Advanced surface vibrational spectroscopic techniques for biomolecular studies

Martynas Talaikis, Lina Mikoliūnaitė, Vaidas Pudžaitis, Gediminas Niaura

Department of Organic Chemistry, Center for Physical Sciences and Technology
e-mail: martynas.talaikis@ftmc.lt

Surface-sensitive vibrational spectroscopic techniques provide in-depth molecular-level information on the interfacial structure of biomolecules with ultra-high sensitivity. The most acclaimed of these methodologies—surface-enhanced Raman spectroscopy (SERS)—is counting almost five decades of extensive studies and development with evergrowing popularity. Widespread applications of SERS in fields including chemistry, biology, medicine, and material sciences propelled the development of novel surface-sensitive methods such as shell-isolated nanoparticle enhanced Raman spectroscopy (SHINERS), surface-enhanced infrared absorption spectroscopy (SEIRAS), multifunctional nanoparticles-based SERS, etc.

Herein we report on the development of magneto-plasmonic nanoparticles Fe_3O_4@Ag suitable for SERS, which exhibit strong magnetic and plasmonic properties, allowing for both efficient separation and spectroscopic sensitivity. By managing the ratio between magnetic and plasmonic parts we were able to tune plasmonic resonance frequency to a specific laser exaction frequency. Furthermore, the increase in signal-to-noise ratio and signal reproducibility exceeded conventional plasmonic nanoparticles. We show the potential of Fe_3O_4@Ag nanoparticles to identify the vibrational spectroscopic biomarkers of kidney cancer—research still undergoing.

SEIRAS was employed to study the imidazole hydrogen-bonding interactions at the electrified interface with water. Imidazole is a side chain group of an essential amino acid histidine critical in the secondary structure of proteins and metalloenzyme catalytic activity. We also present SEIRAS results in the studies of artificial lipid membranes that mimic living cell plasma membranes. Furthermore, interactions of bee venom protein melittin with two artificial constructs—tethered bilayer lipid membrane (tBLM) and hybrid bilayer lipid membrane (hBLM)—were identified to be distinctly different.