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Manipulation and Coupling of Molecular Electronic Spin States

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Organic magnetic structures can be utilized for ultra-high-density information storage, the construction of organic magnets, and novel quantum materials. This presentation primarily covers the reversible manipulation of single-molecule spin states, spin interactions among various magnetic building blocks, and the construction of one-dimensional Kondo chains and spin ladders.

Ordered self-assembled structures of retinoic acid molecules were prepared on the Au(111) surface. Radical structures bearing delocalized 1/2 spin states were obtained through single-molecule bond-selective chemistry by breaking specific C–H bonds. Voltage pulses enabled the reversible switching of this process, achieving reversible manipulation of single-molecule spin states. Spin interactions based on hydrogen-bonded spin coupling and coordination-bonded spin coupling in retinoic acid systems were also investigated.

A method for mechanically manipulating molecular spin states using surface forces was developed. The attractive force from a metallic tip was used to switch the Ni atom in a coordination structure from a high-spin state to a low-spin state, while the repulsive force from a carbon-cage tip was employed to achieve the same high-spin-to-low-spin transition. The force and energy required for the single-atom spin-state transition were quantitatively measured.

Through surface reactions and bond-selective chemistry, one-dimensional Kondo chains were constructed on surface for the first time. After individual molecular units in the chain were converted into radicals, they formed Kondo singlets with surface electrons. The coupling of multiple Kondo singlets gave rise to an odd–even oscillation effect. Furthermore, dimeric and trimeric chains were obtained via surface chemistry, and significant changes in the Kondo chain properties were observed.