Prevalence of non-aromatic carbonaceous molecules in the inner regions of circumstellar envelopes

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Evolved stars are a factory of chemical complexity, gas and dust that provide the building blocks of planets and life, and dust nucleation first occurs in their photosphere. The circumstellar regions enveloping these stars, despite their importance, remain hidden to many observations, and dust formation processes are therefore still poorly understood. Laboratory astrophysics provides complementary routes to unveil these chemical processes, but most experiments rely on combustion or plasma decomposition of molecular precursors under physical conditions far removed from those in space. To reproduce and characterize the bottom-up dust formation process, we have built an ultra-high vacuum machine combining atomic gas aggregation with advanced in situ characterization techniques [1]. We show that carbonaceous dust analogues that formed from low-pressure gas-phase condensation of carbon atoms in a hydrogen atmosphere, in a ratio of carbon to molecular hydrogen similar to that reported for evolved stars, lead to the formation of amorphous carbon nanograins and aliphatic carbon clusters [2]. Aromatic species and fullerenes are not efficiently formed under these conditions, raising implications for a revision of the chemical mechanisms taking place in circumstellar envelopes.

References

[1] L. Martínez, et al., Scientific Reports, 8 (2018) 7250.

[2] L. Martínez, G. Santoro, P. Merino, et al., Nature Astronomy, 4 (2020) 97-105.