

## High-resolution SPM imaging of molecules with a functionalized probe

P. Jelínek

Institute of Physics of the Czech Academy of Sciences, Czech Republic

In this talk, we will discuss a brief history of high-resolution SPM imaging with functionalized probes and future directions. High-resolution SPM imaging of molecules acquired functionalized tips [1] created a lot of excitement among researchers from many fields including material science, physics and chemistry. Here we will briefly describe a common underlying mechanism responsible for the unprecedented spatial resolution of this technique [2]. The first results were obtained using CO-tips, which became very widespread. However, these tips show a weak electrostatic signal and do not allow the acquisition of magnetic contrast. Thus, alternative routes were explored, such as metallocene tips, which allows for magnetic contrast [3,4].

Another interesting alternative is Kelvin probe force microscopy with Xenon functionalized probe. This approach allows us to image the anisotropic charge distribution of the atomic charge, such as sigma-hole [5]. Finally, we outline the future possibilities of using the SPM with functionalized tips for imaging biomolecules.

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[2] P. Hapala et al, *Phys. Rev. B* 90, 085421 (2014); P. Hapala et al, *Phys. Rev. Lett.* 113, 226101 (2016); B. de la Torre et al *Phys. Rev. Lett.* 119, 166001 (2017).

[3] Ormaza et al, *Nano Lett.* 2017, 17, 3, 1877–1882, (2016); Verlhac et al., *Science* 366, 623–627 (2019)

[4] Ch. Wackerlin et al, *ACS Nano* (2022) DOI: [10.1021/acsnano.2c05609](https://doi.org/10.1021/acsnano.2c05609)

[5] B. Mallada et al, *Science* 374, 863 (2021).