RESEARCH PAPER

Role of Binary Nanocomposite for Environmentally Treatments: As a Model of Photocatalytic Activity for Removal Maxillion Blue (GRL) Dye

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ABSTRACT

One of the most difficult problems of elimination colors from industrial effluent utilizing visible-light. Due to its small bandgap, vanadium pentoxide (V_2O_5) is receiving a lot of attention as a potential visible light for the breakdown of organic contaminants. However, the V_2O_5 catalyst's quick electron-hole pair recombination restricts its use in photo-degradation. The performance of V_2O_5 as a photo catalyst can be enhanced by interacting with other semiconductors. In this study, we used a hydrothermal approach to prepare V_2O_5/ZnO nanocomposites. Using characterization methods like (FE-SEM), (EDX), X-ray diffraction (XRD), the physical characteristics of the as-synthesised products were investigated. The creation of pure ZnO, V_2O_5 nanoparticles and the presence of diffraction peaks associated with the hexagonal phase of ZnO, orthorhombic V_2O_5 were both confirmed by the XRD data. The Scherer equation was used to analyze the variance in structural characteristics. The nanocomposite's computed energy bandgap (2.63 eV) from UV-vis spectroscopy suggested that it might be used as a photo catalyst under a UV-visible light. The ZnO/V_2O_5 nanocomposite production was also confirmed by FTIR spectra. FE-SEM images revealed spherical and approximately hexagonal shape. The nanocomposite contains Zn, V, and O, according to EDX examination. Photocatalytic degradation of the ZnO/V_2O_5 nanocomposite to removal GRL dye (59.52%).

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INTRODUCTION

The breakdown of environmental and wastewater contamination brought on by textile effluents has generated a great deal of academic attention during the past two decades. Vanadium pentoxide (V_2O_5) is an excellent semiconductor with a low bandgap energy (2.2 eV) and has been researched as a visible light active catalyst for the photo degradation of organic contaminants. This is one of the many oxide based semiconductors. Additionally, V_2O_5 has commercial uses in optoelectronic devices, gas sensors, and lithium-ion batteries. However, the efficient breakdown of pollutants is reduced by the quick recombination of photo generated electron-hole pairs in the photocatalytic process[1-3]. As a result, numerous approaches have been investigated by the scientific community to address this issue. The coupling of two semiconductors is one of the crucial methods. Coupled semiconductor photo catalysts are used.

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Among several metal oxides, ZnO has gained much attention in material science, physics, chemistry, and biochemistry due to its high stability, transparency, high exciton binding energy (60 meV), high piezoelectric constant, and wide energy band gap .The wide band gap 3.37 eV and fast e−/h + recombination restrict its application as a dynamic photo catalyst . This discrepancy can overcome by combining it with the other metal oxides [4-8]. Remarkably, vanadium oxide (V_2O_5), an n-type semiconductor. ZnO is a Wide bandgap (3.2 eV) n-type semiconducting material is well known for its catalytic uses in gas sensors, dye-sensitive solar cells, photo-catalysts, and other devices[9-13]. It also absorbs a larger portion of the solar spectrum There aren't many reports on V_2O_5 and ZnO semiconductor connection. In this paper, we describe the hydrothermal method for the fabrication of nanoscale ZnO/ V_2O_5 composites as show in Figure 1. Different approaches were used to examine the produced composite's structural and optical qualities. Additionally, the photodegradation of maxillion blue (GRL) was used to gauge the photocatalytic activity of a nanocomposite, and the results are explained in depth [14-16].

MATERIALS AND METHODS

Materials

Ammonium metavandates (NH_4VO_3), Zinc acetate, Oxalic acid was purchased from (Germany, Sigma-Aldrich), and Aqueous ammonia(25%) were used, Maxillion Blue (GRL) dye was prepared. A stander solution was preparing via 0.1g in 1000ml to obtained 100 mg/ L as an appropriate amount of GRL dye double distilled water.

