadium Oxide nanoparticles on photocatalytic degradation of methylene blue dye. The thermally treated material subjected to PXRD (Powder X-ray diffraction) studies confirms monoclinic structure which corresponds to the plane miller indices with (1,1,0), (2,2,0), (1,1,1) and (3,1,1) respectively according to JCPDS NO: 74- 1262. The grain size of zinc vanadium oxide nano powder is calculated by using Debye-Scherrer's formula calculated to be average crystallite size is 21.3nm. The band gap of the sample determined by Diffusion reflectance spectra by plotting Kubelka Munk function versus energy. E_g is found to be 2.38eV. The FTIR spectrum of Zinc Vanadium Oxide Nanoparticles was found to consists of characteristic absorption peaks. It is well known demonstrated for the high level application for the degradation of organic pollutants under visible radiation. The degradation of methylene blue dye was performed at different conditions of variables like catalyst dose, reaction time and dye initial concentration shows a valuable effect on dye degradation under UV light radiation. The photocatalytic degradation of methylene blue dye is studied under UV-visible light. The zinc vanadium oxide photocatalyst it clearly shows that breaking of the dye bonds.

Key Words: Solution combustion synthesis, Energy band gap, Zinc Vanadium Oxide Nanoparticles, photocatalytic degradation

1.1 Introduction

In the recent years world demands global energy, economic and eco-friendly sources of renewable and clean energy. To control the environmental contamination like water pollutants, industrial wastes which contains harmfulchemical dyes. The novel method for contamination in the waste water treatment have a various kind of unfavorable contaminants from waste water. Enormous, branches of Advanced Oxidation Processes (AOP's) which in conversion of organic pollutants to biodegradable compounds for the waste water treatment is current scenario, photocatalytic activity process has emerged as an effective and highly promising technology. At the reasonable time we need minimum chemicals, remove the pollutants from environment to enhance the formation of non-toxic products. The advantages of the photocatalytic activity process are effective degradation , generation of minimum by- products as non-pollutants and energy efficient operations. As a result, the photocatalytic method is facing some serious challenges, including material instability. For the enhancing process efficiency of materialinstability in some review papers, photo catalyst doping, coupling, doping with non-metals, transition metals, noble metals and co-doped are investigated. Synthesis of nano catalyst system for fixing immobility. These are some strategies for improving photo catalyst activity. Some pollutants such as benzene, toluene, and ethylbenzene xylene, photocatalytic approach in water treatment has received a lot of interest, because of its features. Nano catalyst transforms the pollutants into carbon dioxide and hydrogen peroxide during the photocatalytic process. Photo catalyst can be used in H_2 synthesis, reduction, pollution reduction in water. Semiconductors are utilized as photo catalyst because the conductivity is between the valence band and conductionband. When suitable frequency of radiation is incident on the semiconductor material the electrons in the ground state gets excited to conduction band with as positive band

gap in the valence band. The positive gap is a powerful oxidant capable of oxidizing compound. This results in production of oxidation and reduction process producing oxides and super oxides. These oxides and super oxides responsible for degradation of dyes [1]. Majority of dyes are water soluble, non-biodegradable, and environmentally hazardous. Some of the dyesmethyl orange, Rhodamine, Methylene blue dye, Victoria blue, rose Bengal, indigo red, carmine, red 120, Eriochrome, methylene blue, black T, thymol blue are few examples which are investigated by the influence of TiO_2/Zno.[2]. In this current work we are dealing with the synthesis of Zinc Vanadium Oxide material by combustion method. As photocatalyst with band gap 2.5 to 3eV to enhance the photocatalytic degradationof methylene blue dye by photocatalytic activity. The literatures review focuses on the essence of our study and guides the reader to understand research problem. The different literatures are paving, the way to understand modern technology and methodology to achieves the work. Here we the literatures which have advance development in photocatalytic degradation of methylene blue dye using various photo catalysts.**M.A Rauf et.al (2009)** have been studied the $TiO2$ photocatalyst decolorization of dyes and the presence of additivites such as ions. This reviewalso summarizes the degradation pathways that azo dyes undergo, with some of the intermediates that are generated during their degradation. Finally a survey is presented of the various classes of dyes and their relative case of degradation by AOPs. **C. Berthomieu et al. (2009)** have studied the identification of organic polymeric, inorganic materials through FTIR spectroscopy. **G.A Dorofeev, A.N Streleski et. al (2012)** have studied the range of applicability of the Scherrer's, Williamson-hall methods to the substructure analysis by the x-ray diffraction is determined as depending on the method ofnanostructure formation. **Faheem K.Butt, Chuanbao Cao et. al (2013)** have studied the storage measurements along ZnV_2O_4 reveal its superiority over previous reports on hydrogen absorption values concerning oxides, nitrides and chalcogenides to understand the rate limiting mechanism. Various kinetics models are applied the calculations shows that kinetics models are governed by 3D growth with constant interface velocity the measurements point to ZnV_2O_4 spinel oxide as a promising hydrogen storage material. **M.Vanaja, K Paul Kumar et.al (2014)** The photocatalytic activity of the synthesized silver nanoparticles was examined by degradation of methylene blue under sunlight irradiation. Green synthesized silver nanoparticles were effectively degrading the dye nearly 95% at 72 h of exposure time. **L Z Pei, N. Lin et.al (2015)** have been reported the photocatalytic activities ofthe zinc vanadate Nano rods have been evaluated by the photocatalytic degradation of the methylene blue dye under solar light radiation. Themethylene blue dye with the concentration of 10mgm/L can be degraded totally under the solar light irradiation for 4h. **Tin tling Li et, al (2016)** the excellent photocatalytic efficiency of$Ag2Co3/Bi2O2Co3$ photocatalyst could be ascribed to the improved light absorption ability and the reduced recombination of photo-generated electron-hole pairs during photocatalytic degradation reactions. More over the possible transferred and separated behavior of electron-hole pairs and photocatalytic reactions mechanisms on the $Ag2Co3/Bi2O2Co3$ photocatalyst are illustratesin detail. **Abdullah Bafaqeer, Muhammed Tahir et. al (2017**) have reported the hierarchial ZnV_2O_6 nanosheets show excellent performance towards photo reduction of carbon dioxide with water and methyl alcohol, methyl carboxylicacid under visible light. The main product yield methyl alcohol obtained over ZnV_2O_6 3,4 times the amount of methyl alcohol produced over the Zinc oxidecomposites. **Medhat A, Nemitallah, Sherif S et. al (2018)** have studied the effective technique to control the combustion technique instabilization within the gas turbine combustion a fuel flexibility approach is studied. **Muhammed Munir Sajid et.al (2018)** have reported the synthesis of $Zn_3(Vo_4)$ Nano composites exhibited excellent photocatalytic response bycompletely degrading the model pollutant methylene blue dye in 60 min at molar concentration ratio 2:1 in basic medium at pH 12, the $Zn3(Vo4)$ Nano composites degrades methylene blue dye successfully degraded completely within 45 min. **Marcello Picollo, Mary Zio et. al (2018)** have studied the concepts of spectroscopic methodologies for heritage materials, textiles, carpets and glassmetals which shows the usefulness of UV-Vis reflectance spectroscopy and micro-spectroscopy applied to the study of art works. **Muhammed Hussein saghi et.al (2018)** have reported the three substantial variables pH, mixing time, and VO_2 dose were considered in the process modelling accomplished by Box-behenken design the quadratic model revealed that the VO_2 NPs plays the most significant role the model optimization predicts a 96.3 % methylene blue dye removable when pH VO_2 NPs doses and contact time were adjusted to 6, 0.5g/L and 30min respectively.

