Directional motion of individual functional molecules

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Molecular motion on surfaces plays an important role in many processes such as growth of 2D materials, heterogeneous catalytic reactions, and on-surface polymerisation. According to the principle of microscopic reversibility [1], in a thermally equilibrated system, such motion is random in nature. However, understanding how to control and direct motion of individual molecules is of importance and could lead to the production of novel materials or more efficient catalytic processes.

I will first show how local gradients in the tunnel junction of a scanning tunnelling microscope can result in unidirectional motion. For instance, the inhomogeneous electric field can be used to control the motion of a single molecule via an internal dipole moment. The rotation is found to occur around a fixed pivot point, caused by the interaction of an oxygen atom in the molecule with a silver atom of the underlying surface [2]. The disruption of this anchoring point results in a mixture of rotations and translations [3,4], which can be controlled by the choice of manipulation parameters.

Of even greater interest are molecular motors which display intrinsic directionality, that is, molecules which convert external energy into a predefined direction of motion. An example of such a system is the well-known Feringa motor. However, such motors often show a reduction or loss of functionality when taken from their native solution phase and deposited onto a metallic surface. In this talk a new concept in molecular motors will be demonstrated, which uses a small and simple chemical structure to achieve perfect unidirectionality when deposited onto a Cu(110) surface [5]. The motion is triggered by switching between two potential energy landscapes, thus avoiding microscopic reversibility, and leads to 100% unidirectionality in the molecule. Furthermore, this unidirectional motion can be harnessed to perform work by transporting small cargo molecules across the surface.

References

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