SONOCATALYTIC DEGRADATION OF METHYLENE BLUE DYE USING A NANOSIZED ZINC OXIDE POWDER PREPARED VIA SONOCHEMICAL METHOD

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Abstract

Nowadays, many studies focus on the application of sonochemical reactions for treatment of industrial wastewaters. The toxic materials usually have very complex, aromatic molecular structures which make them extremely stable and difficult to biodegrade. Sonocatalytic degradation presents a very efficient method for waste water purification.

In this work we have investigated heterogenic sonocatalytic degradation of methylene blue (MB) aqueous solution, as a common organic pollutant, in the presence of nanosized ZnO powder as catalysts. The phase composition of sonochemicaly synthesized ZnO nanopowder was identified by XRD and the particles morphology was characterized by FE–SEM. The optical properties of ZnO nanocrystals were investigated by ultraviolet–visible (UV–Vis) diffuse reflectance spectroscopy (DRS).

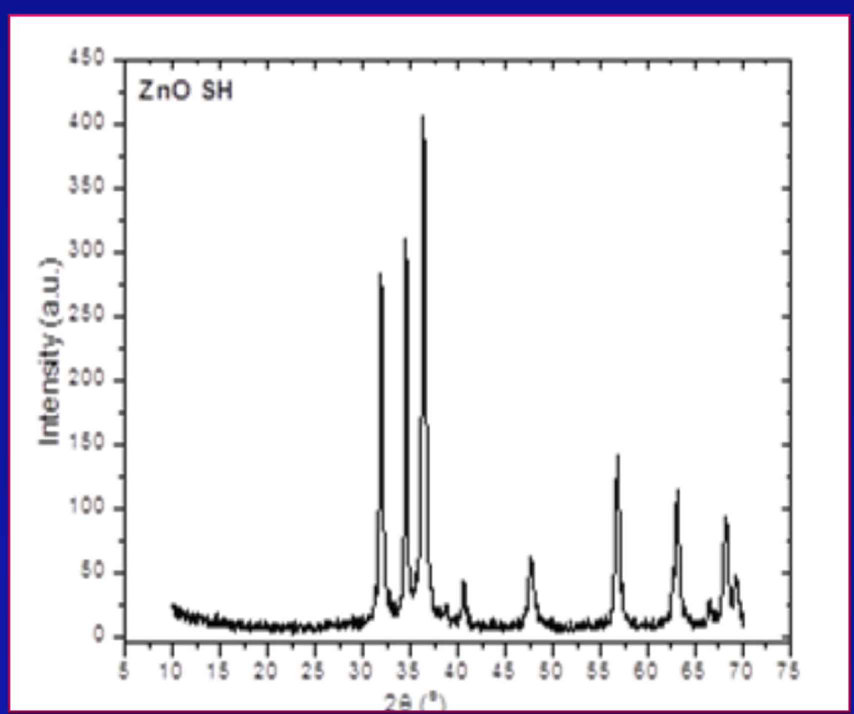

Fig. 1. XRD patterns of sonochemicaly sinthesized ZnO nanopowder.

The typical XRD pattern of the ZnO powder is shown in Fig. 1. All of the diffraction patterns can be indexed as a hexagonal wurtzite ZnO structure which are consistent with the values in the standard card (JCPDS 36-145). No diffraction patterns from any other impurities were detected, which confirms that the synthesized powder was pure ZnO hexagonal phase.

Diffuse reflectance spectra of ZnO powder with nano sized spherical morphology, Fig. 3 revealed characteristic R curve with the absorption edge near 380 nm. The nano-sized ZnO powder revealed the reflectance of approximately 65 %.

