Cosmic dust might condense less gas than previously thought

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The interactions of gases with cosmic dust play a crucial role in the chemistry of the universe. The adsorption of an atom on the surface of a cosmic grain is controlled by the probability that this atom remains adsorbed on a grain, i.e. S, the "sticking coefficient". It takes values ranging from 0 (no adsorption) to 1 (total sticking). This term controls the accretion process, and is key to quantifying gas-grain interactions. It is generally assumed that the temperature of cosmic dust is so cold (< 20K) that any atom or molecule hitting a grain remains stuck, i.e. S=1 in all cases. Indeed, molecular beam laboratory experiments have shown that this is the case for H_2O, CO, N_2, O_2, CH_4 and CO_2/H_2O ice, and H, D, H_2 and D_2. However, the dust grain analogues used in these experiments (carbon, olivine, water ice surfaces…) did not have one essential characteristic of cosmic grains: *their very small size*. Does this nanostructure influence the growth of cosmic ices? To answer this question, we have performed [1] a series of laboratory experiments using an original approach based on X-ray photoelectron spectroscopy (XPS) to quantify the adsorption probabilities of H_2O and CO_2 on submicrometer-sized particles of carbon and olivine, the main minerals that compose cosmic dust (Figure 1, left). The grain analogues were bare or pre-covered by an ice layer to model icy grains. The intensities of the XPS signals related to the growth of H_2O and CO_2 ices as a function of exposure at H_2O and CO_2 gas provide sticking coefficients between 0.05 and 0.2, i.e. *S is far from unity* (Figure 1, right for S of H_2O on bare grains). H_2O and CO_2 ices are therefore much more difficult to form on submicrometer grains than on flat surfaces of the same composition (graphite, olivine, ice...), calling for a downward revision of the molecular sticking coefficient on cosmic grains.

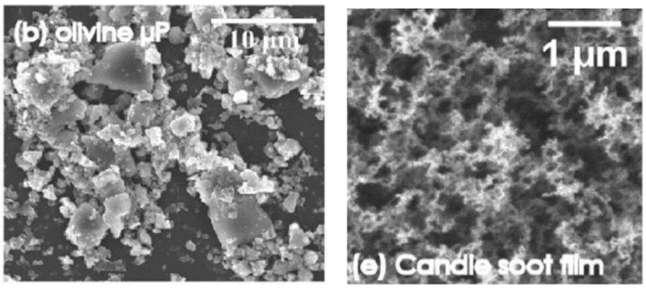
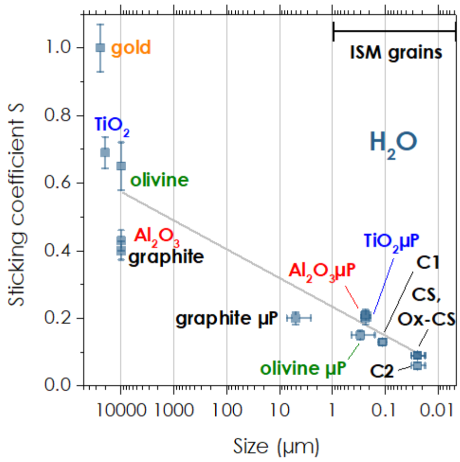


Figure 1. Left: electron microscopy images of olivine and carbon grains analogues. Right: Measured sticking coefficients for H_2O at 20 K on a variety of bare grains.



References

[1] 1. C. Laffon, D. Ferry, O. Grauby, Ph. Parent. *Nature Astronomy* 5, 445-450 (2021)