

Atomic-scale imaging interstellar carbon analogues of C-rich AGB stars: evidence for efficient linear alkane formation.

P. Merino^{1,2,*}, L. Martínez¹, G. Santoro¹, K. Lauawet³, M. Acolla¹, H. Sabbah⁴, J. Sobrado⁵, N. Ruiz del Arbol¹, C. Sanchez-Sanchez¹, J. Azpeitia¹, A. Martin³, R. Otero³, M. Piatek^{6,7,8}, D. Serrate^{6,7,8}, J. Mendez¹, C. Joblin⁴, J. Cernicharo², J.A. Martin-Gago¹.

¹ Instituto de Ciencia de Materiales de Madrid, CSIC, Sor Juana Inés de la Cruz 3, E28049, Madrid, Spain.

² Instituto de Física Fundamental, CSIC, Serrano 121, E28006, Madrid, Spain.

³ Instituto Madrileño de Estudios Avanzados IMDEA Nanociencia, Madrid, Spain.

⁴ Institut de Recherche en Astrophysique et Planétologie (IRAP), Université de Toulouse (UPS), CNRS, CNES, 9 Avenue du Colonel Roche, 31028, Toulouse, Cedex 4, France

⁵ Centro de Astrobiología (CSIC-INTA), Ctra. de Torrejón a Ajalvir, Km 4, Torrejón de Ardoz, 28850, Spain

⁶ Instituto de Nanociencia de Aragón and Laboratorio de Microscopías Avanzadas, Universidad de Zaragoza, 50018, Zaragoza, Spain

⁷ Fundación Instituto de Nanociencia de Aragón (FINA), 50018, Zaragoza, Spain

⁸ Departamento de Física de la Materia Condensada, Universidad de Zaragoza, 50009, Zaragoza, Spain

*Corresponding author e-mail address: pablo.merino@csic.com

The last stages of stellar evolution are the birthplace of a rich supply of molecular species. Long carbon linear molecules –with carbon number exceeding C₁₀– are efficiently formed in the clumsy circumstellar envelopes of AGB stars and have been systematically detected in C-rich objects. However, the processes behind C-chain growth have rarely been addressed by experimental means due to the large instrumental obstacles found to simulate the astrochemical conditions of the vicinities of a star, and normally ice-based C-chain chemistry from small molecular precursors is investigated. Here we synthesize circumstellar carbon analogs by using Stardust, a beyond-state-of-the-art instrumentation permitting to closely simulate the conditions of an AGB star in the laboratory.¹ We unambiguously identify the products with atomic precision by low-temperature scanning probe microscopies. We find among the large number of carbon nanostructures formed, an unexpected abundance of alkanes (Fig. 1). The highly saturated linear carbon chain self-assemble on low interacting substrates, carpeting the underlying surface and forming two-dimensional crystallites. Our experiments demonstrate that highly-saturated aliphatics are efficiently formed when atomic carbon is exposed to H₂ partial pressures comparable with the ones reported for circumstellar envelopes, thus pointing towards the emergence of highly saturated hydrocarbons in circumstellar evolved environments,

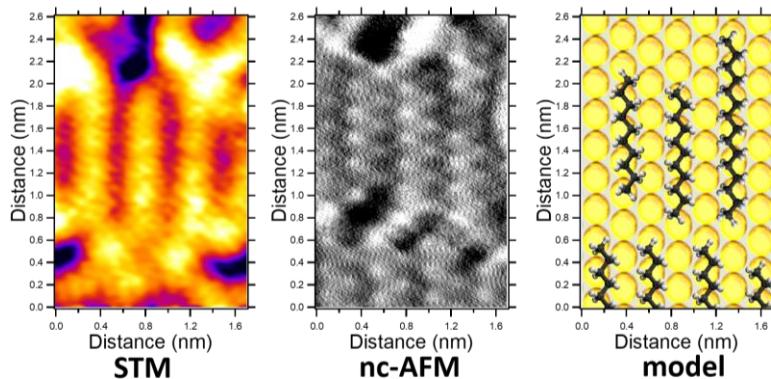


Figure 1: Atomic-scale identification of selected C-chain analogues by scanning probe microscopies.

Acknowledgments: This work has the support of ERC Synergy project Nanocosmos

References

- [1] Martínez, L. et al. Precisely controlled fabrication, manipulation and in-situ analysis of Cu based nanoparticles. Sci. Rep. 8, 7250 (2018).