Solution Grown and Tunable Plastic Magnets: Room Temperature Ferromagnetism in Mesoscopic Conjugated Polymer Rings

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Conventionally, ferromagnetic materials are restricted to metallic regime such as iron and nickel. However, if ferromagnetic behavior could be induced in organic polymers - it would offer versatility in medicinal, environmental, and even computational application of magnets including superior drug delivery, magnetic hyperthermia cancer therapy, oil spill remediation and data storage. Although syntheses in the literature have been attempted to induce ferromagnetism in organic polymers, most require sufficiently low temperature, have very low magnetic strength, and no tunability, inhibiting practical applications. This research proposed the first-ever generalized methodology to create tunable ferromagnetic conjugated organic polymers at room temperature without aid of magnetic metals. Room temperature existence of bipolarons in conductive polymers and the Peierls instability in mesoscopic rings of doped conjugated polymers were hypothesized as rationale for ferromagnetic behavior. Novel one-pot solution based oxidative templating method was employed to form doped mesoscopic conjugated polymer rings/cylinders, evidenced in AFM and SEM/EDS images. VSM data for low radii (mean ~39 nm) polyaniline ring demonstrated hysteresis loop similar to baseline iron nanoparticles, indicating ferromagnetic signature. With increasing ring size (~300 nm) hysteresis loop shrunk and magnetic strength reduced, completely diminishing for larger ring (~ 25 um). Chemical shift from liquid NMR corroborated VSM data, demonstrating tunability of magnetic strength with varying ring size by controlling oxidative templating. Saturated DC susceptibility from PPMS measurement was averaged to be 0.421 emu/g for low radii polyaniline ring, the highest ever magnetic strength achieved for organic magnets.

Awards Won:

First Award of $5,000

American Chemical Society: Second Award of $3,000