Methylene blue dye is an organic chloride salt having 3,7 (dimethylamine phenothiazine-5-ium) as the counterion. It is a synthetic dye which is commonly used in both medical and industrial fields. Applied in Medical diagnostics as to detect certain types of metabolic disorders. Antiseptic form of methylene blue dye treats urinary tract infections and other abnormal conditions. Under a microscope view its applied as staining agent to help to visualize cells and tissues. It visualizes the dead cells and abnormal growth tissues which are infected by various harmful chemicals. The versatile application in the textile industry methylene blue is used to dye different typesof textiles, including wool, silk and cotton as vibrant blue color and good colorfastness. The staining of the dye which is uniformly applied on the materials can be checked through staining and color testing in fabrics. In our daily life we use various kinds of materials like stationary and packing materials a like a paper product by paper coloring materials. The products in the leather industry, textile industry methylene dye are used to dye leather products and textile products providing a deep rich blue color. In the chemicalfield it is used as chemical agent for testing and monitoring and controlling thequality of the products in the manufacturing process as a redox indicator. Mostof the harmful chemicals contaminated in the water resources which reduces the purity and abnormal ph. values in water leading to effect human and plantlife. To enhance the required conditions to test the quality and detect contaminants as it can interact with certain substances in the water. In electronics and plastics methylene blue dye is used as colorant in plastics and synthetic materials to achieve a consistent blue hue. It also treats various healthconditions helps health care providers identify abnormal cells. Methylene bluedye have some of the disadvantages to reduce by some of the techniques. A high concentration of methylene blue can be toxic to humans and animals. Which results in causing irritation to the skin, eyes, and respiratory tract and itmay lead to various serious health disorders if ingested or improperly handled.Releasing the chemicals into the water sources leather and textile industries leads to water pollution which results in harmful to the aquatic living species. It has a high stain property difficult to remove from surfaces, fabrics, or skin. To overcome these disadvantages, we use zinc vanadium oxide nanoparticles by the process involving photocatalytic degradation of dyes. When zinc vanadium oxide absorbs a energy from a light source (UV or Visible light) theelectrons gets excited to the conduction band from valence band leaving the holes behind in valence band. After the excitation of electrons to the conduction band, the electrons and holes reacts with surrounding water and oxygen molecules, to the formation of reactive oxygen species, such as hydroxyl radicals(-OH) and superoxides (anions)(O_2). These reactive oxygenspecies are highly reactive can break down the non-biodegradable pollutants[3].

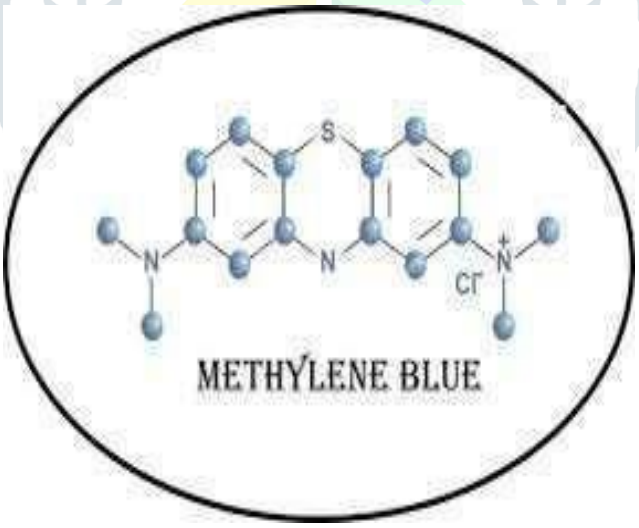

Fig1 : Structure of methylene blue Ref.[Sciencedirect.com]

Zinc Vanadium oxide is an inorganic compound that belongs to vanadate family. The major application of Zinc Vanadium oxide is used as a pigment incoatings and paints, non-toxic, corrosion, inhibiting alternative to lead. It is a bright yellow to orange color, suitable for such applications requiring color stability and corrosion protection. It is a heterogeneous photo catalysis owingto it has extraordinary chemical constancy, low optical damage, higher catalyticactivity. In this current work we are dealing with the synthesis of Zinc Vanadium Oxide nanoparticles by combustion method for photocatalytic degradation of methylene blue dye[4]. Zinc Vanadium Oxide are utilized as photo catalyst because the conductivity is between the valence band and conduction band. When zinc vanadium oxide absorbs a energy from a light source (UV or Visible light) the electrons gets excited to the conduction bandfrom valence band leaving the holes behind in valence band. After the excitation of electrons to the conduction band, the electrons and holes reacts with surrounding water and oxygen molecules, to the formation of reactive oxygen species, such as hydroxyl radicals(-OH) and

super oxides (anions)(O_2). These reactive oxygen species are highly reactive can break down the non-biodegradable pollutants. The photocatalyst can degrade organic pollutants in water, such as dyes, pesticides, and other harmful chemicals, are degraded by the reactive oxygen species into smaller, less harmful molecules like CO_2 and H_2[5].The optical band gap of the photocatalyst in the range of 2.5 to 2.8 eV, which is preferable to light absorption of energy to enhance the photocatalytic efficiency under solar radiation. The efficiency of a photocatalyst can be increased by increasing thesurface area of the material, which provides active sites for the reaction to takeplace. Which is influenced by the environmental conditions pH, temperature, and the concentration of organic pollutants also which influence the photocatalytic degradation process [6].

