Organic-Inorganic Hybrid Functional Materials for Switching, Sensor, and Spintronic Technologies

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Organic materials are important to development of organic light emitting diodes (OLEDs) used in display technologies, organic photovoltaics (OPVs) used in the manufacturing of plastics that convert light to energy, and organic semiconductor technologies used for information processing and computing. Research in the Frank group utilizes theory and techniques in photochemistry/photophysics, charge-transfer/charge transport, and spin-state dynamics/spin-spin exchange, and electronic structure theory to design complex functional materials with unique applications for quantum computing, biosensing, and low energy demand device architectures. Using the principles of organic synthesis, coordination chemistry, and polymer synthesis, we design and prepare conjugated organic molecules, coordination complexes, and polymers that combine optical, magnetic and electrical properties. We then investigate the effect of stimuli (optical, magnetic, electrical) on the electronic structure and secondary functional properties (optical, magnetic, electrical) to determine the effects of structural parameters on electronic coupling, reorganization energies, electrochemical behavior, and efficiencies, for device fabrication. The effect of such perturbations on the electronic structure or targets is studied by solution-state and spectroscopy, physical measurements in the solid state, and computation. The goal of our research is to gain insight into (i) the effect of spin state on excited state processes and ground state charge transport processes, (ii) the effect of structure on long-range and short range order in organic materials on surfaces, and (iii) the effect of gated topological changes on electronic coupling relevant to electron and energy transfer processes. Such insights ultimately inform design principles for materials development in quantum information processing, spintronics, energy harvesting and storage, and chemosensing/biosensing applications. Our most recent results in the areas of (i) radical-based organic spintronic materials, (ii) conformational effects of substrate structure on graphene OFETs, (iii) optical gating of electron and energy transfer processes in functional pi systems and electronically bistable metal complexes, and (iv) mechanistic studies of magnetic nanoparticle –based magnetoreception in biological systems will be discussed.