SUMMARY OF Ph.D. DISSERTATION

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Title

Establishment of Soft-Landing Isolation Technique for Gas-Phase Synthesized Clusters in Organic Monolayer Matrices

Abstract

Gas-phase synthesized clusters possess novel size-specific properties which are distinctly different from those of corresponding bulk materials. Surface modification via non-dissociative deposition of the size-selected clusters, a so-called soft-landing, is thus an emerging approach in designing novel nanostructured materials with desirable properties. In particular, transition-metal–benzene sandwich clusters are regarded as attractive building blocks for nanoscale photo-magnetic devices, because the gas-phase studies have unveiled their unique size-dependent electronic and magnetic properties. In this study, I established an innovative matrix-isolation technique for transition-metal–benzene clusters of the form $M_n(benzene)_{n+1}$ (M = Ti, V, Cr) via their soft-landing into self-assembled monolayer (SAM) matrices, primarily composed of organothiolates on gold, at hyperthermal collision energy. Surface spectroscopic and microscopic methods have been devoted to characterize the adsorption properties and thermal chemistry of the matrix-isolated clusters.

Chapter 1 summarizes background and previous studies related to the cluster science as well as soft-landing technique.

Chapter 2 presents experimental detail where the soft-landing setup, preparation and characterization of the SAM matrix, and surface science technique are specified.

Chapter 3 describes the soft-landing isolation of $M(benzene)_2$ in the *n*-alkanethiol SAM matrices. The matrix-isolated clusters keep their native sandwich structures intact and exhibit clear orientational preference. In addition, the clusters obtain unusual large desorption activation energies (over 100 kJ/mol) in the SAM matrices to be considerably suppressed the thermal desorption up to room temperature.

Chapter 4 discusses the effect of fluorination of the SAM matrix on the adsorption properties and thermal chemistry of the isolated clusters. The fluorination poses a change in orientational preference and increase in thermal stability of the isolated clusters, a result which provides the possibility that the adsorption regime of the clusters can be finely controlled by varying the chemical species forming the SAM matrix.

Chapter 5 describes the achievement of the soft-landing isolation of the multiple-decker $V_2(benzene)_3$ cluster in the SAM matrix. The first observation of the infrared spectrum for $V_2(benzene)_3$ was carried out via the soft-landing isolation technique in this study.

Chapter 6 illustrates a newly designed a “portable cluster source” and its application for microscopic study of soft-landed clusters. Installing the portable cluster source into scanning probe microscope enabled the measurements of physical topographic images of the clusters soft-landed on the SAM matrices.

Chapter 7 summarizes the results obtained in this study.