Table 1: Physical and Chemical Properties of ZnV_2O_6

1	Molecular Formula	ZnV_2O_6
2	Appearance	Yellow or LightYellow powder
3	Density	$4.3gcm^{-3}$
4	Molar Mass	$263.5gmol^{-1}$
5	Melting Point	1000°C
7	Solubility In Water	Insoluble
8	Solubility	Acidic and BasicSolution
9	Refractive Index	1.5 to 2.5
10	Crystal Structure	Monoclinic
11	Hygroscopic	No

Ref: Sciencedirect.com

1.2 Photocatalytic Activity

In the presence of a photo catalyst, the ability of a material to accelerate a chemical reaction. When exposed to light, it refers to the photo catalyticactivity, here we are generally concerned with how dyes can be degraded or transformed by the photo catalysts under light radiation. Basically in literaturethe common photo catalysts includes titanium dioxide, Zinc oxide and other semiconductor materials. These materials absorb light and generate electron- hole pairs, which includes in crucial for driving redox reactions. The mechanism involved in the photo catalytic activity is light absorption, where photo catalysts absorb photons with energy equal to or greater than its band gap, the electrons excites from valence band to the conduction band. Which leads to generate electrons and holes can initiate redox reactions, reduction ofoxygen to form reactive oxygen species by the electrons, such as superoxide anions with holes oxidizes water or hydroxyl ions to produce hydroxyl radicals(OH)[6]. Further the dye degradation of reactive species, primarily OH, attackthe dye molecules on resulting them to breakdown into smaller, less harmful molecules. The process results in complete mineralization, and evaporation of water, carbon dioxide and other simpler molecules. In the photo catalytic activity the factors affecting the degradation of dye. If the dye concentration ismore it can lead to light absorption by dye itself rather than the photo catalyst,reducing efficiency. The potential of hydrogen in the solution affects the surface charge of the photo catalyst, which influences the adsorption of dyes. Intensity of wavelength, light affect the no of electron-hole pairs generated. Ultra-violet light is commonly used because many photo catalysts have a bandgap that matches UV light energy[8].

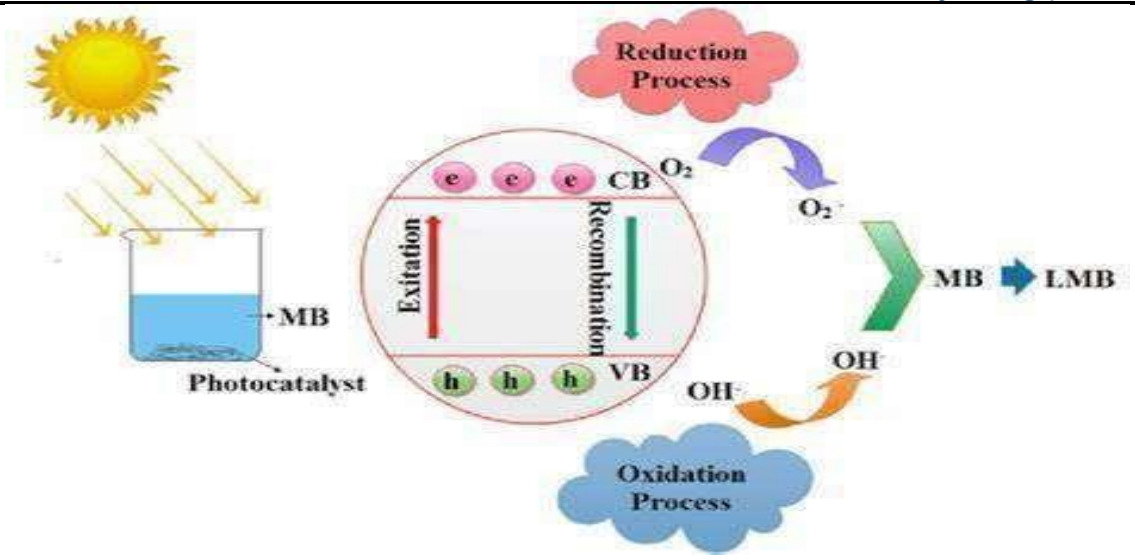

Fig. 2: Schematic representation of photo catalytic activity process

Ref. [Sciencedirect.com]

2 Methodology

2.1 Preparation of precursor solution

The synthesis procedure is followed according to the literature[7]. The materialsused in the synthesis are Zinc nitrate hexahydrate ($Zn(No_3)_2.\ 6H_2O$), ammonium meta vanadate (NH_4VO_3) metal precursor salts, acetone(CH_3COCH_3) and urea(NH_2CONH_2) as fuel. 0.297g of ($ZnNo_3)_2.6H_2O$) and 0.116g of (NH_4VO_3) is dissolved in 10ml of Acetone (CH_3COCH_3). The molar ratio of precursor salts are taken in 1:1 ratio. The prepared precursor solution is addedby 0.0608g of (NH_2CONH_2) which helps in increase pH of the solution. Then the prepared precursor solution is taken in clean beaker and stirred for 30 minusing magnetic stirrer, by which time all the solute get dissolved in solvent and until the uniform solution is formed. To obtain the weight of salt to prepared 10ml of precursor solution is by using the formula.

