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From laboratory to space: proton irradiation of carbonaceous dust analogues deposited by atmospheric pressure plasma

'Fluffy'hydrogenated amorphous carbon (a-C:H) was synthesized using a dielectric barrier discharge plasma, driven by nanosecond high-voltage pulses at 1 kHz frequency in a helium–butane mixture [1,2,3]. The a-C:H samples were characterized by various microscopy and spectroscopic techniques. The results show that a-C:H samples exhibit infrared absorption features that closely match those observed for carbonaceous dust in the IRAS 08572+3915 galaxy. We discuss the nano- to microscale structure of the analogues and a method to derive the hydrogen-to-carbon (H/C) from FTIR data, corelated with results from three different experimental characterization techniques. By relying on the average H/C value determined through mass spectrometry and Raman spectroscopy, the absorption strength values were constrained to best match the dust analogue, allowing the calculation of the H/C ratio from the infrared spectra. The analysis indicates that the dust analogue predominantly consists of a hydrogen-rich aliphatic network with small, isolated aromatic regions.
The a-C:H dust analogue was then irradiated with 3 MeV protons and analysed ex situ. Morphological and chemical changes were observed, including variations in H/C, CH_2/CH_3, and sp^2/sp^3 ratios, indicating dehydrogenation and graphitization. Proton bombardment shifted the initial location of a-C:H in the hydrocarbon ternary phase diagram toward the region defined by IRAS 08572+3915 observations. The decay of the 3.4 μm band due to proton fluence was used to calculate CH destruction cross-sections, which are consistent with the direct effects of cosmic rays on the disappearance of this feature.

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