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Tuning charge and spin interactions at hybrid organic/metal and organic/topological insulator interfaces

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Interfacing materials with different functionalities is an efficient way to manipulate their respective properties and promote the emergence of novel phenomena. Controlling interfacial interactions is however a complicated task in most cases. In that respect, the tunability offered by ligand chemistry in organic materials is an interesting asset that can be exploited at hybrid interfaces [1,2]. Here we present two examples where the molecular strategy is employed to tune the interactions of localized transition metal ions with underlying spin-degenerated electrons in non-magnetic metals, and with spin-textured electrons in topological insulators. In both cases, we obtain a comprehensive picture of the phenomenology by combining scanning tunnelling microscopy/spectroscopy, X-ray absorption and magnetic circular dichroism, angle-resolved photoelectron spectroscopy, and ab-initio calculations.
For molecular films on topological insulators, the tunability of ligands is exploited to tune the interaction of Co ions with the underlying topological surface state (TSS), going from the strongly interacting regime where the TSS is quenched in the first quintuple layer [3], to the weakly interacting regime where both the TSS and the Co magnetic moment are preserved [4]. The ultimate test of the tunability of interfacial interactions by ligand chemistry is carried out in a study of the Kondo interaction on a spin-degenerated metallic substrate [5]. Here, by varying the ligand configuration, we are able to depart from the mixed-valence configuration to the Kondo regime and smoothly modulate the exchange interaction between the spin of the ion and that of the metallic electron gas. Altogether, the different organic/inorganic interfaces cover the whole interaction window, from the strong (mixed-valence), to the intermediate (Kondo), and finally weak (decoupled) regimes.

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Primary authors: MUGARZA, Aitor (Catalan Institute of Nanoscience and Nanotechnology (ICN2), 08193 Barcelona, Spain & ICREA-Institució Catalana de Recerca I Estudis Avançats, 08010 Barcelona, Spain); BARLA, Alessandro (ISM-CNR); MORENO, Cesar (Catalan Institut of Nanoscience and Nanotecnology - ICN2); CUXART, Marc G. (Catalan Institute of Nanoscience and Nanotechnology (ICN2), 08193 Barcelona, Spain); VALBUENA, Miguel Ángel (IMDEA-Nanociencia, 28049 Madrid, Spain); NISTOR, Corneliu (ETH Zürich); IMAZ, Inhar (Catalan Institut of Nanoscience and Nanotechnolgy - ICN2); HIEULLE, Jeremy (Catalan Institut of Nanoscience and Nanotechnolgy - ICN2); PERSICHETTI, Luca (ETH Zürich); GARGIANI, Pierluigi (ALBA Synchrotron Light Source, E-08290 Cerdanyola del Vallès, Spain); GAMBARDELLA, Pietro (ETH Zürich); ROBLES, Roberto (Centro

de Física de Materiales CFM-UPV); VALENZUELA, Sergio O. (Catalan Institute of Nanoscience and Nanotechnology (ICN2), 08193 Barcelona, Spain & ICREA-Institució Catalana de Recerca I Estudis Avançats, 08010 Barcelona, Spain)

Presenter: MUGARZA, Aitor (Catalan Institute of Nanoscience and Nanotechnology (ICN2), 08193 Barcelona, Spain & ICREA-Institució Catalana de Recerca I Estudis Avançats, 08010 Barcelona, Spain)

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