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Revealing plasmonic-induced electron transfer with high resolution x-ray absorption spectroscopy in TiO2/Au nanocomposites

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With the increasing demand for energy faced by modern society, the efficient exploitation of clean energy sources is fundamental. In this scenario TiO2 represent a particularly interesting material: it is cheap and abundant and at most importantly it catalyzes for chemical reactions, from water splitting to waste water treatment, when illuminated with UV light. Research is thus looking for ways to make TiO2 more and more efficient under visible light, since UV represents only 4% of the solar spectrum. Coupling TiO2 with metal nanoparticles is particularly promising: the collective excitation of conduction electrons, i.e. the localised surface plasmon resonance, resonates in the visible leading to huge absorption at specific wavelengths. Devices based on this coupling show good efficiencies under visible light illumination, demonstrating that energy is absorbed by plasmonic nanoparticles and then transferred to TiO2 for photo-catalysis.

The process at the base of the efficient coupling of TiO2 and plasmonic nanoparticles is still debated and device optimization would highly benefit from a deeper understanding of the mechanism working at the atomic level.

We present how we addressed this level of the problem using high resolution x-ray absorption spectroscopy: we probed the local electronic structure of Ti atoms in TiO2/Au systems while exciting the collective excitation of Au nanoparticles with a 532 nm laser. Spectral differences observed are the signature of electrons injected into TiO2 and trapped for long time near Ti atoms at the surface, favored by local distortions that is thus important for efficient catalyst production.

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