

Energy-level splitting of ligand-stabilized Au₅₅ clusters observed by low-temperature scanning tunneling spectroscopy

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Low-temperature ultrahigh-vacuum scanning tunneling microscopy and spectroscopy were employed to analyze the electronic structure of Au₅₅ clusters stabilized by [P(C₆H₅)₃]₁₂C₁₆ ligands. It is important to investigate the clusters at low temperature. Under this condition the thermal motion of the clusters as well as the thermal drift of the STM are sufficiently reduced, so that measurements can be performed reproducibly with highest spatial and spectroscopic resolution. A monolayer of clusters was prepared on an Au(111) surface. Within many small areas (ca. 50 nm²) the clusters are arranged in a rather perfect hexagonal closest packing. Clusters located within such areas were chosen for further STM and STS investigations since they are largely immobile. At 7 K we imaged for the first time the actual arrangement of the C₆H₅ rings of the ligand molecules. Spectroscopic data acquired from different locations within a cluster reveal discrete energy levels which can be attributed to the Au₅₅ core. The electronic states of the ligand molecules do not show significant influence on the tunneling spectra. The results are acquired from a series of measurements on the clusters as well as on the ligand molecules. The individual energy-level spacings in vicinity to the Fermi level can be deduced then from the bias ratio of the double tunnel-junction (tip-cluster and cluster-substrate). The latter was determined by accompanying current-distance STM measurements. Experimental results are compared with those obtained by tight-binding calculations.