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Evaluation of the photocatalytic property of flame-sprayed ZnO powder

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Abstract – The photocatalytic property of flame-sprayed zinc oxide (ZnO) powder was evaluated using the ultraviolet–visible absorbance parameter through the process of photooxidative decomposition of methyl orange (MO). The powder was prepared by the spraying of a starting solution containing zinc nitrate ($Zn(NO_3)_2.6H_2O$) and urea ($CO(NH_2)_2$) in a flame. The zinc oxide presented a high photocatalytic activity, where more than 70 % of MO was degraded after 60 minutes (Figure 1), probably associated with the small crystallite size of zinc oxide powder (Figure 2) as well as with the specific surface area (16.41 m^2/g).

Zinc oxide powder was prepared by the flame-spraying of a starting solution in a flame, and then evaluated its photocatalytic property using the degradation process of a standard solution of MO. A photochemical reactor comprised of two half-cylinders; each contained six lamps of 8 W Sylvania Blacklight blue UVA (maximum radiation at 355–360 nm; length of 28.7 cm) set against the aluminum reflector of a half-cylinder was used. The reaction vessel consisted of a quartz Drechsel bottle fitted with a rubber septum that facilitated withdrawal of samples from the reaction solution. A total of 50 mg of the ZnO powder and 125 mL of 20 ppm MO solution were mixed and homogenized in a dark chamber for 15 minutes using an ultrasound finger probe (Cole-Parmer CP-750), and later transferred to the reaction vessel. A syringe was used to collect 4.0 mL in volume of the samples, at fixed time intervals (of 5 minutes) after the commencement of irradiation for the determination of MO absorbance using UV– visible (UV–vis) spectrophotometry to follow the kinetics of its disappearance. A UV–vis spectrophotometer (Biospectro) was used to measure and record the absorbance rate of the solution samples in the 465 nm range, after the completion of photocatalysis. The suspension was filtered through a 0.2µm syringe filter to remove the photocatalytic particles before measuring the rate of degradation of MO. The samples were then placed in a PMMA cuvette with a 10 mm optic path and the absorbance of MO was then determined.

The X-ray diffraction (XRD) analysis revealed a crystalline powder after the synthesis, where the hexagonal ZnO with the wurtzite structure (JCPDS # 36-1451) can be identified.

The ZnO powder showed a high photocatalytic property, where more than 70 % of MO was degraded after 60 minutes and probably associated to the small crystallite size of the powder. This supposition can agree with Pratsinis [1] that reported that the nanoparticles can improve the catalytic performance of many processes relying on available particle surface area. The production of nanosized particles can be attributed to the combustion of urea in the flame zone, which provided additional heat to the particles, and coupled with the evolution of a large amount of gasses contributed to nanoparticle formation [2]. Moreover, the zinc oxide powder showed a specific surface area of 16.41 m^2/g. The decrease in the crystallite size increases the specific surface area, leading to increase the number of active sites of photocatalyst for adsorption of substrate molecules [3].

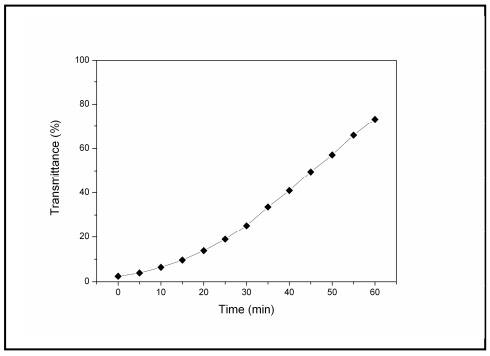

Figure 1: Transmittance versus time indicating the photocatalytic activity of the ZnO powder.

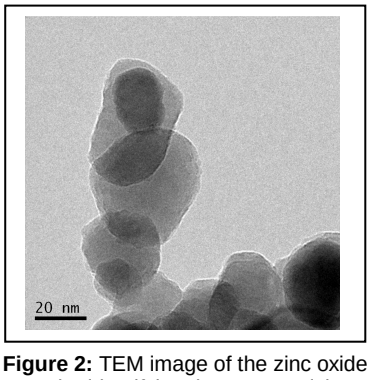

Figure 2: TEM image of the zinc oxide powder identifying the nanoparticles.

References

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