

Alfred Nobel Symposium
Energy in Cosmos, Molecules and Life
June 18-22, 2005

Molecules at Surfaces and Mechanism of Catalysis

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Molecules interacting with a solid surface may undergo chemical transformations along an energetically more favorable and hence faster pathway. This principle of heterogeneous catalysis is of tremendous practical relevance and can now be studied down to the shortest length (nm) and time (fs) scales. The rate of such a process is governed by energy exchange between the various degrees of freedom of the adsorbed species and those of the solid. Mutual interactions between adsorbed particles may give rise to the formation of ordered two-dimensional phases on atomic scale. If a catalytic reaction is operated under steady-state flow conditions, the system is, on the other hand, far away from equilibrium and can exhibit phenomena of spatio-temporal self-organization, such as oscillatory or chaotic temporal behavior and formation of concentration patterns on mesoscopic (typically tens of μm) scale. These effects can be rationalized in the framework of nonlinear dynamics and manifest themselves also in other, quite different areas of nature.