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PHOTOCATALYTIC DEGRADATION OF AZO DYE CONGO RED USING COPPER OXIDE/NICKEL OXIDE NANOCOMPOSITE

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Abstract

Nanocomposite of CuO/NiO was prepared using controlled co-precipitation method. The synthesized materials were characterized using XRD. UV/Vis absorption spectroscopy of the synthesized samples was studied. The Photocatalytic activity of the nanocomposite for the photodegradation of Congo red was studied at different pH values, different illumination time and at different amount of catalyst loading.

Keywords: Nanocomposite, Co-precipitation, Photocatalytic activity, Photocatalyst.

INTRODUCTION

Wastewater from textile industries poses a threat to the environment as large amount of chemically different dyes are used for various industrial applications. They also uses substantial amount of water in their processes to form highly colored effluent which generally has hazardous effect in our ecosystem due to the presence of organic chemicals. Water contamination becomes a serious issue due to the fact that 2% of dyes produced in these industries are discharged directly in aqueous effluent [1]. So it was necessary to find a new way to remove colored dyes before discharging them into the environment [2, 3]. The various conventional technologies currently employed in the removal of colored effluents in industrial water are classical and do not lead to complete destruction of the dyes. These methods do not work efficiently due to high solubility of dyes as well as their resistance to chemical and biological degradation; also they just transfer the contaminants from one phase to another [4]. Therefore, there is a need to develop a novel treatment method that is more effective. In recent years, photocatalytic reaction has attracted extensive interests as a potential way to treat wastewater. The aim of the present work is to study the factors effecting on photocatalytic oxidation process of Congo red using CuO/NiO nanocomposite and to find out the optimal conditions used in photocatalytic process.

II. EXPERIMENTAL

AR grade chemicals obtained from Merck were used for the preparation of CuO/NiO heterojunction. CuO/NiO (CNF) were prepared by the co-precipitation method in presence of capping agent. CNF annealed at 500^0c for three hours, was used for analysis.

XRD studies were carried out using XPERT-PRO model powder diffractometer (PAN analytical, Netherlands) employing Cu- K_α radiation (λ = 1.54060A^o) operating at 40kV, 30mA.The UV/Vis spectrum was obtained using JASCO V-650 UV visible spectrophotometer.

III. RESULTS AND DISCUSSIONS

3.1 XRD Analysis

X-ray diffractograms of CNF is shown in Figure 1. In order to confirm the phase purity of the samples prepared, the interplanar spacing (d_{hkl} values), 2θ values and relative intensity values corresponding to the observed diffraction peaks were compared with the standard values of CNF the observed diffraction peaks were compared with the standard values of CuO and NiO as reported by JCPDS-International Centre for Diffraction Data. The data obtained for CuO/NiO matched with JCPDS-ICDD pattern number #78-0423 of NiO and JCPDS-ICDD pattern number #80-1917 of CuO separately. The variation observed in the d values of the crystal planes in case of CNF when compared to NiO and CuO, confirms the formation of composites. The average crystallite size was calculated from the line broadening of the XRD pattern, making use of Scherrer formula. Average Crystallite size of CNF is 16.29 nm.

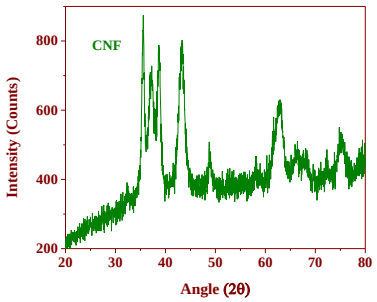

Fig.1 XRD of CNF

3.2 UV/Vis Spectrum Analysis

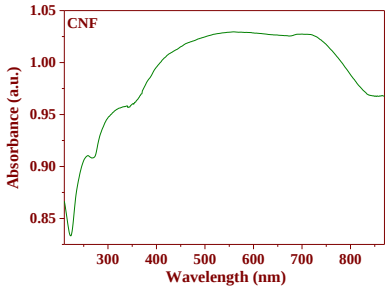

Fig.2 UV Absorbance spectrum of CNF

The UV/Vis absorption of CNF taken in the wavelength range 210 to 870 nm with 1 nm resolution is shown in the Figure 2. A wide range of absorption in UV and visible range was observed. Absorbance spectrum shows the presence of multiple peaks which confirms the presence of subgaps.