Preparation Vanadium Oxide Pentahydrate of Zinc Oxide Composite ZnO/V_2O_5

ZnO/V_2O_5 nanoparticles were prepared by thermal hydrolysis of ammonium metavandates (NH_4VO_3), and these experiment was carried out in a 150 mL Teflon cup enclosed in a stainless steel autoclave (Berghof, DAB-3.(

In all experiments, 25 mL of ammonium metavandates aqueous solution (0.5 gm NH_4VO_3, 25 ml water), in the presence 75ml of an aqueous Zinc acetate solution (20.6 gm Zinc acetate, 75 ml water), were mixed, Then this solution was mixed very well for further 60 minutes. followed by the addition 6.3 gm of Oxalic acid and 65ml of Aqueous ammonia (25%) to the mixture, then this solution was mixed very well for further 120 minutes, the outcome was then poured into the teflon cup. The Teflon cup was then sealed within the autoclave, which was then shut and placed inside an electric furnace maintained at 160 °C for 24 hr. The autoclave was finally cooled to room temperature, and the resulting powder was separated by centrifuge at 6000 rpm speed for several times (at least three times), washed with distal water at least for four times , and dried overnight in an oven at 60°C as appear in Fig. 2.

Photocatalytic experiments

Stock solutions of 1g of GRL dye (1000 mL) were prepared, .The different concentrations of dye (10-50) mg L^{-1} in 200 mL solution GRL dye ,

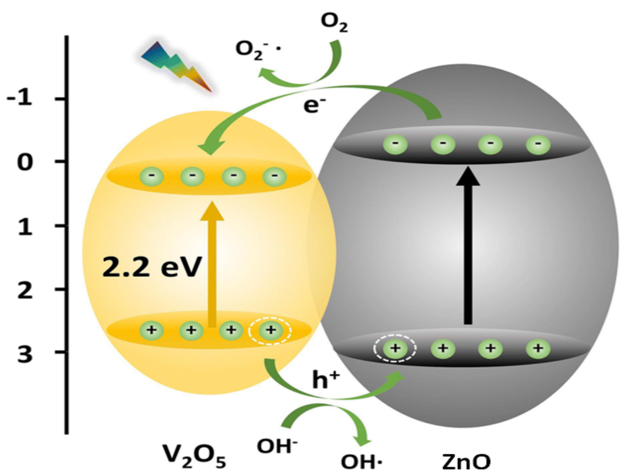

Fig .1. The charge transfer channel over V_2O_5/ZnO composites during the GRL degradation process is schematically illustrated.

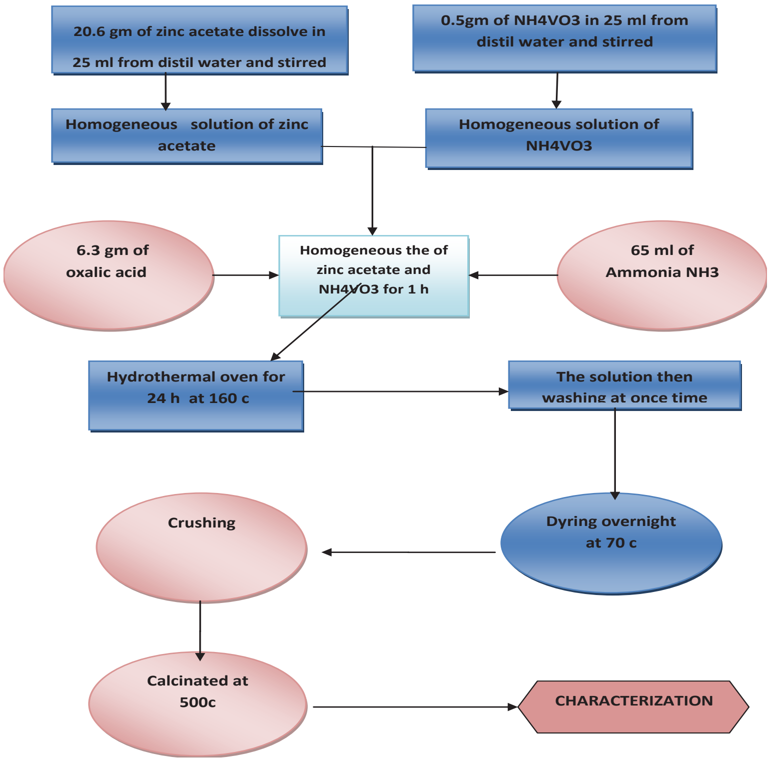

Fig. 2. Preparation Vanadium Oxide Pentahydrate of Zinc Oxide (ZnO/ V_2O_5) nanocomposite.