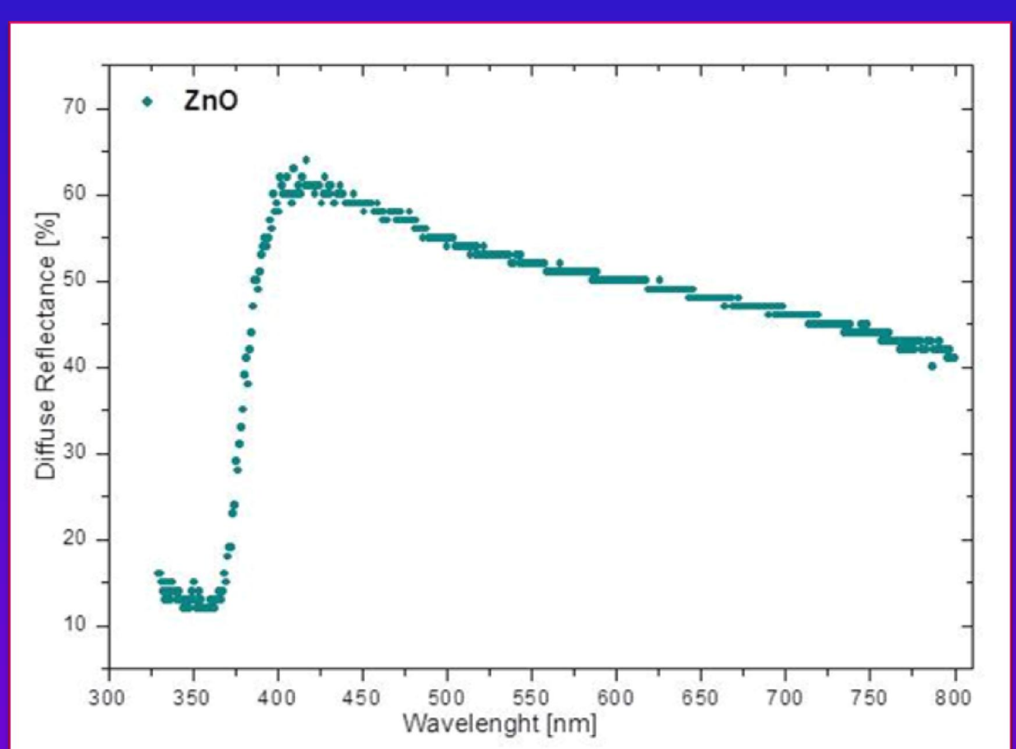

Fig. 3. Diffuse reflectance spectra of ZnO nano-sized powder.

Materials

Materials	Quantity
ZnO SH	50 mg
MB 5 ppm	50 ml
MB 10 ppm	50 ml
MB 20 ppm	50 ml

Results

Particles morphology of the synthesized ZnO powder is shown in Fig. 2a and 2b. As it can be seen ZnO powder, consists of spherical nano-sized particles with average diameters less than 50 nm.

