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Green Synthesis of Ag 1D Nanochains and Application for Methylene Blue Degradation

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Introduction.

The biosynthesis of nanoparticles is a representative intersection between nanotechnology and biotechnology, has increased attention due to the growing need to develop environmentally benign technologies in material synthesis [1]. Such nanoscale materials possess unique electrical, optical as well as biological properties and are thus applied in catalysis, biosensing, imaging, drug and delivery [2-3]. Silver nanoparticles are essential materials that have been studied extensively, especially the formation of anisotropic 1D arrays by the association of their collective properties [4]. The “bottom-up” synthesis approach of nanomaterials first forms the nanostructured units, and then assembles to obtain the final material [5]. In nature, biomolecules participate to form total self-assembly. Therefore, self-assembly using a green approach can depend either on the characteristics of the plant extract [6]. In this work, we present a facile strategy for the green synthesis of silver nanochains using the *Hamelia patens* plant extract as reducing and capping agent, that is achieved through the self-assembly into a colloidal solution and at room temperature conditions. Also, the efficiency of silver nanochains was evaluated for the catalysis of an organic dye.

Methods.

The extract was prepared using 2% w/v concentration of *Hamelia patens* leaves in 50 ml of deionized water, and then the solution was heated to 50 °C, under magnetic stirring for 15 min. The reaction solution was filtered using a filter paper. The precursor was prepared in aqueous solution at 12 mM $AgNO_3$ (≥99.9%). Silver nanostructures were prepared by adding the aqueous extract from the plant to the precursor, using a volumetric ratio of 2:1 at room temperature. The catalytic activity of Ag nanochains was evaluated without any catalyzer for the degradation of 0.05 mM methylene blue (MB). 0.5 mg of nanostructures (12 mM) were mixed with 2.5 ml of MB. The morphology was evaluated by scanning electron microscopy (SEM) in a JEOL JSM-7600F microscope with an energy dispersive spectrometer (EDS). Philips Tecnai F20 microscope operated at an accelerating voltage of 200 kV was used for transmission electron microscopy (TEM). UV–vis absorption spectra was obtained using an Ocean- Optics USB4000 spectrometer in the range of 300–700 nm.

Results.

The nanostructures synthesized with the *Hamelia patens* plant were characterized by scanning electron microscopy (SEM) (Fig. 1a-b). In the micrographs are observed linked particles as chains-like, a higher magnification illustrates that the structures are inside the nanometric range, with average sizes of 20 nm. The chemical analysis performed by EDS (Fig. 1c), verifies that the particles are formed by silver, Cu appears which comes from the sample holder. The high-resolution transmission electron microscopy (HRTEM) shows nanochains with 18 nm particle size. The nanoparticles are linked on the close-packed plane (111), as illustrated in the FFT (insert).

In this study, the color of the reaction mixture changes from yellow to dark brown in 5 min, indicating the presence of the silver nanomaterials. The nanometer nature of the silver can be determined by the Uv-vis technique since only nanometer sizes are registered due to quantum confinement. Figure 2a shows the Uv-vis spectra of the silver nanochains synthesized. The characteristic absorption band of the silver nanoparticles is observed between 400 and 500 nm, the surface resonance plasmon (SPR), it is monitored each 15 min, and as the time increases, the absorption increases and the peak widens. Figure 2b shows the UV-vis spectra corresponding to the catalytic properties of the Ag-nanochains, for the degradation of methylene blue (MB) at room temperature conditions, the reaction was evaluated without catalyst (i.e., NaBH4). From the curves, it can observe that the intensity of the dye decrease as the redox reaction progresses. It was found that the nanomaterial showed a 90% dye degradation obtained after 150 min. This result indicates that the silver nanostructures can be used in the removal of organic dyes in residual water. In other investigations [7-8], they used silver nanoparticles with a catalyst ($NaBH_4$) to accelerate the degradation of MB. However, to know the real effect of the nanochains in this work, it was not used as a catalyst.

Conclusions

In summary, 1D silver nanoarrays can be obtained using the *Hamelia patens* plant extract. The SEM micrographs show silver nanochains-like with a uniform distribution. The TEM analysis showed that the planes through which the nanoparticles are linked to form the chains are (111) and that the particle sizes are 18 nm. In addition, Ag nanochains show 90% degradation of MB after 150 min.

