Surface-Aligned Reactions at Selected Impact Parameters

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Experiments in crossed molecular beams have yielded a wealth of information concerning the dynamics of chemical reaction under single-collision conditions. The results have, however, of necessity, been averaged over collisions with impact parameters (i.e. collision 'miss-distances') ranging from zero to infinity, obscuring the effect of this important parameter on the molecular dynamics. Here we describe a method by which this averaging is avoided by aiming a highly-collimated reactive 'projectile' molecule at a fixed 'target' molecule, both of which are precisely located by Scanning Tunnelling Microscopy (STM). The projectile was CF_2 recoiling from electron-induced bond-breaking in chemisorbed CF_3 on Cu(110) at 4.6 K. The collimation of the CF_2 'surface molecular beam' restricted it to a lateral spread of ±1° as a consequence of its chemical interaction with the Cu-rows of the underlying surface. This collimation effect was successfully modelled by Molecular Dynamics. In the experiments the recoiling CF_2 projectile was aimed with zero and 3.6 Å impact parameters at a second CF_2 and with 1.8 Å impact parameter at an I-atom. The pattern of reactive and non-reactive scattering was determined by STM in each case. Such collimated 'surface-molecular beams' have the interesting potential that the molecular projectiles can be aimed with selected impact parameter in scattering experiments involving the wide range of target species that today can be identified by STM at a surface.