High spatial resolution mapping of catalytic reactions on single nanoparticles

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The critical role of low-coordinated metal atoms in surface reactions and heterogeneous catalysis has been firmly established. But despite the growing availability of tools enabling detailed in situ characterization, it has so far not been possible to directly probe the influence of various surface sites on the reactivity of single nanoparticles. Here we show that differently active regions within a given particle can be distinguished by mapping the chemical reactivity of N-Heterocyclic Carbene molecules (NHCs) attached to catalytic particles using synchrotron radiation-based infrared nanospectroscopy (SINS) [1]. It is demonstrated that compared to flat regions on top of the particles, the particles' periphery, containing low-coordinated metal atoms, is more active in catalysing oxidation, as well as reduction, of chemically active groups in surface-anchored NHCs. These results indicate that high spatial resolution vibrational spectroscopy measurements can correlate between surface properties and reactivity, uncovering differences in reactivity between neighbouring sites across the surface of single catalytic nanoparticles.

References

[1] Wu, C. Y.; Wolf, W. J.; Levartovsky, Y.; Bechtel, H. A.; Martin, M. C.; Toste, F. D.; Gross, E. Nature 2017, 541.

Figures

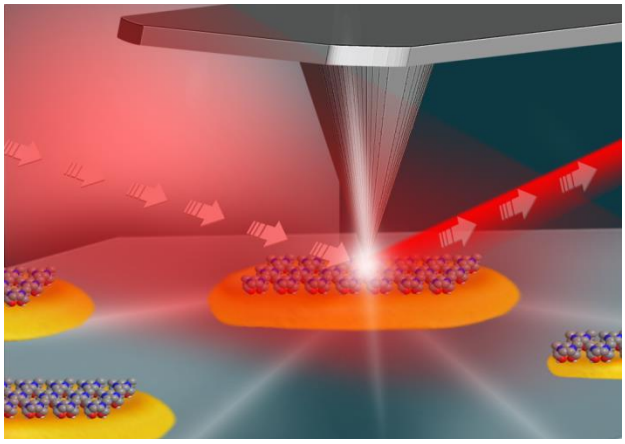

Figure 1: Schematic representation of the experimental approach. Chemical reactivity on the surface of single nanoparticles was measured by focusing a bright infrared beam into the apex of a thin tip with a diameter of 20 nm that monitored the chemical reactivity on the particle's surface.