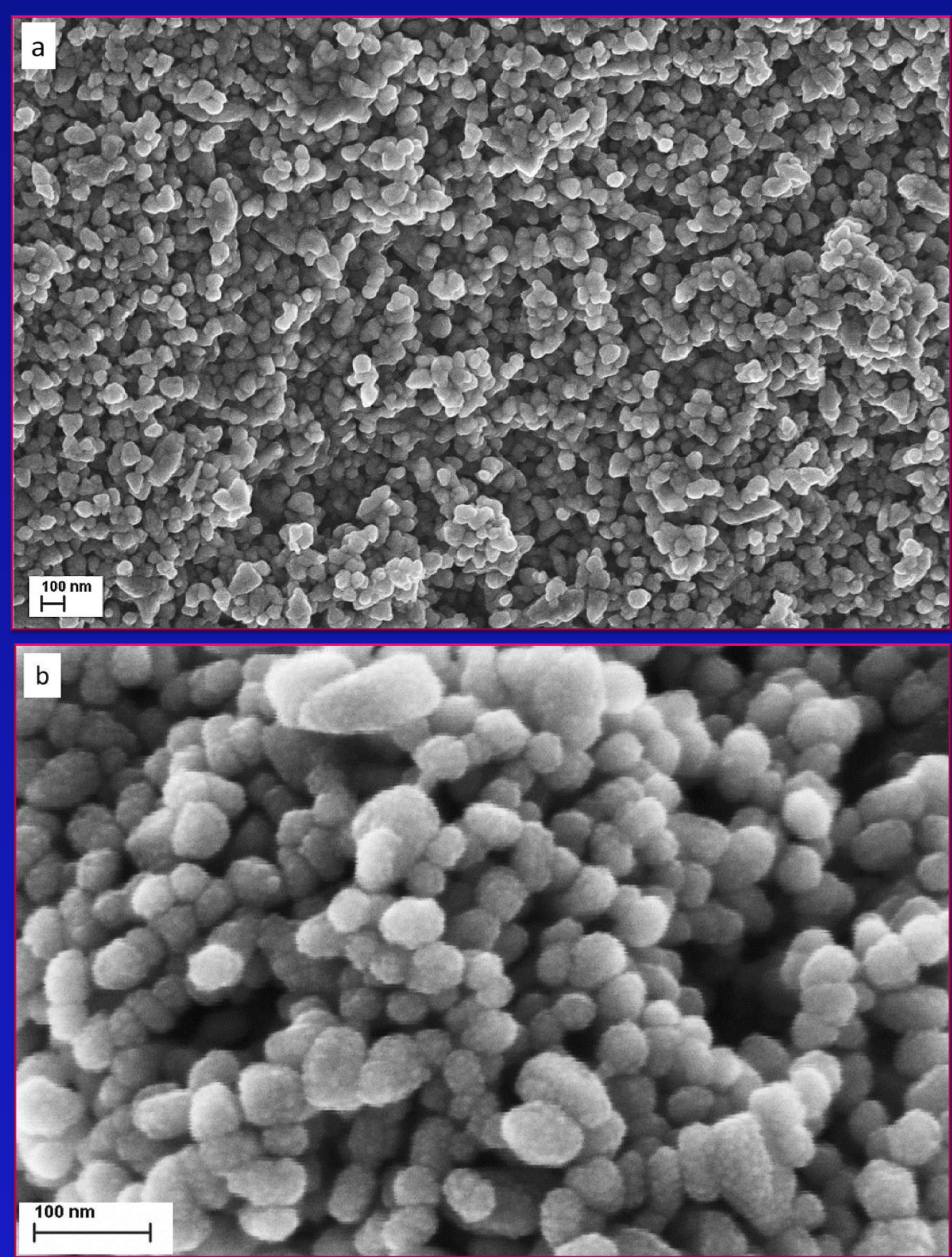

Fig. 2. Representative FE SEM images of sonochemicaly synthesized ZnO nanopowder.

The direct band gap energy (Ebg) of the ZnO powder was determined by the extrapolation of the linear part of the absorption function $(FxE)^2$, presented in Fig. 4. A slight red-shift of 0.04 eV which occurs in the absorption edge, meaning that nano-spherical ZnO particles absorb an amount of visible light spectra.

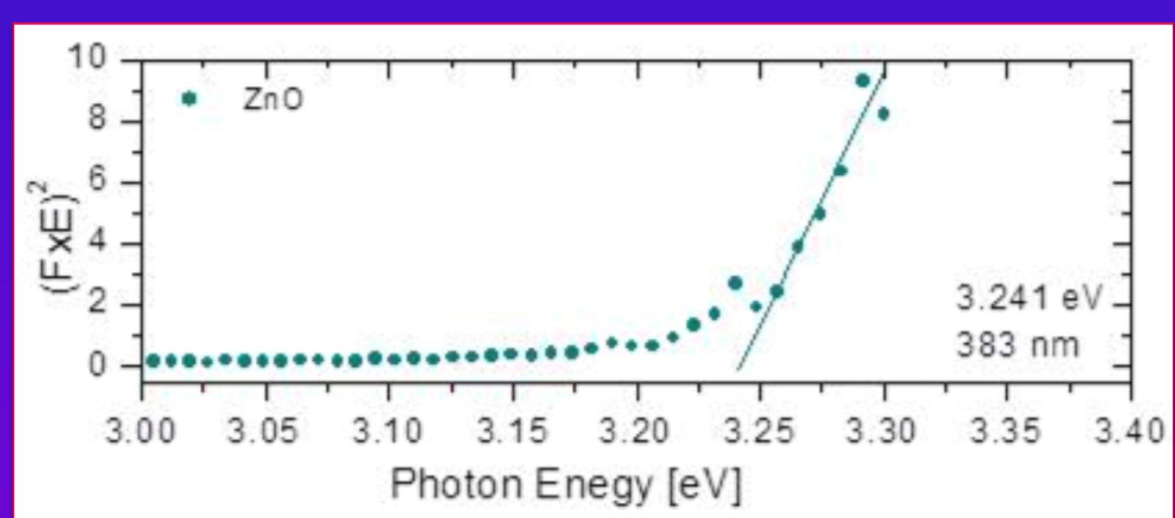

Fig. 4. Kubelka-Munk curve for the ZnO powder.

