QUANTIFYING IMPACT OF THE LOW-COST SERS SUBSTRATE ON SERS SIGNAL

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Introduction. Surface-Enhanced Raman Spectroscopy (SERS) allows structural detection of molecules absorbed on rough noble metal surfaces by amplifying a normally weak Raman signal. It can be applied in forensic science, biosensing, food safety, and medical diagnostics [1]. Although costly gold and silver films are used as SERS substrates, AuNPs (gold nanoparticles) on aluminum foil can become a low-cost alternative.

Instruments and materials. AIST-NT AFM, LabRAM HR Evolution Raman Spectrometer HORIBA Scientific with x50 and x100 objectives, 633 nm and 785 nm lasers, UV-vis spectrometer, spherical gold nanoparticles (AuNPs) of 60 nm and 100 nm diameter, solution of 2-naphthalenethiol (NT) in acetonitrile, aluminum foil.

Methods. We modified 60 and 100 nm AuNPs in solution of acetonitrile for 1 or 2 hour than dropcasted those NT modified AuNPs on aluminum, silver and silicon substrates. Using intensity of strongest Raman vibration of NT we calculated the enhancement factor (EF) for NT (Raman active molecule) absorbed on AuNPs on the surface of aluminum foil, when excited with lasers in visible range (785 and 633 nm) using the following formula: $gp \_ \frac{ISERS/NSERS}{NRS/N_{N}RS}$, where I_{SERS} and I_{NRS} are SERS and Normal Raman Scattering intensities normalized by the acquisition time and power. N_{SERS} and N_{NRS} are the number of molecules probed in the SERS and Normal Raman Scattering measurements.

Results. Using two excitation wavelength of 633 and 785 nm we calculated EFs for NT modified AuNP on A1, silver and silicon. For AuNPs on aluminum substrate, maximum EFs with 785nm laser excitation were above five millions, or at least as high as EF on commercially available, expensive, gold nanostructured SERS substrate Klarite (benzenethiol EF ~ $5 * 10^6$) [2]. The highest EF for NT modified AuNPs on silver substrate was about x 5-10 lower than the highest EF on aluminum probably because of the formation of silver oxide. The highest EF for NT modified gold nanoparticles on doped silicon substrate ($3 * 10^5$) was lower than maximum EFs for both AuNP on Al and AuNP on Ag substrates.

Conclusions. The efficiency and competitiveness of a low-cost gold NP/aluminum as a low cost SERS substrate material was demonstrated. We have found out that the enhancement factor for 2-naphtalenethiol as Raman reporter molecule on gold nanoparticles over aluminum can be as high as several millions. EF for NT on AuNP/gold film will be measured and compared to that on AuNP/Al as soon as gold substrates would become available.

References.

1. Paul L. Stiles, Jon A. Dieringer, Nilam C. Shah,and Richard P. Van Duyne; Surface-Enhanced
2. Raman Spectroscopy, Annu. Rev. Anal. Chem. 2008.
3. Jiwei et al., Fabrication of nanowire network AAO and its application in SERS, Nanoscale Research Letters 2013, 8: 495