Metallic Silver Nanoparticles as efficient photocatalysts to convert H_2O_2 in hydroxyl radicals for organic pollutant degradation in water

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ABSTRACT

Ag nanoparticle (NP) colloids are produced from borohydride reduction of silver nitrate in water by varying the amount of sodium citrate. These nanoparticles are used as photocatalysts with H_2O_2 to degrade a p-nitrophenol (PNP) solution. X-ray diffraction patterns have shown the production of metallic silver nanoparticles, whatever the concentration of citrate. The transmission electron microscope images of these NPs highlighted the evolution from spherical NPs to hexagonal/rod-like NPs with broader distribution when the citrate amount increases. Aggregate size in solution has also shown the same tendency. Indeed, the citrate, which is both a capping and a reducing agent, modifies the resulting shape and size of the Ag NPs. When its concentration is low, the pH is higher, and it stabilizes the formation of uniform spherical Ag NPs. However, when its concentration increases, the pH decreases, and the Ag reduction is less controlled, leading to broader distribution and bigger rod-like Ag NPs. This results in the production of three different samples: one with more uniform spherical 20 nm Ag NPs, one intermediate with 30 nm Ag NPs with spherical and rod-like NPs, and one with 50 nm rod-like Ag NPs with broad distribution. These three Ag NPs mixed with H_2O_2 in water enhanced the degradation of PNP under UV/visible irradiation. Indeed, metallic Ag NPs produce localized surface plasmon resonance under illumination, which photogenerates electrons and holes able to accelerate the pro-duction of hydroxyl radicals when in contact with H_2O_2. The intermediate morphology sample presents the best activity, doubling the PNP degradation compared to the irradiated experiment with H_2O_2 alone. This better result can be attributed to the small size of the NPs (30 nm) but also to the presence of more defects in this intermediate structure that allows a longer lifetime of the photogenerated species. Recycling experiments on the best photocatalyst sample showed a constant activity of up to 40 h of illumination for a very low concentration of photocatalyst compared to the literature.

Keywords: Silver nanoparticles; organic pollutant degradation; surface plasmon resonance; photocatalysis.

Biography:

Julien G. Mahy is a chemical engineer from the University of Liège (ULiège, Belgium). He made a PhD thesis, under the supervision of Pr. Stéphanie Lambert and Pr. Benoît Heinrichs, focused on the development of a TiO_2 aqueous sol-gel process in order to produce, at large scale, photocatalysts with hydrophilic property and high activity, both under visible and UV/visible light, for water and air remediation. In 2018, after a short period working in industry in CRM group as project leader, he accepted a postdoctoral position in collaboration between the NCE (ULiège) and the "Institut für Energie- und Umwelttechnik e.V. (IUTA)", Duisburg (Germany) to work on the development of a

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Since October 2021, he is FNRS postdoctoral researcher at the Université de Liège with the support of Pr. Stéphanie Lambert and Pr Nathalie Job and at the INRS, Québec, with the support of Pr. Patrick Drogui. His work consists in the development of inorganic materials and processes in environmental applications such as water and air decontamination process by photocatalysis, adsorption and electrochemistry.

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