Molecular Beam Studies of the Dynamics and Kinetics of Heterogeneous Reactions on Single Crystal Surfaces

Robert J. Madix
Department of Chemical Engineering
Stanford University

Research Scope and Objectives

Molecular beam and surface science technology is being used to study (1) the effects of internal and translational energy on activated adsorption on metal surfaces, (2) the mechanism of simple surface reactions, and (3) the dynamics of highly exothermic reactions.

Description of Research Effort

The activated adsorption of N_2 on W(110) has been studied using molecular beams to achieve translational energies from 2 to 30 kcal/gmol. The beams are formed in nozzles with and without helium seeding. For the lowest kinetic energy the probability of dissociation upon collision is about 10^{-3}, increasing to 2×10^{-1} at energies above 20 kcal/gmole. The dependence of the dissociation probability on nitrogen coverage suggests the process is direct in nature, not trapping dominated. The results show that adsorption is translationally activated and that the reactive collision is not adequately described by a one-dimensional barrier. As the beam energy is increased, the apparent saturation coverage by nitrogen increases, producing an unusual desorption state above a nitrogen atom coverage of 0.25. Nitrogen desorbed autocatalytically from this state in a fashion observed previously for high concentrations of oyxgen from Pt(100). The emergence of this state at higher surface coverages indicates that the state of nitrogen adsorbed on tungsten and other metals may be quite different from the state normally observed in low pressure studies.

Future Research

Studies in the near future will concentrate on the dynamics of activated adsorption of N_2 and other gases on W(110). In addition reactions on Ni(100) will be examined which are related to steam reforming.