A Simple Method for Coating Polypropylene with Gold Nanoparticles

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The formation of monolayer ensembles of colloidal nanoparticles (NPs) on different kinds of substrates has been drawing a lot of attention due to the fact that such nanostructured ensembles possess unique physical and chemical properties which depend on the NPs size and shape, as well as on the inter-particle distance. These systems are quite promising for applications on catalysis, microelectronics, bio-sensing and bio-imaging, as well as antibacterial surfaces [1]. Some of the most recurrent procedures for the formation of colloidal monolayers are drop-casting, dip-coating, sample immersion and transferring of densely packed ensembles of metal NPs from liquid surface by means of the Langmuir–Blodgett technique [2]. Generally, the surface of the substrate needs to be treated before NPs can be deposited. UV plasma cleaning followed by silanization with organosilane molecules is one of the most common procedures, but it is laborious and time consuming [3]. On the other hand, polypropylene (PP) is currently one of the most utilized polymers in industrial processes (textile, food packing, automotive and electronics) due to its remarkable chemical and physical properties, which make it suitable to replace glass, metals, cartons and other polymers. In this work, we propose a simple method to deposit a monolayer of Au NPs onto the surface of PP centrifuge tubes by pouring the colloidal solutions onto the substrate.

NPs were prepared based on the classical Turkevich/Frens method with slight modifications [4], following the three steps described next. Step 1: A solution of 2.2mM sodium citrate in Milli-Q water (50ml) was heated to its boiling point, and at that time, 330µl of 25mM $HAuCl_4$ solution were added; once the solution turned ruby red in color, the colloid was cooled in the same vessel until it reached 90C. Step 2: 330µL of a $HAuCl_4$ solution (25mM) were injected and left to react for 30min. This process was repeated twice. Step 3: The sample was diluted by extracting 18.5mL of sample and adding 17.7mL of Milli-Q water and 800µL of 60mM sodium citrate. This solution was then used as a seed solution, and the steps 2 and 3 were repeated three more times to complete four growths. UV-Vis absorption spectra were acquired with a portable spectrometer and normalized with its maximum of absorbance; figure 1a shows the red shift behavior of the plasmon band located at 521, 523, 525.5 and 530.5nm, respectively for each growth, which means that nanoparticles are becoming bigger in each growth. Figures 1b-e show the scanning electron microscopy analysis (SEM, JEOL, JSM-7800F, operating at 1kV); the calculated mean sizes of the Au NPs were 31±4, 39±4, 46±4, and 54±5nm, respectively for each growth. For nanoparticle deposition, 15ml of each growth solution from step 3 of the synthesis were poured into centrifuge tubes immediately after each extraction; 24 hours later, the colloids were emptied from the tubes, and the tubes washed with plenty of Milli-Q water several times, and finally, were left to dry. Through visual inspection, a red hue was observed on the inner surface of the tubes. PP substrates were cut out in pieces of 3x3mm for SEM analysis. Figure 2 shows the SEM images corresponding to the substrates for each growth;

our preliminary results indicate that a single layer of Au NPs can be formed on the PP surface with very low aggregation. Using the open source software ImageJ, we calculated the density of the deposited NPs; the corresponding determined values were 14, 47, 19 and 26 NPs/μm^2 for first to fourth growth, respectively. It seems that the second growth shows the best efficiency to coat PP surfaces. Here, we have presented a simple methodology to deposit spherical Au NPs of different sizes onto the surface of PP substrates, with the advantage that PP does not require any pre-treatment.

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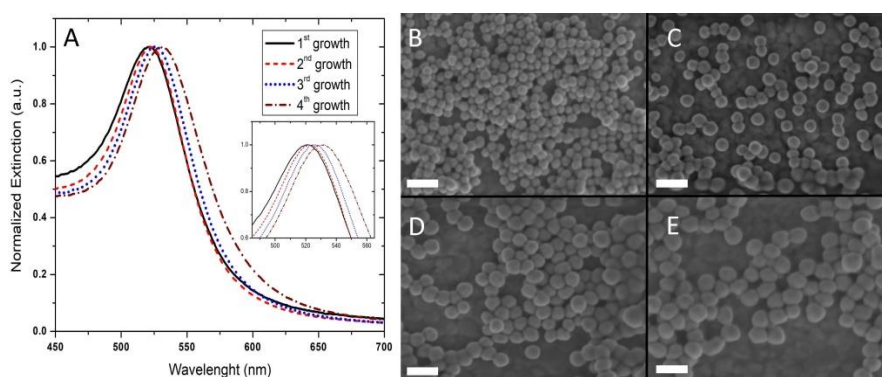
Figure 1. A) UV-Vis absorption spectra of the fourth growths. B) - E) SEM images of the spherical gold NPs synthesized, first to fourth growth respectively. Scale bar is 100 nm.
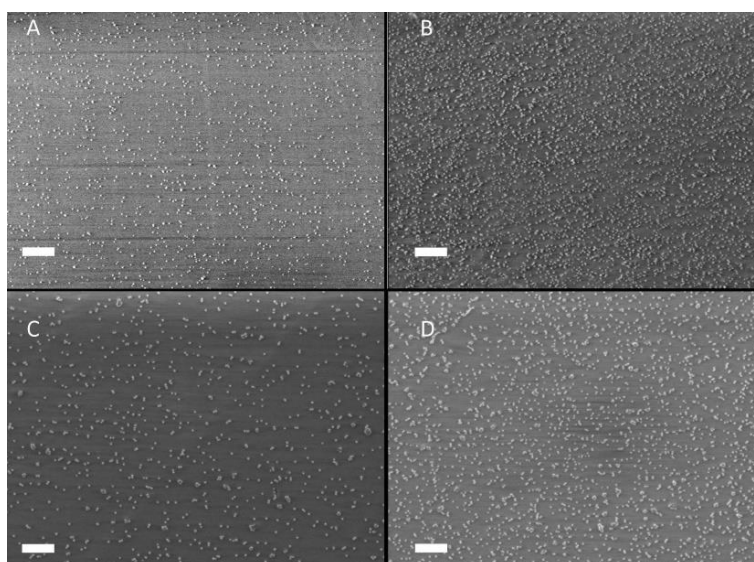

Figure 2. SEM images of spherical gold NPs on the polypropylene substrates (A - D, first to fourth growth respectively). Scale bar is 1μm.