Magnetic Coupling in GNR QDs & Looking Beyond

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Carbon-based quantum dots (QDs) enable flexible manipulation of electronic behavior at the nanoscale, but controlling their magnetic properties requires atomically precise structural control. While magnetism is observed in organic molecules and graphene nanoribbons (GNRs), GNR precursors enabling bottom-up fabrication of QDs with various spin ground states have not yet been reported. Here the development of a new GNR precursor that results in magnetic QD structures embedded in semiconducting GNRs is reported. Inserting one such molecule into the GNR backbone and graphitizing it results in a QD region hosting one unpaired electron. QDs composed of two precursor molecules exhibit nonmagnetic, anti ferromagnetic, or anti ferromagnetic ground states, depending on the structural details that determine the coupling behavior of the spins originating from each molecule. The emergence of localized states are demonstrated through STM, STS + mapping and HR-AFM.

Looking Beyond: Such structures are promising molecular building blocks of carbon based future devices with spin controllable or quantum computing capable elements. Challenges from control to de-coherence and even available instrumentation to tackle future "Q-SPM" challenges remain.

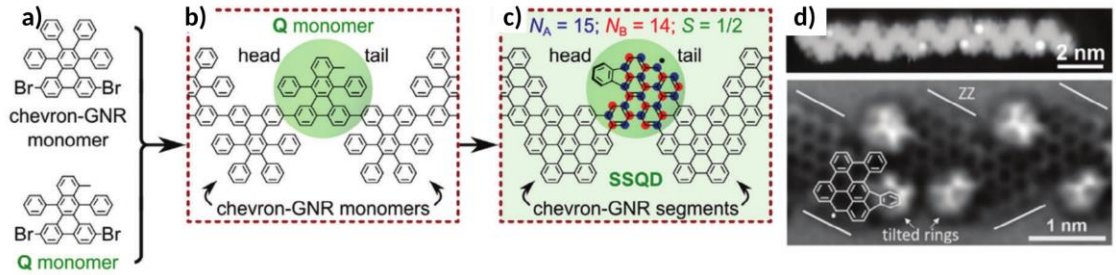

Figure 1. a) Precursors used to make GNR QDs. b) GNR single-spin quantum dot (SSQD) structure before and after cyclo-hydrogenation. c) Final structure of a SSQD after cyclodehydrogenation. d) The top panel shows an STM topographic image of a single GNR. The bottom panel shows HR-AFM image acquired on a GNR showing 6 Q-monomers. The image shows the zigzag (ZZ) edges and the tilted benzene rings attached to the five-membered rings. One of the GNR segments is overlaid with its chemical structure.

Reference:

[1] Jacobse PH, Sarker M, Saxena A, et al. Small **20**, 2400473 (2024)