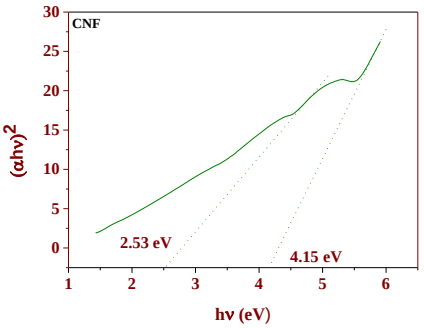

Fig.3 Tauc plot for CNF

From absorbance spectrum, Tauc plot was drawn and the corresponding energy gap was found. $(\alpha h\nu)^2$ vs $h\nu$ was also plotted. The optical band gap determined from the absorption spectra using Tauc's relation for CNF is shown in Figure 3.

3.3 Photocatalytic Studies

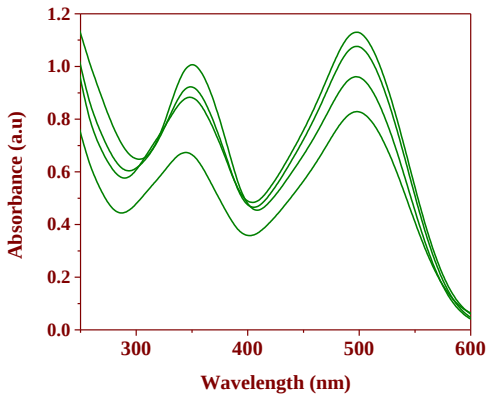

Fig.4 Absorbance spectrum showing photocatalytic degradation of Congo Red

A set of Photocatalytic degradation of Congo red was carried out to measure the photocatalytic activity of CuO/NiO Photocatalyst. A black light blue flourescent bulb was positioned at the axis to supply UV illumination. The experiments were performed by suspending photocatalyst into reactor with Congo red dye solution. The reaction was carried out isothermally at 30^0C. The concentration of residual Congo red in the solution after irradiation was determined by monitoring the absorbance intensity of solution samples at their maximum absorbance wavelength by using UV-Vis spectrophotometer which was recorded on a JASCO V 650 with a spectrometric quartz cuvette at room temperature.

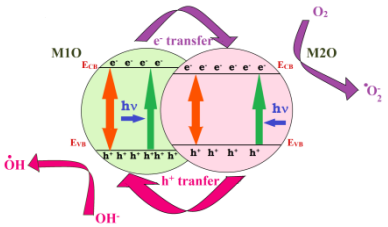

Fig.5 Mechanism suggested in the case of Photocatalytic degradation process using M1O/M2O (CuO/NiO)

The variations in different experimental conditions affecting on Photocatalytic oxidation of Congo red using catalyst CuO/NiO such as, pH value, illumination time and amount of catalyst loaded were taken into account to reach to integrated model for the photocatalytic degradation of Congo red. Generally, the effect of pH on organic degradation assisted by the semiconductor oxides has been related to the establishment of acid-base equilibrium governing the surface chemistry of metal oxides in water. The role of the effect of pH on the photodegradation of Condo red over CuO/NiO catalyst is reported in the pH range of 2–9 using 0.1 gm of catalyst and 300mL of 50 ppm dye solution under UV light at 30^0C for two hours. Maximum efficiency was obtained for pH 6. The effect of illumination time on photodegradation efficiency of Congo red was carried out by measuring the photodegradation efficiency at different periods of time using 0.1 gm of catalyst and 300mL of 50 ppm dye solution under UV light at 30^0C. The results revealed

that the photocatalytic activity increases with increase of the illumination time and reaches maximum after 120 min illumination time. Such data reveals the relative high activity of the prepared catalysts which enables the complete degradation of the Congo red in such short illumination time and the catalyst has active sites for carrying out the reaction. The effect of catalyst loading dose on the photodegradation efficiency of Congo red was observed by taking different amounts of catalyst ranging from 0.05 to 0.15 gm into 300mL of 50 ppm dye solution under UV light at 30^0C for two hours. These results showed that increment of catalyst loading from 0.05 to 0.1 gm increased the photodegradation efficiency of Congo red from 85 to 96% and after that the further increase in catalyst loading dose above 0.125 gm does not affect on the photodegradation efficiency. This is attributed to the increase in the catalyst loading dose which increased the number of active sites available on the catalyst surface for the reaction, which in turn increased the number of holes and hydroxyl radicals. Figure 3 shows the UV spectrum analysis for different time intervals done for the photodegradation of Congo red for time variation with 0.1 g 300mL of 50 ppm dye solution under UV light at 30^0C for two hours.

4 CONCLUSIONS

Nanocomposite of CuO/NiO was prepared through controlled co-precipitation method in presence of capping agent. Results show that CuO/NiO is a good Photocatalyst for degradation of Congo red.

5. REFERENCES

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