and different Weight (0.1-0.6 g) of ZnO/ V_2O_5 nanocomposite was studied at a concentration of 10 mg L^{-1}(in 200 mL GRL dye) and intensity of light is 2 mw/cm2, and effect of different light intensity of dye by nanocomposite was studied at smeller optimum condition . All experiments were carried out in a photo- reaction vessel, an adsorption was performed for 10 min. before the photocatalytic process, ads the beaker was put under the UV-visible lamp for 1 h, using UV Visible spectrophotometer 1650 spectrophotometer, Japan) at 590 nm. experimental tests were performed, and calculate the amount of absorbance before photo catalysis and after photo catalysis for 1 hr by use centrifuge at 12000 r/min for 10 min . The photo degradation efficiency was calculated via eq. (1).

$$PDE\%=(Co-Ct)/Co \quad *100 \qquad (1)$$

Co: is the initial concentration of GRL and Ct: is concentration of GRL after testing for a period of time (t).

RESULT AND DISCUSSION

X-Ray Diffraction Spectroscopy (XRD)

Spectroscopy via X-Ray Diffraction (XRD) The phase stability and phase transition of the ready catalysts, V_2O_5, were investigated using XRD. Table 1 displays the outcomes of employing the full width at half maximum (fwhm), and the Scherrer equation (as given in eq. 2).

$$P = \frac{K\lambda}{\beta Cos\theta} \qquad (2)$$

Based on the peak width (B), one may calculate the particle size (P), which yields a shape factor (k) of 0.9, a wavelength of the x-ray source of 0.1541 nm, and a B value for the whole peak width at half maximum corrected for instrumental broadening. The XRD pattern of synthesized catalyst is shown in Fig. 3. Two types of phases were detected in Fig. 3. One type of phase is well indexed to V_2O_5 with an orthorhombic structure. The other type of phase is known to exist in ZnO's hexagonal structure. This XRD pattern revealed no further possible impurities, such as VO_3 and $V2O_3$, indicating that the final product solely contained the distinct diffraction peaks of V_2O_5 and ZnO [17].

Field Emission Scans Electron Microscopy (FE-SEM)

Fig. 4 indicates that better dispersion of the FE-SEM is with exact great agglomeration. From XRD crystalline size result and FESEM micrographs, it could be concluded that all ZnO/V_2O_5 prepared have small nano-particles crystallize. However, SEM measurements proof a full agreement with the crystal size estimated by XRD measurements. ZnO/V_2O_5 shows the agglomeration phase this attributed to the low crystalinity, furthermore also results show sample ZnO/V_2O_5 is homogenous in shape and size. The aggregation of particles (or formation of larger particles) should have been originated from the large specific surface area and high surface energy of ZnO/V_2O_5 nano-particles. Thus, due to the large specific surface area and high surface energy, ZnO/V_2O_5 nanoparticles aggregate severely. The study of FE-SEM micrographs reveals a less number of pores with smaller lump size, so for behavior of particles to produce nano rode

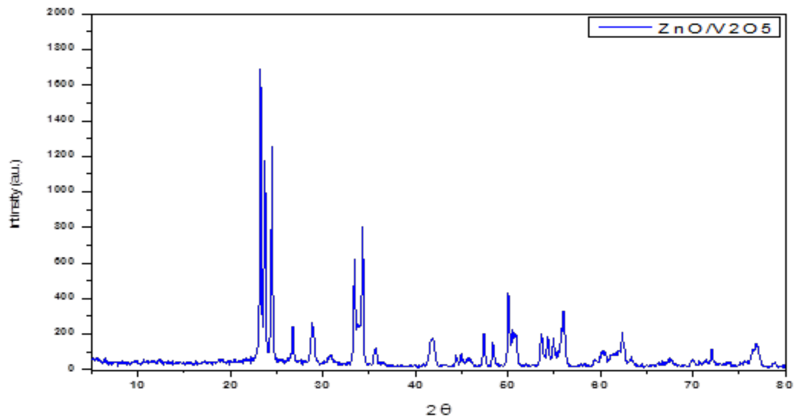

Fig. 3. XRD diffraction patters of ZnO/ V_2O_5 prepared by hydrothermal technique.