W=$Mt \times W \times V$

Where, 'W' is the weight of the salt in 'g'

'M_t' is molecular weight

'V'is volume of the solvent (ltrs)

2.2 Combustion Process

The uniformly mixed precursor solution is transferred into a crucible. The crucible is kept in a muffle furnace maintained at 500-degree Celsius. Evaporation of water due to the temperature at 500 degrees Celsius on forming a viscous gel to get a uniform redox mixture. Spontaneous combustion occursand propagates throughout the redox reaction. Finally nanoparticles of corresponding zinc vanadium oxide is formed. Firstly, the solution undergoesevaporation that result concentrated, the reaction is typically rapid, generatingheat and releasing gases CO_2, N_2, water vapor leaving behind a porous powder.

In a chamber we have to kept the crucible up to 15min. During the flame propagation large quantity of gases and high temperature produced helps in theformation of respective zinc vanadium oxide nanoparticles after calcination process. The mixture in a muffle furnace at a high temperature at 500 °C this temperature allows to solid state reaction to proceed forming.

Chemical Reaction for the synthesis of Zinc Vanadium Oxide(ZnV_2O_6)

$$Zn(NO_3)_2 + 2NH_4VO_3 + CO(NH_2)_2 \rightarrow ZnV_2O_6 + CO_2 + 3N_2 + 5H_2O + H_2$$

3. Results and Discussion

3.1 Analysis for structural properties of ZnV_2O_6 nanoparticles usingX-Ray Diffraction technique

The X-ray diffraction technique which is used to determine the phase composition and crystallographic structure of the synthesized Zinc vanadium oxide nanoparticles. The XRD patterns were recorded using a Panalytical X' Pert Pro Diffractometer with Cu Kα1 radiation (λ=1.54Å) operated at 40kV and 40mA. The diffraction data were collected in the 2θ range of 5° to 89°, with a step size 0.02°. The diffraction peaks were matched with the standard patterns available in ICDB database. The XRD pattern of Zinc vanadium oxide crystallites in the monoclinic structure. No peaks corresponding to secondary phase which indicates no impurities were observed, indicating a high phase purity of the sample. The characteristic peak of x-ray diffraction pattern of ZnV_2O_6 from the value 2θ, 20.44°, 27.64°, 28.34° and 29.2° which corresponds to the plane miller indices with (-2 0 1), (1 1 0), (-2 0 2) and (-11 1) respectively (According to JCPDS NO: 74-1262). The grain size of ZnV_2O_6 is calculated by using Debye-Scherrer's formula calculated to be average crystallite size is 13.8nm. The broadening of XRD peaks reflects the nano crystalline nature of the resulting sample. Since the effective XRD peak broadening can be caused by lattice strain and small crystallites.

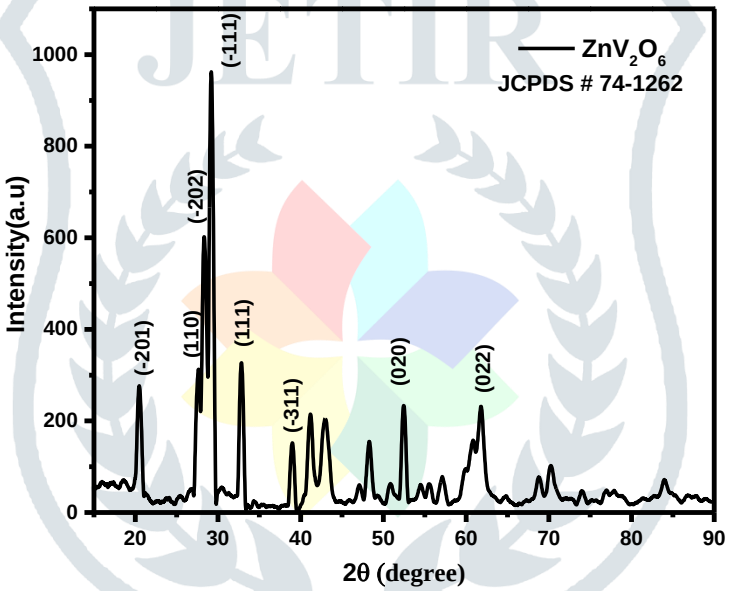

Fig.3 XRD Spectrum of ZnV_2O_6 *Nps*

Table .2 Crystallite size of using $ZnV2O6$ *Debye's scherrer's formula*

Material	2θ(degree)	Plane (hkl)	Grain Size
$ZnV2O6$	20.44 °	(-201)	14.56
	27.64 °	(110)	16.44
	28.34 °	(-202)	17.01
	29.26 °	(-111)	17.32

3.12 Analysis of Williamson-Hall plot for determine crystallite size andstrain of ZnV_2O_6 Nps

The Williamson-Hall plot which is used to determine the strain and crystallitesize of the ZnV_2O_6 Nps. By Plotting Full wave half maximum peaks versus sin of angle which is used in the X-ray diffractometer to find FWHM. The strain of the crystallite using Williamson-Hall plot found to be 4.49×10^{-3} and the crystallite size determined to be 19.38nm.

