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The effects of surface-coating alcohols on water uptake on ice

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The efficiency of water uptake by ice particles contributes to ice cloud development in the atmosphere with implications for the water cycle and climate on Earth. Here, we investigate heavy water (D2O) uptake by water ice with and without alcohol coatings. Methanol and n-butanol are used as alcohol surfactants with different carbon numbers. Water interactions with ice are probed using a recently developed environmental molecular beam (EMB) technique that allows for experiments at vapor pressures up to 10-2 mbar. When probing alcohol-coated ice, a micrometer thick water ice is first condensed on a substrate and subsequently covered by an alcohol monolayer. The application of a large range of alcohol partial pressures confirms the stability of the adsorbed monolayer. A mixed molecular beam of D2O and helium is directed at the ice surfaces under different conditions, and the scattered and desorbed D2O is measured and analyzed quantitatively to obtain water uptake coefficients. The results illustrate that sticking of impinging D2O molecules is almost perfect, but uptake in the presence of alcohol surfactants is strongly dependent on carbon chain length. Molecules from butanol-coated ice scatter and thermally desorb more efficiently than from ice coated by methanol. Hydrogen/deuterium exchange is eliminated as a possible sink of D2O because no HDO is detected beyond the 1% noise level. Between 170 K and 190 K temperature does not obviously influence the water uptake coefficient. These results provide a quantitatively constrained demonstration that adsorbed volatile organic compounds fundamentally alter ice surfaces and thus have the potential to be important in cloud processes ranging from formation to gas-phase scavenging.