Table 1. Summary of the average crystallite size estimated from XRD patterns using the Rietveld analysis, and the Scherer formula of synthesized ZnO/ V_2O_5 powders.

Peak Position(2θ)	FWHM(β)	Size(nm)	Average size (nm)
31.43444	0.38548	19.83054046	
34.08412	0.43771	17.34595087	
35.92505	0.43247	17.46740518	
47.22224	0.48707	14.93912168	
56.30185	0.43452	16.11390552	
62.57344	0.53132	12.77267988	76.52520263
67.67855	0.50263	13.12293336	
68.81961	0.60239	10.87604268	
66.21758	0.01086	612.5066599	
72.30414	0.06007	106.7446385	
72.30414	111.80568	0.057350847	

shapes instead of spindle particles[18-20].

EDS data indicated vanadium connected with Zinc and oxygen in distinct particles, (Fig. 5). The XRD analysis identified the nanocomposite elements. As determined by EDS, the predominant elements samples were vanadium, Zinc, oxygen, and carbon. Vanadium was primarily associated with Zinc [21, 22].

Effect of mass dosage

Effect of amounts (0. 1, 0.2, 0.4, 0.6) gm of ZnO/ V_2O_5 nanocomposite on the cracking and degradation of (GRL) dye, photocatalytic degradation in the solution GRL dye concentration 10 mg/L, reaction at 25°C, time is 1h. First order experimental data were analyzed as shown in Fig . 6.

The influence of adsorbent dose on the removal of 10 mg/L GRL dye as appear in Fig. 6. The increasing of weight of ZnO/ V_2O_5 composite about (0.1 - 0.2)gm, the PDE% improved of [48.6 - 84.08 %] after 1houre [23].

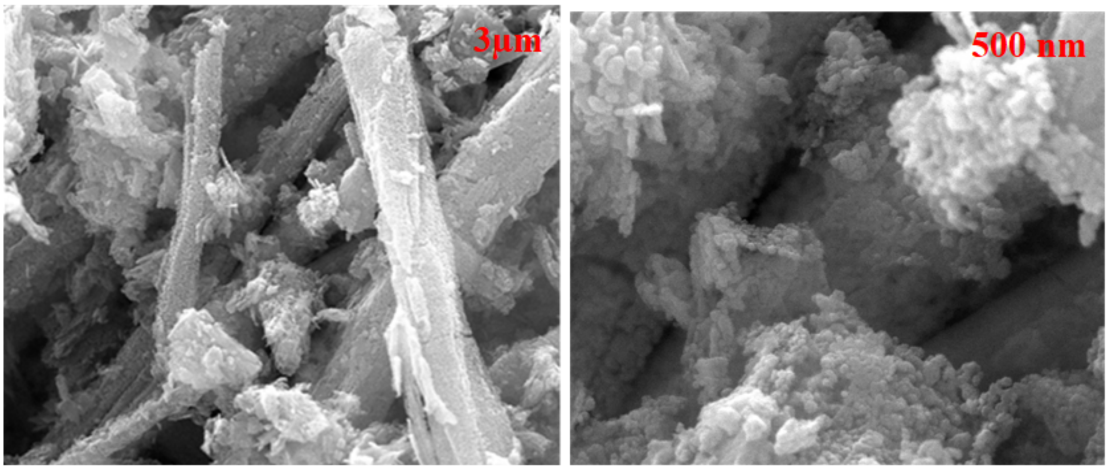

Fig. 4. FE-SEM images of ZnO/V_2O_5 nanocomposite.