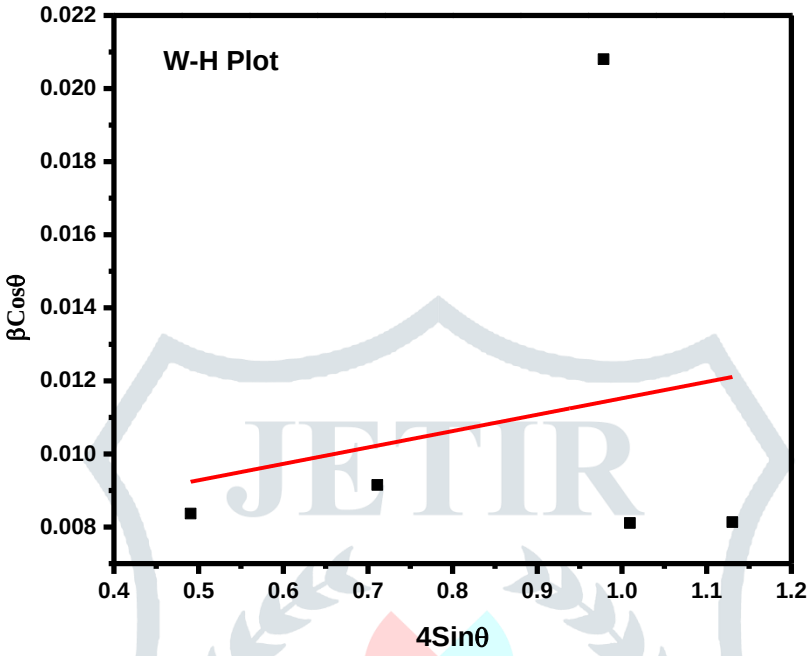

Fig.4 Williamson-Hall plot for ZnV_2O_6 Nps

3.2 Diffuse Reflectance Spectroscopy (DRS)

Diffuse reflectance spectroscopy is a technique which is used to find out the opticalparameters like band gap energy of a material. Fig. 5 shows the plot of wavelength versus reflectance the reflectance wavelength which corresponds to the peak is found to be λ=548nm.

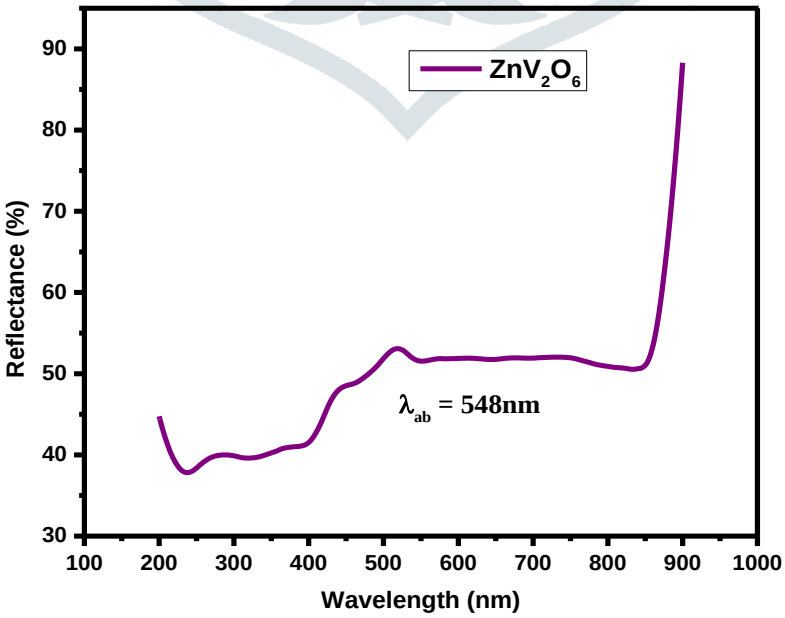

Fig.5 UV-Vis Spectrum of ZnV_2O_6 Nps

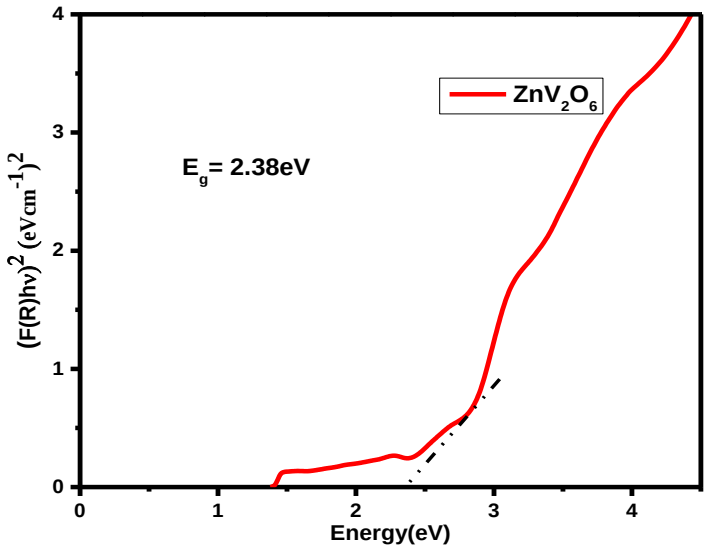

Fig.6 Kubelka-Munk Plot to deter

Using Kubelka-Munk plot optical band gap of the synthesized sample is determined , by plotting $(F(R)E)^{\frac{1}{n}}$ versus photon energy E, where n depends on the type of electronic transition. F (R) is a Kubelka Munk function. The optical band gap energy found to be 2.38 eV.

3.3 Analysis for functional groups of ZnV_2O_6 using Fourier-Transform Infrared Spectroscopy Analysis (FTIR)

The figure 7 shows the FTIR spectrum of $ZnV_2O_6 Nps$. FTIR was done usinga Cary 630 FTIR Spectrometer. It is used to detect the functional (or) OH- groups and molecular structures of the ZnV_2O_6 Nps by the combustion methodat substrate temperature about 500º C. As shown in the figure (5.4) the FTIR spectra of ZnV_2O_6 Nps in the range of 400 to 4000 cm^{-1}. In the present workthe presence of chemical bonds such as cm^{-1} in the FTIR symmetric stretchingthe V-O-V stretch is 640cm^{-1}. The bond 1348cm^{-1} corresponds to the V=O stretching and the bond at 1597cm^{-1} to O=H stretching. The wave numbers which will agree with the corresponding chemical (or) structural bonds as reported in table.3

