Engineering of a 2D Metal-organic Network Featuring a Large Unquenched Orbital Magnetic Moment

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Free transition metal atoms have high spin and orbital magnetic moments. However, in solids, the orbital moment is partial or totally quenched by crystal field effects. This quenching reduces drastically the magnetic anisotropy, that is associated to the orbital moment anisotropy. The reduction of the coordination of transition metals has been proposed as a route to achieve an unquenched orbital moment. 2D metal-organic networks on surfaces are promising candidates to reduce the coordination and stabilize a large orbital moment.

On the other side, π-conjugated metal-organic networks have been attracting great attention since they can present exotic quantum phases of matter [1]. The conjugation also enhances the coupling between magnetic moments and can lead to antiferromagnetic ground-states [2]. The absence of stray fields and magnetic robustness of antiferromagnetic materials make them promising candidates to replace ferromagnets in the next generation of spintronic devices.

In this work, we investigated the structural, electronic and magnetic properties of a π-conjugated 2D metal-organic network consisting of 2,3,6,7,10,11-hexahydroxytriphenylene (HOTP) molecules coordinated with Co atoms on Au(111). We performed a multidisciplinary study, combining scanning probe microscopy and spectroscopy, X-ray absorption spectroscopy, X-ray linear and X-ray circular magnetic dichroism [3]. Our results reveal a network based on three-fold Co+2 coordination displaying a large unquenched orbital magnetic moment with an orbital to effective spin moment ratio of 0.8, as also a large magnetic anisotropy with an in-plane easy axis. Furthermore, density functional theory complemented by a Hubbard model (DFT+U) predicts an antiferromagnetic ground-state, that is compatible with our experimental results.

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