Making More-Complex Molecules Using Superthermal Atom/Molecule Collisions

Atoms adsorbed on cold surfaces react with energetic impinging atoms.

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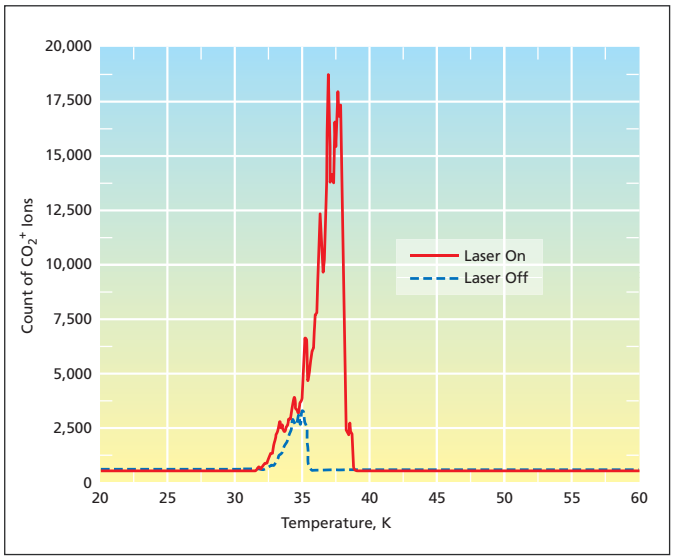
A method of making more-complex molecules from simpler ones has emerged as a by-product of an experimental study in outer-space atom/surface collision physics. The subject of the study was the formation of CO_2 molecules as a result of impingement of O atoms at controlled kinetic energies upon cold surfaces onto which CO molecules had been adsorbed. In this study, the O/CO system served as a laboratory model, not only for the formation of CO_2 but also for the formation of other compounds through impingement of rapidly moving atoms upon molecules adsorbed on such cold interstellar surfaces as those of dust grains or comets. By contributing to the formation of increasingly complex molecules, including organic ones, this study and related other studies may eventually contribute to understanding of the origins of life.



These Plots of the CO_2^+ Reading of the mass spectrometer versus desorption temperature have been interpreted as signifying that CO_2 had been adsorbed on the surface in the reaction O + CO → CO_2. The plot labeled "Laser Off" is that of a background reading that must be subtracted from the total-reading "Laser On" reading to obtain the net CO_2^+-ion count from the superthermal reaction.

In the study, CO was adsorbed onto a cryo-cooled surface, then the surface was exposed to a beam of ground-state O atoms at a kinetic energy of 10 eV per atom. After an exposure time of 135 minutes, the surface was retracted from the O-atom beam into the field of view of a quadrupole mass spectrometer. The reaction products were desorbed by heating the cold surface according to a defined temperature-vs.-time schedule (temperature-programmed desorption). Desorbed molecules were ionized, then detected in the mass spectrometer. The temperature dependence of the CO_2 peak in the mass-spectrometer readout (see figure) indicated that large quantities of CO_2 were desorbed; this observation was taken to be evidence for the reaction O + CO(s) → CO_2(s).

Generalizing the method used in this study, it may be possible, for example, to make simple and more-complex amines, even amino acids by reacting ice mixtures of CH_4 and NH_3 with superthermal O and H beams. In general, by choice of atomic projectiles, kinetic energies, atomic quantum states, surfaces, and exposure times, it may be possible to create new molecular species and stabilize them on the solid surfaces on which they were created.

This work was done by Brian Shortt, Ara Chutjian, and Otto Orient of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-41300

Nematic Cells for Digital Light Deflection

Smectic A (SmA) prisms can be made in a variety of shapes and are useful for visible spectrum and infrared beam steerage.

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Smectic A (SmA) materials can be used in non-mechanical, digital beam deflectors (DBDs) as fillers for passive birefringent prisms based on decoupled pairs of electrically controlled, liquid crystalline polarization rotators, like twisted nematic (TN) cells and passive deflectors. DBDs are used in free-space laser communications, optical fiber communications, optical switches, scanners, and *in-situ* wavefront correction.

Depending on the applied voltage, the TN cell rotates the polarization of incident light by $\pi/2$ (no field, OFF state) or leaves the polarization intact (when the applied electric field reorients the liquid crystal molecules perpendicular to the plates of the cell, ON state). The decoupled pair of a rotator and a deflector has no moving parts, and can be cascaded into N stages, making 2^N addressable beam directions. This approach allows for the separation of time response and beam deflection angles, and