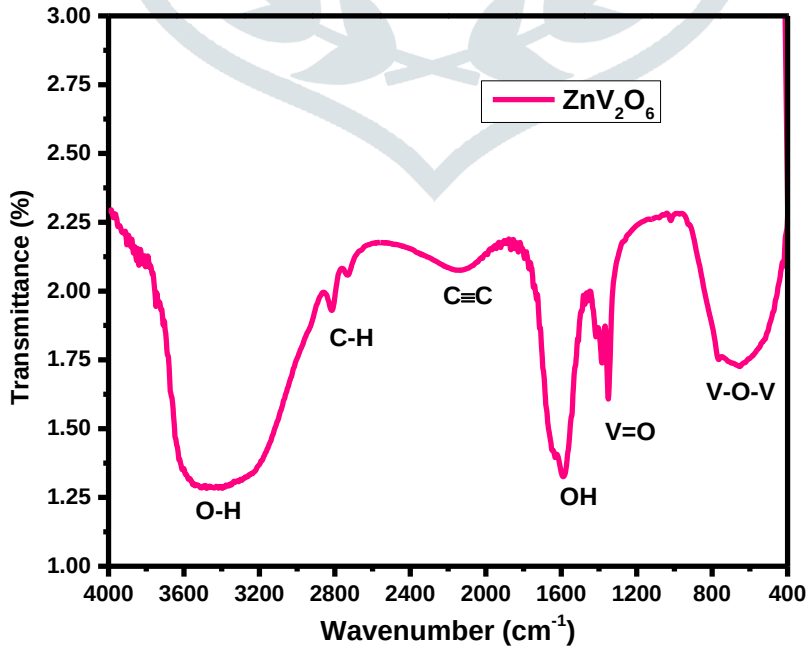

Fig.7: FTIR spectrum of ZnV_2O_6 N

Table. 3: Wave number and chemical bond related to the peaks inFTIR spectra of ZnV_2O_6 Nps

Wave number(cm^{-1})	Functional group
640	V-O-V
1348	V=O
1597	O=H
2149	C=C
2800	C-H
575	ZnO
3400	O-H

3.4 Analysis for Surface morphology of ZnV_2O_6 Nps using ScanningElectron Microscope (SEM)

Scanning Electron Microscope (SEM) using ZEISS evo Ls, the surface morphology of $ZnV2O6$ Nps prepared by combustion method, at temperature about 500ºC is been studied. SEM images in figure 8 showsa non-uniform surface morphology irregular shapes, having a high surface-to-volume ratio, rough and porous surfaces of $ZnV2O6$ Nps.

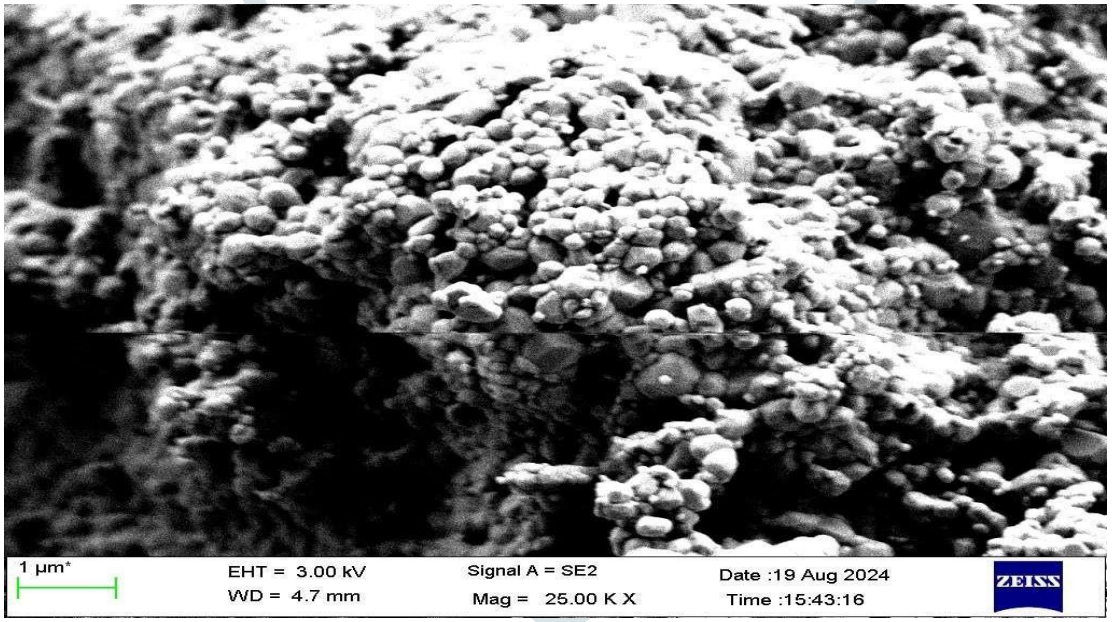

Fig. 8 : SEM image of $ZnV2O6$ N p s

3.5 Analysis for Elemental composition of of ZnV_2O_6 Nps using Energy Dispersive X-Ray Spectroscopy Analysis (EDAX)

The elemental composition and its proportion in the prepared $ZnV2O6$ Nps is studied using Energy Dispersive X-Ray Spectroscopy Analysis (EDAX). Using the same machine for SEM analysis. The composition and proportionof the elements in the $ZnV2O6$ Nps is tabled in table 4. The EDAX Spectrum of $ZnV2O6$ Nps synthesized in the present study is shown in figure 9, which establishes presence of Carbon K_α X-rays at 0.30keV, Oxygen K_αX-rays at0.52keV, Vanadium K_α X-rays at 4.95keV and Zinc $L_\propto$ X-rays at 0.93keV.

