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

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 sonocatalytically 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).

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 nanosized particles with average diameters less than 50 nm.

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.

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.

Experimental procedure

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 %.

The direct band gap energy (Ebg) of the ZnO powder was determined by the extrapolation of the linear part of the absorption function (FxE²), 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.

Materials

<table>
<thead>
<tr>
<th>Materials</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>ZnO SH</td>
<td>50 mg</td>
</tr>
<tr>
<td>MB 5 ppm</td>
<td>50 ml</td>
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<tr>
<td>MB 10 ppm</td>
<td>50 ml</td>
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<tr>
<td>MB 20 ppm</td>
<td>50 ml</td>
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Fig. 1. XRD patterns of sonochemically synthesized ZnO nanopowder.

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

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

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

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

References