Absorption band tuning and photocatalytic activity enhancement in hybrid plosmonic oxide Ag/ZnO nanostructures

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Zinc oxide is a wide band-gap semiconductor with intense applications in optics, electronics, catalysis, energy storage devices and environmental remediation [1]. However, with band gap of 3.2 eV ZnO is activated by UV irradiation. In this regard, different efforts have been made to modify the absorption band edge towards visible light [2]. Combining ZnO with plasmonic metals represents one of the most promising methods to decrease the band gap and increase visible light absorption [3].
In this work, we have coupled silver nanoparticles to ZnO nanocrystals to synthesize Ag/ZnO hybrid nanostructures (HNS) with two different approaches [4, 5]. In both methods, wurtzite ZnO nanocrystals were synthesized by arc discharge of zinc rods in water. Ag/ZnO-chem sample was prepared using trisodium citrate to reduce the Ag^{3+} ions in 0.1 mol L^{-1} $AgNO_3$ aqueous solution to Ag and deposit it on the surface of the ZnO nanostructures. In Ag/ZnO-PD sample instead, UV irradiation was used to reduce Ag^{3+} ions to Ag nanoparticles on the surface of the ZnO nanostructures. The fabricated Ag/ZnO HNS have different optical and photocatalytic properties. Figure 1. a) reports the UV-vis absorption spectra of both samples with respect to the bare ZnO nanoparticles. The absorption spectrum of the Ag/ZnO-chem HNS is extended further to the visible spectral range due to the plasmonic resonance of the deposited Ag nanoparticles. In the Ag/ZnO-PD sample the spectrum did not change remarkably in comparison with the pristine ZnO sample, most probably due to the small size of the deposited Ag clusters. Photocatalytic methylene blue degradation mediated by the Ag/ZnO HNS was investigated using a Xenon 100 W solar simulator. Figure 1. b) shows the photocatalytic activity of the Ag/ZnO-PD sample, which degraded the dye after 10 minutes of solar irradiation followed by 1 hour stirring in dark. Notably, the Ag/ZnO-chem sample completely degraded the dye after 30 minutes in dark, i.e. without the involvement of radiation. Neither ZnO nor Ag nanoparticles could degrade the same dye in the absence of light. Currently, we are investigating this highly efficient photocatalytic activity of Ag/ZnO-chem HNS and the role of the Ag-ZnO Schottky barrier formed in hybrid plasmonic oxide nanostructure.

References

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Figures

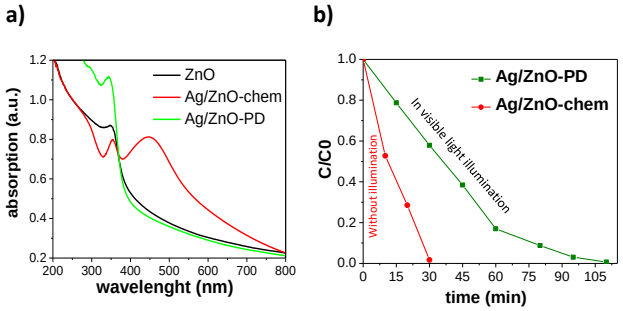

Figure 1. a) UV-vis absorption spectra and b) Relative dye concentration during photocatalytic activity of ZnO and Ag/ZnO.