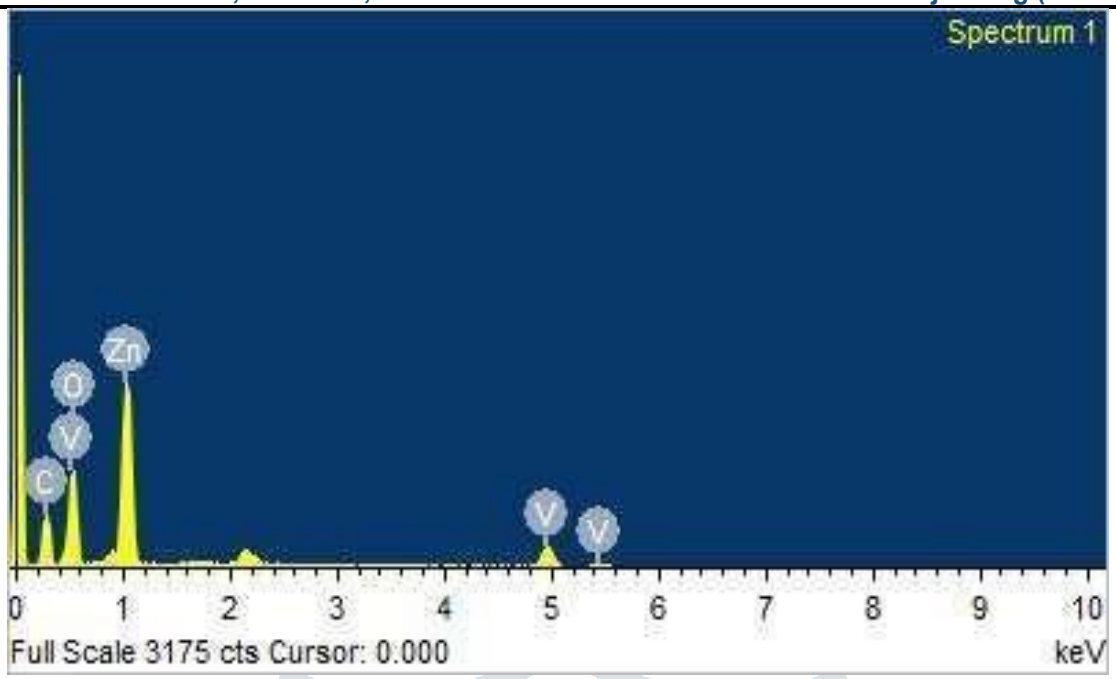

Fig. 9: EDAX spectrum of ZnV_2O_6 Nps Analysis for functionalgroups

Table 4: Composition and Proportion of elements in ZnV_2O_6Nps

Elements	Weight %	Atom %
C K_α	16.21	35.11
O K_α	23.73	38.59
V K_α	21.24	10.85
Zn L_α	38.83	15.45
Total	100.00	100.00

3.6 Application of (ZnV_2O_6) Nps on Photo catalytic degradation of methylene blue dye

Methylene blue (MB) was used as a dye pollutant to assess the photo catalyticactivity of the synthesized compounds. 100 mL of MB solution were combinedwith catalyst in a standard process. The suspension was then stirred for 30 minutes in the dark to reach an adsorption-desorption equilibrium condition. The visible light source was a metal halide lamp with a cutoff filter (greater than 420 nm) added. A cooling water recirculation system (SH-BILON-T- 1000S) was used to maintain the temperature at 25 °C. To eliminate any remaining catalyst from the solution, 2 mL of the suspension was taken out and centrifuged at intervals of 30 minutes. The absorbance intensity was measured with a UV- Vis spectrophotometer, and the catalyst degradation rateswere calculated using equation (12).

$$\%Degradation = \frac{(C_o - C_t)}{C_t} \times 100$$

Where, C_o is the MB dye concentration at the start time, or t=0, and Ct is the MB dye concentration at specific time intervals.

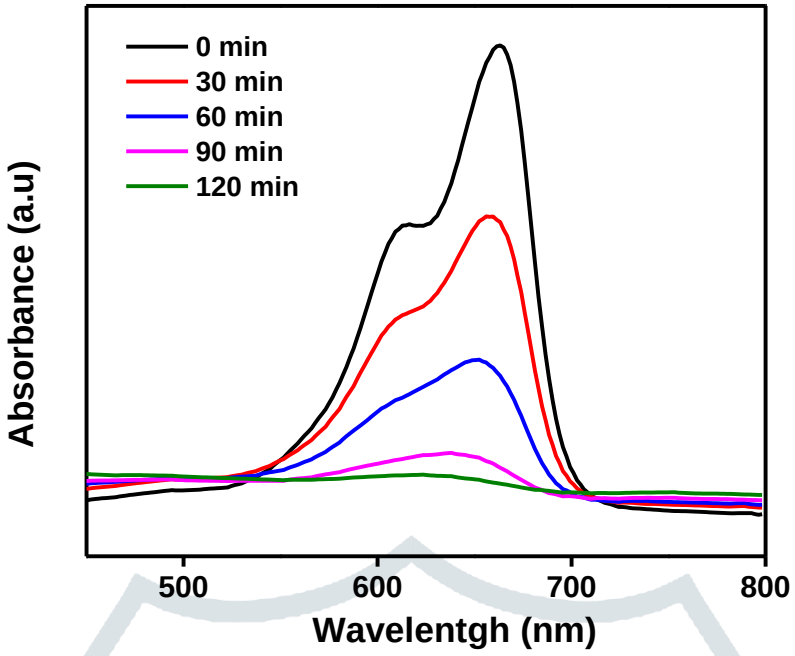

Fig. 10: Schematic Representation of wavelength versus absorbance

A sample of polluted water of methylene blue dye is taken in a beaker under the UV-visible light. The Methylene blue dye concentration is taken from 5ppm to 20ppm for the effective photo catalytic activity of the reaction to takeplace. The photo catalyst ZnV_2O_6 is taken as dose of 20mg per 100ml for 5ppmof dye concentration. At 5ppm of methylene blue dye concentration with 20mg of ZnV_2O_6 shows a maximum degradation of non-biodegradable pollutants. We neglect to take high concentration of dye due to reduction of active sites on the surface of the ZnV_2O_6 photo catalyst which results in decreasing the degradation percentage. The factors which affects the rate of degradation is pHof the reaction solution. The pH value which plays a crucial role in the photo catalytic water treatment it purely depends on pH, which involves in influencing the size aggregates of the photo catalyst ZnV_2O_6 . The catalyst particles with charge in valence and conduction band which helps in the pH reaction in photo catalytic water treatment optimizing the pH which results in achieving optimum degradation efficiency. In this present work ZnV_2O_6 as photo catalyst to degrade the methylene blue dye in water is studied. The complete degradation of methylene blue was observed for the pH value of 12 within 2 h of time. Fig. 5.6(a) represents the plot between wavelength and absorbance the absorbance is the ratio of incident to transmitted radiant power through sample. When incident radiated source is incident on the sample of polluted water where zinc vanadium oxide acts as photo catalystthe incident light from the UV-Vis light source the amount of light absorbed by the sample in response to degradation of methylene blue from toxicity. At t=0 min the amount of light transferred through the sample is high where photo catalytic degradation take place by the photo catalyst due to increase in absorbance of light by the sample.

