# Report on the outcomes of a Short-Term Scientific Mission[1]

**Action number: CA21126**

**Grantee name: Gema Navarro Marín**

## Details of the STSM

Title: STM visualization of the organic content in meteorites

Start and end date: 06/06/2026 to 23/06/2026

## Description of the work carried out during the STSM

During the research stay, Dr. Gema Navarro Marín was introduced to the different set-up available in the ESISNA group at the ICMM-CSIC. Under the leadership of Prof. José Ángel Martín Gago and Dr. Carlos Sánchez Sánchez this group has developed an extensive expertise in the subdiscipline known as on-surface synthesis, with a particular focus on unconventional chemistry reactions and the fabrication of distorted graphene nanoribbons. The goal of this research was to explored and analysed the versatility of organic compounds present in meteorites, taking advantage of the high-resolution power of the STM technique.

As a first step, the grantee became familiar with the Scienta Omicron LT-STM/nc-AFM system, experimental facility where the research investigation was carried out. As part of her research plan, Gema was trained in the preparation of the transfer stage using the flash-annealing technique. Following this methodology, 20 µL of organic molecules from a meteorite extraction solution were deposited in ambient conditions on a silicon substrate. Afterwards, the silicon sample was subsequently introduced to the UHV system and flash-annealed to transfer the organic materials onto a Au(111) substrate. In general, two deposition were performed, in the first attempt the organic materials were flashed onto a gold substrate held at -10 °C and later on, explored by Scanning Tunnelling Microscope (STM) at 4.5 K. Following this initial morphological characterization, a second deposition was performed but at -30 °C instead. In both instances, the cooldown of the Au(111) substrate was guaranteed by means of a liquid nitrogen circulation unit during the deposition. After transfer to the microscope, the modified Au(111) surface was dossed with CO molecules for a short period of time, in order to facilitate the tip functionalization for the Bond Resolved STM (BR-STM) images. Using this procedure, a submonolayer coverage of the organic materials was obtained. The deposit molecules were then characterized by LT-STM measurements.

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the Grant Holder Manager to verify the grant documents compliance and proceed with the payment.

## Description of the STSM main achievements and planned follow-up activities

The morphological analysis of the interface formed by the transferred organic materials on Au(111) surface revealed the formation of both extended molecular island and individual species. In particular, the isolated molecules were predominantly visualized at the kinks and elbows sites of the Au(111) herringbone reconstruction. A lateral growth of the aliphatic molecular islands was observed with the decrease of the temperature. However, the number of isolated molecule remined almost invariant after the two deposition experiments, most likely due to the reduced surface mobility induced by the low temperatures. Nevertheless, features with different shapes and lateral average dimensions ranging from 1.3-1.9 nm were distinguished. BR-STM imaging technique provide a better visualization of the internal structure of the features. However, we believe that in general the molecules adopted a non-planar adsorption geometry, reason why the individual bonds cannot be fully resolved.

The STM images acquired during the present study can be beneficial for the recognition and discrimination of organic molecules in meteorites. In particular, this set of images is intended to form part of a reference gallery for training artificial intelligence algorithms, thereby contributing to the main objective to the COST Action 21126 which focus on the study of the physics and chemistry of cosmic carbon nanomaterials. Future work will pursuit to expand this dataset through additional experimental measurements. These complementary studies, subject to the availability of further financial support, will provide a more comprehensive characterization and can contribute to the preparation of a scientific publication.