Radical recombination during the phase transition of interstellar CO ice

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Complex organic molecules (COMs) can be produced efficiently in CO-rich ice mixtures that simulate the outer layers of the ice mantle on cosmic dust grains. Prior laboratory experiments have confirmed the formation of various 2- and 3-carbon COMs when CO and hydrogen atoms are condensed together at ~10 K. It was proposed that the reactions are largely driven by radical recombinations. However, the mechanism that brings the radicals together in the CO-rich ice has been debated. Thermal diffusion, which is widely regarded as the main mechanism to bring reactants together, is inefficient at ~10 K. We performed laboratory experiments to study the mechanism. An ice mixture of CH_3OH and CO, which is an analog of the outer layer of the ice mantle on cosmic dust grains in molecular clouds, was exposed to UV irradiation to produce radicals such as HCO and CH_2OH, whose concentration was monitored during subsequent warm-up of the ice. We find clear evidence that during the CO phase transition from amorphous phase to polycrystalline phase, most of the radicals recombine to form other molecular species, therefore supporting a recently proposed mechanism of COMs formation via CO phase transition.