SYNTHESIS OF MAGNETIC NANOPARTICLES WITH PLASMONIC PROPERTIES. APLICATIONS IN SURFACE ENHANCED RAMAN SCATTERING.

A.García-Leis\textsuperscript{1} and S. Sánchez-Cortés\textsuperscript{2}

\textsuperscript{1}Cuban Center for Advanced Studies, Highway Novia del Mediodia Km. 2, 17100-Havana, CUBA
e-mail: adigarleis@gmail.com

\textsuperscript{2}Instituto de Estructura de la Materia, Consejo Superior de Investigaciones Científicas (CSIC), Serrano, 121. 28006-Madrid, SPAIN.

The most widely studied superparamagnetic nanoparticles are of magnetite (Fe\textsubscript{3}O\textsubscript{4}), which offers a large variety of applications, such as information storage, tissue imaging, cell separation, drug delivery, and so on\textsuperscript{1,2}. In many areas of biological application, the ability to engineer surface properties is important, so magnetic nanoparticles (MNPs) are designed to have the desired biocompatibility and interfacial reactivity. Among many approaches to the modification or functionalization of the surfaces of MNPs with different materials, such as polymers, organic monolayers, oxides, and metals, one of the most promising systems involves MNPs coated with gold and silver shells\textsuperscript{2}.

Nanoparticles made of noble metals, such as silver and gold, are known to exhibit a strong surface enhanced Raman scattering (SERS) effect, which is mainly due to the enhancement induced by localized surface plasmon\textsuperscript{3}. Therefore, silver or gold coating of magnetic nanoparticles should lead to the formation of a magnetic SERS substrate.

In this work we describe the synthesis of magnetite by co-precipitation method\textsuperscript{4}. The synthesis of core@shell (Fe\textsubscript{3}O\textsubscript{4}@Au, Fe\textsubscript{3}O\textsubscript{4}@Ag) was performed by a novel process consisting on the reduction of the metal on the magnetite seeds employing hydroxylamine as a reducing agent.

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{structure.png}
\caption{Structure of (a) Paraquat (PQ), (b) Diquat (DQ) and (c) Lucigenin (LG).}
\end{figure}

The plasmonic properties of Fe\textsubscript{3}O\textsubscript{4}@Au and Fe\textsubscript{3}O\textsubscript{4}@Ag and their effectiveness as SERS substrates are shown for three organic molecules: Paraquat, Diquat and Lucigenin (Figure 1).

In figure 2, a comparison between the SERS spectra of Lucigenin obtained by using core@shell Fe\textsubscript{3}O\textsubscript{4}@Au and Fe\textsubscript{3}O\textsubscript{4}@Ag nanoparticles and the corresponding control SERS spectra obtained on Ag and Au colloids is shown. The enhancement of the Raman signal as well as the signal/noise rate was seen to be larger employing the core@shell substrates.
Figure 2. SERS Spectra of LG on: (a) Fe₃O₄@Au and Au colloid (AuCT) and (b) Fe₃O₄@Ag, and Ag colloid (AgHX).

The resulting nanoparticles were characterized by XRD, TEM, UV-Visible, IR, Raman, and magnetization measurements.

Figure 3. TEM images of (a) Fe₃O₄, (b) Fe₃O₄@Au y (c) Fe₃O₄@Ag.

As can be seen in the TEM micrographs, shown in figure 3, the magnetite nanoparticles (a) have 10nm of diameter while the core@shell nanoparticles have 45nm diameter in the case of Fe₃O₄@Au (b) and 140nm of diameter for Fe₃O₄@Ag (c). The coverings are homogeneous in both cases and the magnetic properties are maintained.


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