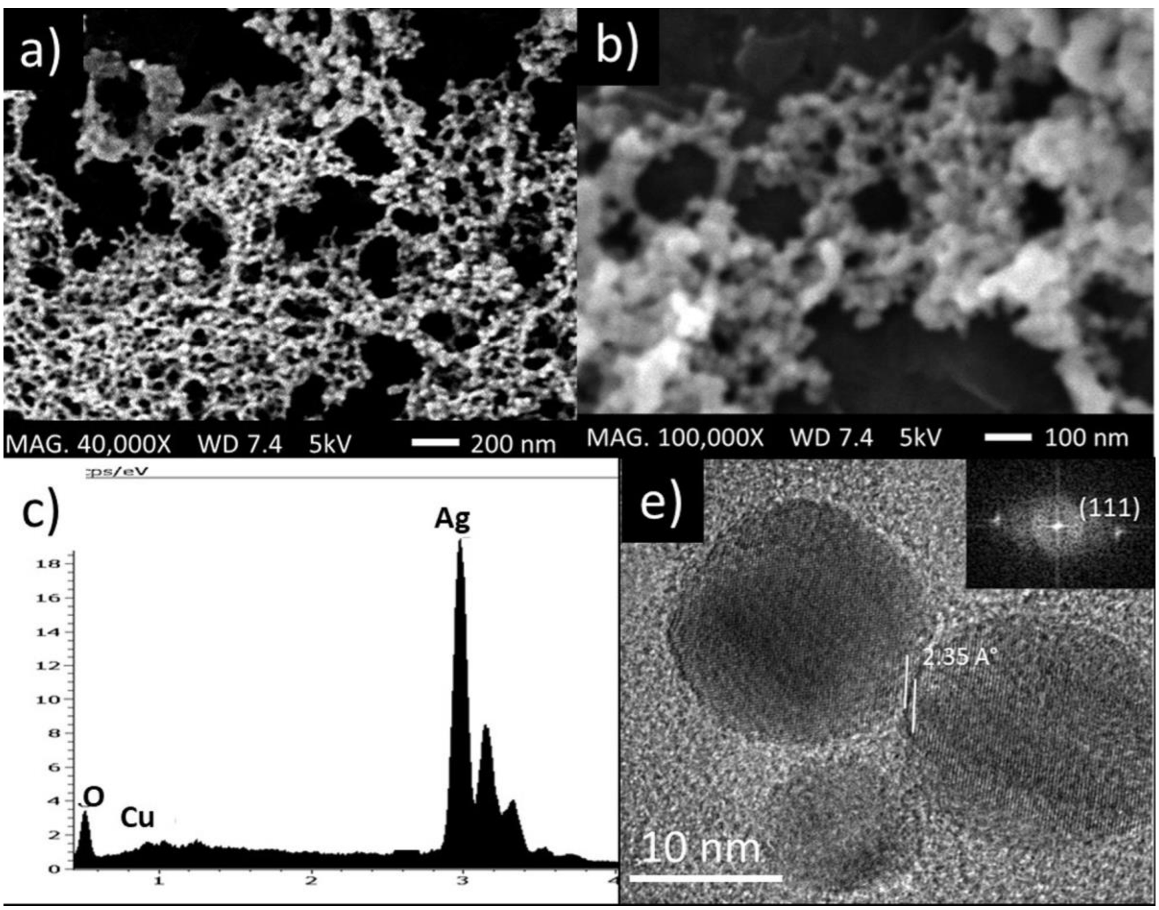

Figure 1. Figure 1. SEM images of Ag nanochains (a) 40,000X, (b) 100,000X, (c) EDS and (d) HRTEM.

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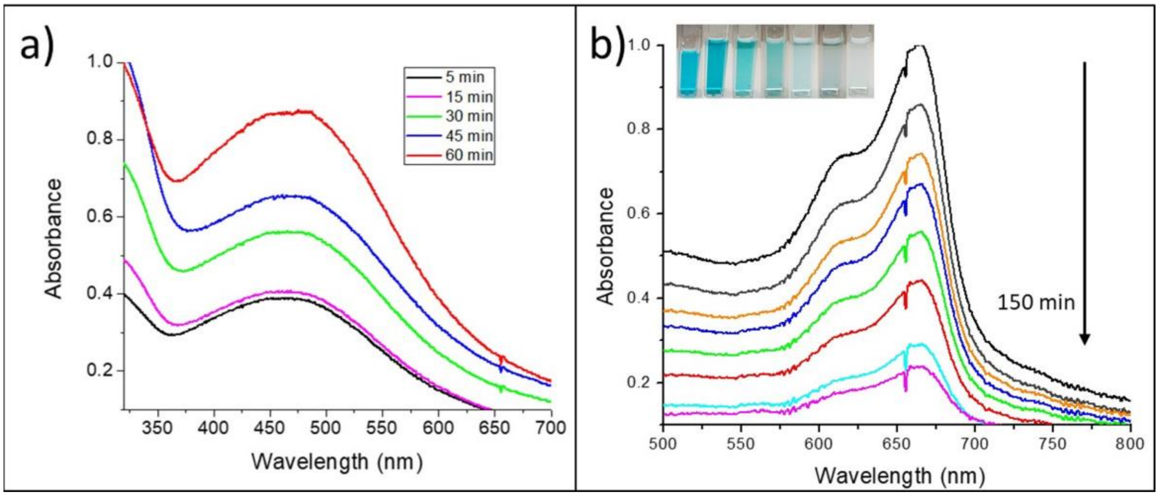

Figure 2. Figure 2. UV–visible spectra of (a) silver nanochains and (b) MB reduction in the presence of synthesized Ag-nanochains.

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