In Control of Molecular Motion: From Molecular Switches to Molecular Motors

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Inspired by Nature we design nanoscale systems in which the control of dynamic properties of molecules is coupled to specific functions. Chemical systems ultimately require control over structure, organization and function of multi-component molecular assemblies at different hierarchical levels. Major challenges are the design of kinetic driven processes and control over translational and rotary motion.

Molecular switches and motors offer ample opportunity to control functions in a dynamic way. The use of molecular switches allows control of function and assembly in a non-invasive manner. This will be illustrated in molecular systems for data storage, electronic communication, and regulation of transport through protein channels. Following the development of the first light-driven unidirectional molecular motor, the focus is now on the control of dynamic functions in more complex systems as well as autonomous motion. Synthetic approaches to various molecular switches and motors and the construction of integrated molecular systems featuring trigger and motor elements are discussed.

Specific challenges that we address are the acceleration of molecular rotary motors and the construction of a nanoscale “windmill park” powered by light. Recent advances in the design of a new generation motors that allow the increase of the speed of rotation over a million fold are presented. Furthermore the motion of a large collection of motors on a surface and molecular transmission phenomena are discussed. Besides rotary motion induced by light, we present unique molecular motors that run on a chemical fuel and discuss our attempts to achieve autonomous motion.