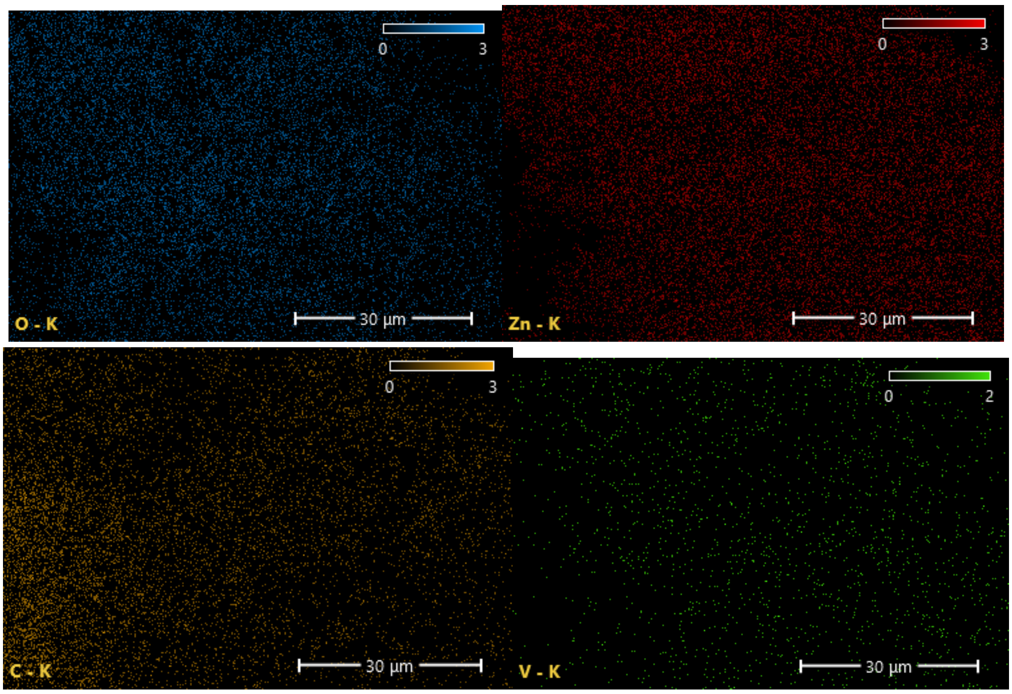

Fig. 5. EDS map images of ZnO/V_2O_5 nanocomposite.

Effect of concentration of GRL dye

Several dye concentrations (10-50 mg/L), were carefully chosen to study the influence of initial GRL dye concentration on to ZnO/V_2O_5 composite. The quantities of GRL adsorbed at solution pH 6, weight of nanocomposite about 0.6 g appear in Fig. 7. GRL dye solution plays a pivotal role in estimate rate of degradation, also the time dependence of photocatalytic degradation of GRL under several concentrations. The experimental result could be analyzed to assume first order kinetic appear in Fig. 7. The increasing of GRL dye concentration about 5 – 20 mg/L, the removal percentage improved of [59.52 - 34.1%] after 1houre time of adsorption[23-25].

Effect of light intensity (L.I)

The effect of light intensity (0.8- 2.6) mw/cm^2, was observed via change the distance among light source and exposed surface of the material. photo degradation of GRL dye via the influence of L.I was studied in ZnO/V_2O_5 composite 0.4 g,