Due to the high concentration of the sampleand incident wavelength is more compared to the required wavelength to degrade the dye pollutants. As shown in Fig.5.6(b) then at t=30 min theabsorbance of light through the sample is decreased due to decrease in incidentwavelength through the sample. The degradation takes place t=30 min decrease in the concentration of the dye sample which is kept absorbance alsodecreases due to decrease in wavelength. As Shown in Fig. 5.6(a). In Fig.5.6(b)the photo catalytic degradation of methylene dye in 85% over time is shown. In 2hours the degradation of methylene blue dye achieved 85% by photo catalytic activity. The current study which involves in aim to degrade the non- biodegradable pollutants of methylene blue dye by ZnV_2O_6 photo catalyst is studies under UV-Vis light source. The maximum degradation of M.B dye is obtained by the ZnV_2O_6 under photo catalytic activity.

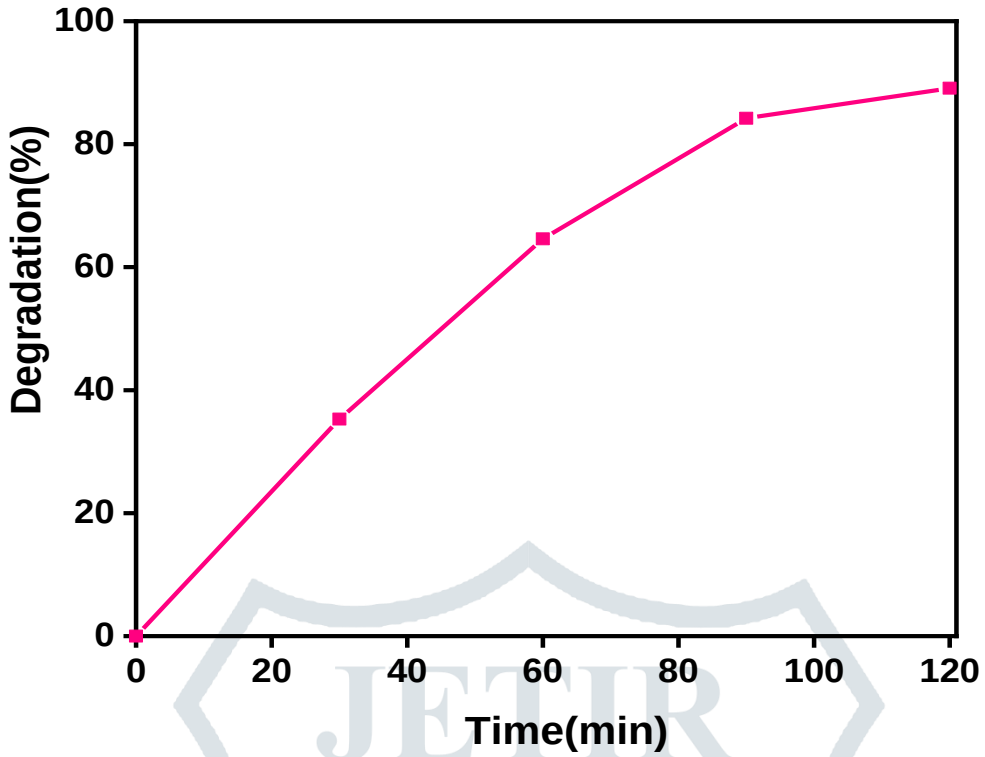

Fig. 11 : Methylene blue dye degradation over time

4. Conclusion

In this present work, (ZnV_2O_6) Nps is been synthesized by combustion method. The (ZnV_2O_6) Nps are subjected to characterization techniques. The structural, elemental composition, and band gap energy is studied by using the techniquesdiscussed in the chapter 3. X-ray diffraction analysis result shows that zinc vanadium oxide nanoparticles have a good crystallanity in generally grain size is 13.8nm. Fourier transform infrared spectra shows the chemical bonds, functional group, are corresponds related to zinc vanadium oxide (ZnV_2O_6) nanoparticles. The photo catalytic degradation of the methylene blue dyeis studied under UV visible light. The zinc vanadium oxide (ZnV_2O_6) photo catalyst it clearly shows the breaking of the dye bonds. It enables the performance of the photo catalyst. But the zinc vanadium oxide photo catalyst could not achieve 100% degradation of dye. Freshly prepared 5ppm concentration of methylene blue dye and pH of the reaction maintained at 7. After the second cycle, the same procedure is repeated. Here second and thirdcycles shows lower degradation on rates compared to the first cycle. In 2 hoursthe degradation of methylene blue dye achieved 85% by photo catalytic activity. The current study which involves in aim to degrade the non-biodegradable pollutants of methylene blue dye by ZnV_2O_6 photo catalyst is studies under UV-Vis light source. The maximum degradation of M.B dye is obtained by the ZnV_2O_6 under photo catalytic activity. In future the waste water treatment by the metal oxides have a large scale application by removing the organic polluted dyes from the leather, textile and paper industry.

Due to the usage of water in future is large in advanced technologies, industries and in human life. Most of the water resources are gotpolluted with the harmful chemicals, dyes and non-biodegradable pollutants. This affects the living system while consuming waste water with low purity due to water recyclability. It results in the lack of water usage which is contaminated and have large scale usage of water in many industries. To overcome the waste water treatment in this current study we are dealing with the degradation of methylene blue dye from leather, textile and paper industry.On photo catalytic activity the degradation of pollutants in dye were degraded by using $\boldsymbol{ZnV_2O_6}$ photo catalyst in water resources. The achievement of 85% degradation of methylene blue dye was investigated by photo catalytic activity. The complete degradation of methylene blue could not be achieved by $\boldsymbol{ZnV_2O_6}$ photo catalyst. It can be achieved by enhancing the catalytic properties of photo catalyst by different dosage concentration of methylene blue dye.

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