From sputtering onto liquids to functional nanoparticle - hydrogel composites

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In this work, multifunctional hydrogel-metal nanoparticles composites were synthesized in a two-step process. First, colloidal solutions of silver nanoparticles (Ag-NPs) were prepared by sputtering a silver target onto a liquid substrate. In the present case, the host liquids are vacuum – proof polymerizable poly(ethylene glycol) methacrylates which can subsequently be used to synthesize hydrogel - nanoparticles metal composites with interesting optical properties. The electrical power applied (P) to the sputtering plasma and the processing time (T) were varied to modify the concentration of the nanoparticles. Ex situ Transmission Electron Microscopy (TEM) data highlight the presence of two populations of NPs. The largest populations comprises small, few nm in diameter, nanoparticles. The second population is comprises a smaller number of bigger Ag-NPs having a diameter in the range of several tens of nm. Electron diffraction studies highlight that the Ag-NPs are crystalized. Interestingly, the viscosity of the colloidal solutions increases with the energy (E) delivered to the plasma, with E = P x T. This observation would suggest plasma-induced polymerization of the liquid substrate for high E conditions.
In the second step, the as-prepared colloidal solutions were polymerized by radical photopolymerization in the presence of a crosslinking agent (ethylene glycol dimethacrylate) and a photoinitiator (diphenyl(2,4,6-trimethylbenzoyl)phosphine oxide). Scanning electron microscopy observations show that silver nanoparticles are well dispersed inside the hydrogels but also that the morphology of the gel changes with the working conditions, i.e. with the energy E delivered to the plasma during the elaboration of the colloidal suspensions.
Finally, the hydrogel-silver nanoparticle composites were tested for the detection of Hg^{2+} cations in aqueous solutions. The detection was enabled by monitoring the UV-Vis absorption spectrum of the composite. Absorbance decreased as a function of the concentration of Hg^{2+} metal cations and immersion time (Fig. 1).

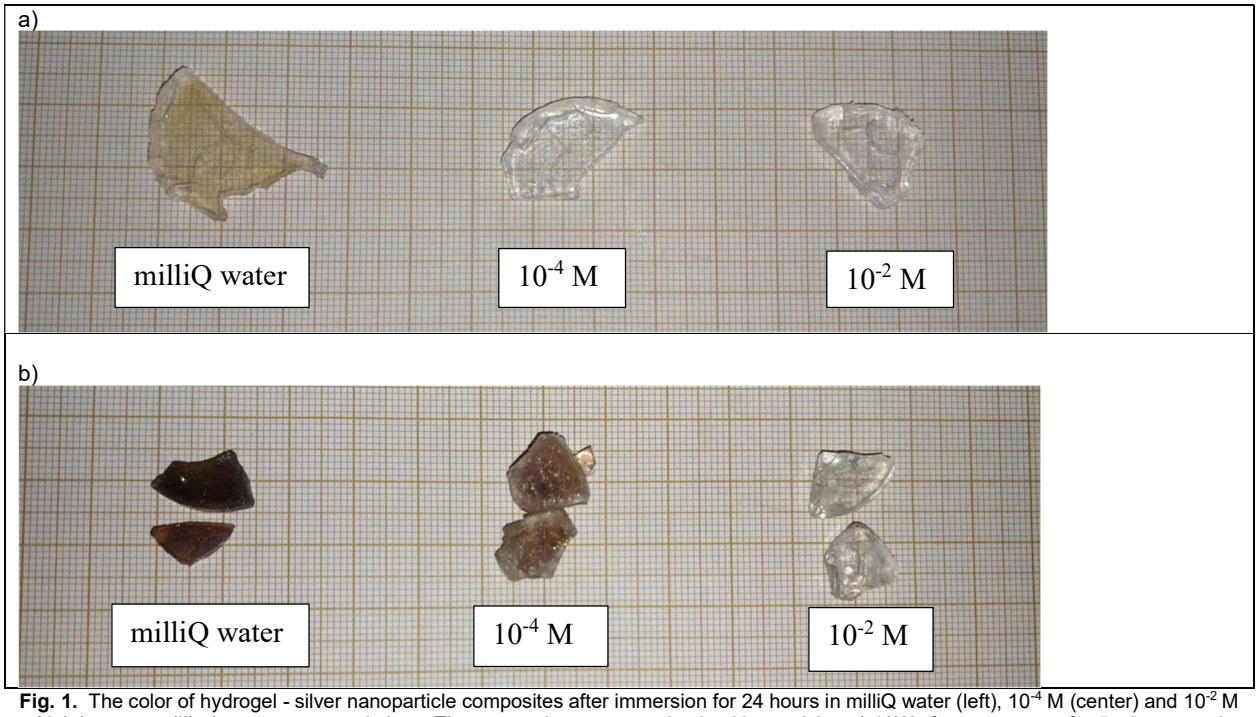

Fig. 1. The color of hydrogel - silver nanoparticle composites after immersion for 24 hours in milliQ water (left), 10^{-4} M (center) and 10^{-2} M (right) mercury (II) nitrate aqueous solutions. The composites were synthesized by applying a) 10W of sputter power for 5 minutes and b) 80W for 5 minutes.

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