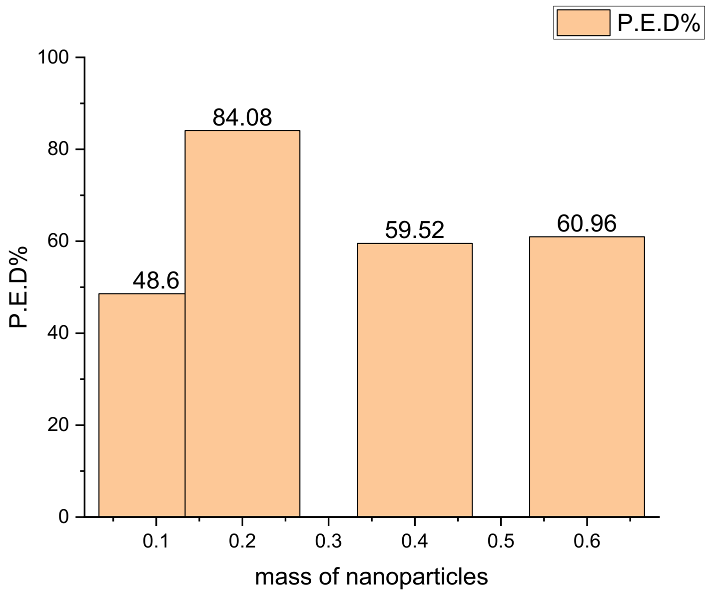

Fig. 6. Effect of Photo catalytic and Photo degradation efficiency of GRL at several dosages.

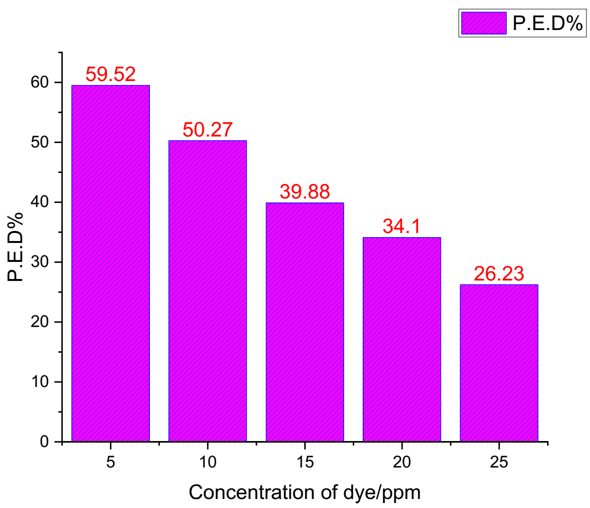

Fig. 7. Photocatalytic degradation of GRL at several Concentration.

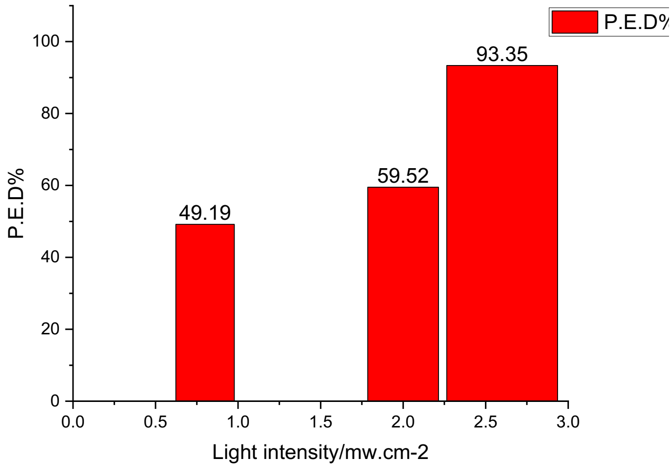

Fig. 8. Effect of light intensity onto Photocatalytic degradation of GRL dye.

concentration of GRL dye 10 mg/L. All reactions were discovered to continue following the first-order kinetics depicted in Fig. 8. As more radiation is accessible to excite the catalyst and, as a result, more charge carriers are created, the rate of photocatalytic degradation and PDE% increased with increasing U.V intensity light[3, 14, 26].

CONCLUSION

The hydrothermal method was used to create the ZnO/ V_2O_5 nanocomposite. XRD examination revealed the ZnO/ V_2O_5 nanocomposite production. The creation of nano-rods with some spherically shaped particles is seen in the FE-SEM image, while vanadium, zinc, and oxygen are detected in the EDXS study. In the presence of low concentrations and increase weight composite , the photocatalytic degradation of GRL dye was most effective. With the weight of ZnO/ V_2O_5 nanocomposite rising by (0.1 - 0.2)g, PDE% increased by [48.6 - 84.08%] after one hour.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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