Effect of metallic nanoparticles size on nanoparticle enhanced Laser Induced Breakdown Spectroscopy (NELIBS)

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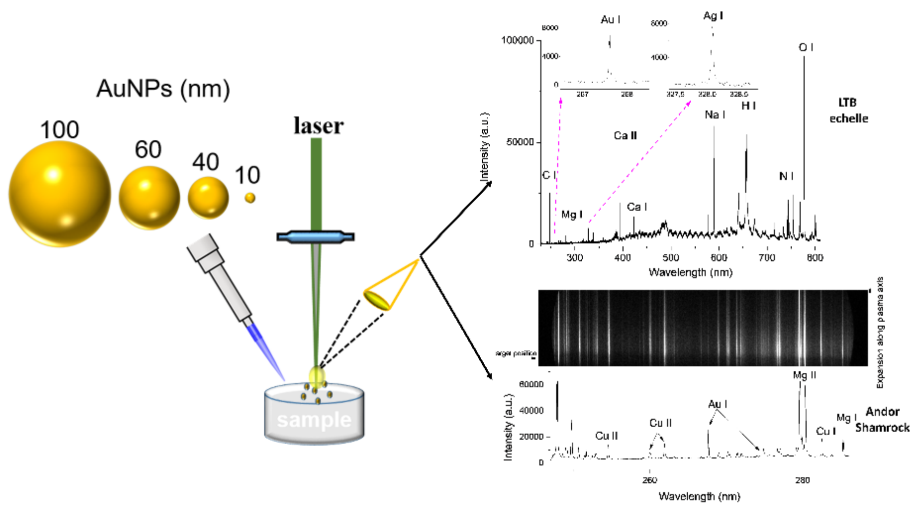
Laser-Induced Plasma emission is characteristic of the elemental composition of the irradiated material. Therefore, it is studied and used to estimate the elemental composition of different materials through several elemental analysis techniques, like Laser Induced Breakdown Spectroscopy (LIBS). Because of the relatively low precision of the technique, it is possible to use a promising variation of the LIBS technology, that is the Nanoparticle-Enhanced LIBS (NELIBS) [1]. This technique is based on the deposition of metallic nanoparticles (NPs) on the sample surface before the laser irradiation. The effect of the coupling of NPs plasmon with the laser pulse leads to a significant enhancement of the analytical signal. The size and the surface concentration of the used NPs has then an impact on the signal enhancement [2].
In this work, NELIBS plasma emission was investigated by depositing spherical gold (Au NPs) and silver (Ag NPs) nanoparticles with different sizes (10 nm to 100 nm) and concentrations on different substrates (silicon, copper and LFS (lateral flow strips)). The purpose was looking into the effect of NPs size and the material sample on the laser-induced plasma emission in order to deduce the spectra intensity enhancement in function of size and surface concentration of nanoparticles. For each nanoparticle size, calibration curves have been plotted. The spectra were recorded using two spectrometers. The ones with a large spectral range obtained by an Echelle spectrometer (LTB), were used to measure the plasma properties (temperature and electron density). The ones with a high resolution obtained by a Shamrock Czerny-Turner spectrometer, were used to plot the calibration curves. The relation between NPs size and surface concentration with the slopes of their calibration curves, gives the possibility to determine an unknown NP size. It also shows that, provided with the ideal size, type and concentration on nanoparticles, we can obtain an effective plasmon coupling that has a big effect on plasma spectrum enhancement for NELIBS experiments and the increase of the LOD (Limit Of Detection) of the sample elements.



References: [1] M. Dell'Aglio et al, Spectrochim. Acta B 148 (2018) 105-112.
[2] Z. Salajkova et al, Spectrochim. Acta B 179 (2021) 106105.