Probing Interfacial Reactivities at Patterned Nanoparticle Assemblies Using Atomic Force Microscopy

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Nanoparticles consisting of metallic or semiconductive nanocrystal cores encapsulated with organic monolayer shells are fine-tunable in terms of size, shape, composition, surface and electronic properties at the molecular level, and thus serve as intriguing building blocks towards chemically and biologically functional platforms. Key to the exploitation of such platforms is the ability to probe the interfacial chemical or biological interactions and reactivities in real time. This paper describes findings of an investigation of nanostructured thin film assemblies of gold nanoparticles derived from interparticle covalent or hydrogen-bonding linkages. The morphological changes induced by both potential and pH manipulations are probed. Our strategy couples the selective assembly via hydrogen-bonding linkage at patterned monolayer substrates with the capability of atomic force microscopy to detect frictional and topographical changes in the interfacial processes. The selective assembly provided an ideal imaging platform with an internal standard. The detection of reversible changes in both friction and height in the nanoparticle-assembled platform allowed us to gain new insights into the ionic fluxes and interparticle spatial evolution within the nanoporous structure. Such insights have important implications to the design of nanoparticle-based interfaces for nanostructured catalysis and molecular recognition (e.g., ion-channeling, antibody-antigen interaction, and chaperonin complexation, etc). The strategy of coupling patterned nanoparticle assembly with AFM imaging capability, along with surface infrared reflection spectroscopic and electrochemical characterizations, is effective in providing information on the detailed structural and morphological properties of the nanostructured materials. Implications of the results to its application in a variety of chemical or biological interfacial characterizations will also be discussed.