Raman Enhancement on Anisotropic Two-dimensional Layered Materials

Lianming Tong, Jingjing Lin, Na Zhang, Nannan Mao, Jin Zhang

Center for Nanochemistry, College of Chemistry and Molecular Engineering, Peking University, Beijing 100871, China
tonglm@pku.edu.cn

Abstract

Surface-enhanced Raman scattering (SERS) on two-dimensional (2D) layered materials have stimulated increasingly interests since the discovery of graphene-enhanced Raman scattering (GERS), and has become a unique platform to study the chemical mechanism (CM) of the enhancement due to its natural separation from the electromagnetic mechanism [1]. Up to now, the investigations have been focused on highly symmetrical hexagonal structured materials, such as graphene, hexagonal boron nitride (h-BN) and molybdenum disulfide (MoS_2), and the CM mechanism is explained as charge transfer (CT), dipole-dipole interaction and a combination of these two effects, respectively [2]. Indeed, the high symmetry of such materials simplifies the parameters that affect the CM channels, however, anisotropic 2D materials would provide new insights into the CM process.

Here, we utilized anisotropic 2D materials, such as black phosphorous (BP) and rhenium disulphide (ReS_2), as a substrate for Raman enhancement, and studied the chemical enhancement [3, 4]. A highly symmetric molecule, copper phthalocyanine (CuPc), is used as the Raman active probe. The Raman enhancement was clearly observed, and was attributed to the charge transfer process. What is more, the substrate with reduced symmetry induced anisotropic enhanced Raman spectra of CuPc molecule. According to detailed Raman tensor analysis and density functional theory calculations, anisotropic charge interactions between the 2D materials and molecules are responsible for the angular dependence of the Raman enhancement. Our findings not only provide new insights into the CM process in SERS, but also open up new avenues for the exploration and application of the electronic properties of anisotropic 2D layered materials.

References

[1]Xu W., Mao N., Zhang J., Small, **9**(2013), 1206-1224.
[2]Ling X., Fang W., Lee Y-H., Araujo P.T., Zhang X., Rodriguez-Nieva J.F., Lin X., Zhang J., Kong J., Dresselhaus M.S., Nano Lett., **14**(2014), 3033-3040.
[3]Lin J., Liang L., Ling X., Zhang S., Mao N., Zhang N., Sumpter B., Meunier V., Tong L., Zhang J., JACS, **137**(2015), 15511-15517
[4]Mao N., Tang J., Xie L., Wu J., Han B., Lin J., Deng S., Ji W., Xu H., Liu K., Tong L., Zhang J., JACS, **138**(2016), 300-305

Figures