Gr-mediated (anti)ferromagnetic interaction in a MPc/Gr/Co spin interface

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Paramagnetic metal organic molecules can open the route to engineer spintronic devices when their magnetic moments are stabilized against thermal fluctuations, e.g. by a controlled interaction with a magnetic substrate. We report on robust spin interfaces, exhibiting a residual magnetic coupling up to room temperature (RT), with tunable (anti- or ferromagnetic) alignment constituted by Metal Phthalocyanine (MPc) ordered arrays on a Co-intercalated Gr substrate.
The highly corrugated moiré superstructure of Co-intercalated Gr/Ir(111), drives the assembly of evenly-spaced molecular bits, providing preferential adsorption regions for the phthalocyanine molecules [1,2]. Our X-ray absorption and photoemission results show that the graphene layer shields the electronic/magnetic state of the molecules, screening the electronic interaction with the metallic surface. The magnetic response of the molecular spin interfaces, and its robustness against thermal fluctuations, were investigated by X-ray magnetic circular dichroism. Mn-, Fe- and Cu-phthalocyanines assemble on Gr/Co with identical structural configurations, but MnPc and FePc are strongly antiferromagnetically coupled with Co up to room temperature, while CuPc couples ferromagnetically with weaker thermal stability [1,3]. The robust antiferromagnetic alignment is stabilized by a super-exchange interaction, driven by the out-of-plane molecular orbitals responsible of the magnetic ground state and electronically decoupled from the underlying metal via the graphene layer, as confirmed by ab initio theoretical predictions. The robustness against thermal fluctuations of the magnetic activity at the spin interface can be further optimized by maximizing the magnetic moment of the intercalant, with unprecedented room temperature remanence.
The Gr layer plays a dual role, on the one hand it acts as a spacer, driving the ordering of the adsorbed molecules and protecting their electronic-magnetic configurations. On the other hand, it actively mediates the magnetic interaction, allowing for magnetic activity up to room temperature.

References

[1] Avvisati G. et al., NanoLetters, 18 (2018) 2268-2273
[2] Avvisati G. et al., J. Chem. Phys, 150 (2019) 054704
[3] Avvisati G. et al., Phys. Rev. B 98 (2018) 115412

Figures

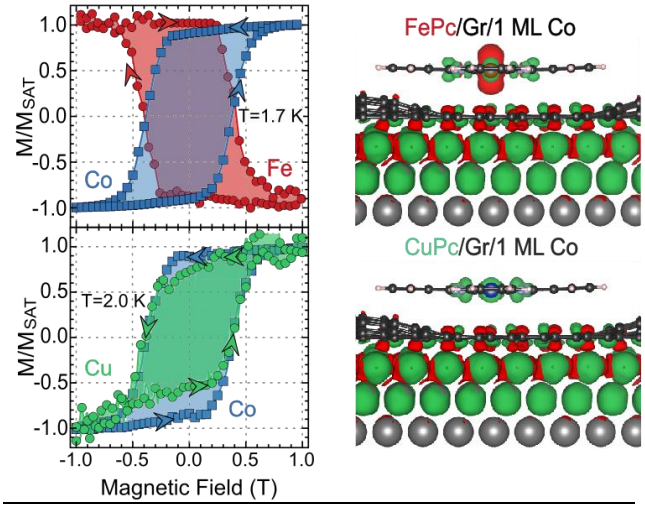

Figure 1: (Left) Element-selective hysteresis loops for FePc (top) and CuPc (bottom) adsorbed on Gr/1 ML Co. The spin density isosurfaces, picturing the spin polarization of the involved orbitals, are presented in the right part.