Experimental procedure

In a typical experimental procedure 5, 10 and 20 ppm water solution of MB containing 50 mg of nanosized ZnO powder were used. Prepared suspensions were treated with the ultrasound irradiation which has an output of 150 W. Concentration of the MB dye in the water solution containing ZnO nanoparticles before and after sonocatalytic degradation was calculated according to the absorbance maxima value at 665 nm characteristic for MB. The experiments were performed on a UV–Vis spectrophotometer in the wavelength range of 300–800 nm.

Sonocatalytic degradation of MB dye of different concentration in the presence of nanosized ZnO powder is shown in Fig. 5. Efficiency of the degradation process for the MB concentrations of 5 and 10 ppm is near 100 %% for 6 and 8 h respectively. For the highest concentration of MB dye, 20 ppm, degradation efficiency is significantly lower, about 75 % for the 12 h.

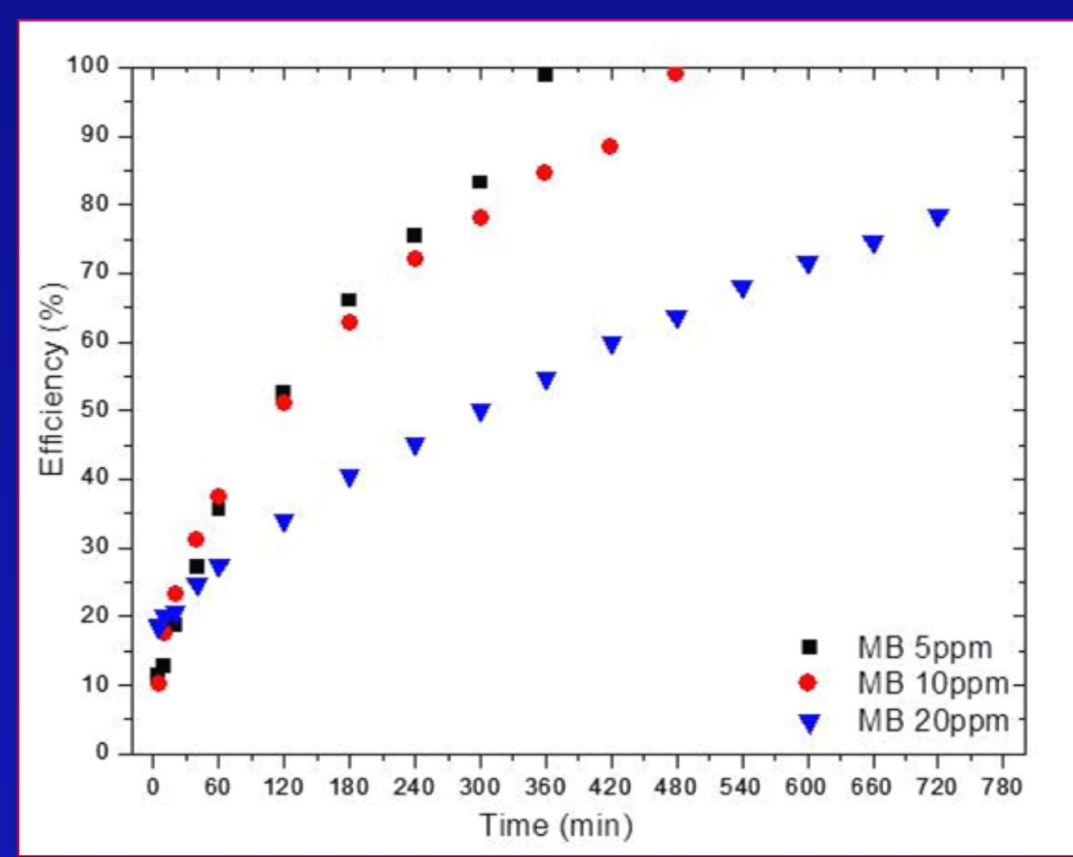

Fig. 5. Degradation curves of MB dye in the presence of ZnO powder

Conclusion

- ZnO nano-powder was sonochemically synthesized.
- (UV–Vis) diffuse reflectance spectroscopy showed that nano-spherical ZnO particles can absorb an amount of visible light spectra.
- Sonocatalytic degradation of methylene blue (MB) aqueous solution in the presence of ZnO nanopowder was preformed.
- Degradation efficiency of MB dye (for all examined concentrations) was found to be close to 100 % after ultrasound treatment in the presence of ZnO nanoparticles.

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