Formation of covalent carbon molecules inside clusters of C_{60} molecules after collisions with slow Ar^+ ions

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Synopsis We report on the collisions of slow 3 keV Ar^+ ions with clusters of C_{60} molecules. We show that covalently bonded molecules C_N (with $N \geq 61$) are formed within the van der Waals $[C_{60}]_k$ cluster. Classical molecular dynamics reproduce well the experimental results.

C_{60} molecules have been identified in the interstellar medium [1]. In order to better understand our molecular universe it is important to know more about their growth in space and their processing by energetic radiations (photons, electrons, and ions).

We have experimentally studied the collisions of 3 keV Ar^+ ions with clusters of C_{60} molecules. An ion beam collides with a cluster beam and cationic products of the interaction are analysed by time-of-flight mass spectrometry. The slow Ar^+ projectile is chosen in order to maximise the energy deposit in binary collision with cluster nuclei. Indeed it was recently shown that such collisions, associated with a localised energy deposit, lead to some specific decay channels which in turn can trigger reactivity inside of molecular clusters [2, 3].

Experimental mass spectra show that clusters mostly suffer a complete evaporation due to the large amount of energy transferred. However, a relatively strong signal of multiply charged species is observed. The associated appearance sizes ($n_{2+} = 2$ and $n_{3+} = 7$) are much smaller than the ones observed or expected for van der Waals species [4, 5] and thus this constitutes an evidence for the formation of covalent species.

Moreover the observation of dominant signals assigned to odd numbered C species such as C_{121}^+ (see Fig. 1) is also associated with the formation of covalent species and typical of nuclear scattering on molecular nuclei [6].

We have performed classical molecular dynamics simulations similarly to a previous work [3]. As shown in Fig. 1, the simulation results are in good agreement with the experimental ones. The main discrepancies are due to different observation timescales, 10 ps and a few μs respectively.

Thus we can establish a scenario for the growth processes of carbon species due to binary collisions with molecular nuclei associated with a strong and localised energy deposit. Reactive species are formed through non statistical decay mechanisms and therefore larger species are formed with a higher efficiency compared to the case of electronic excitations, e.g. in fs laser interaction [7] or collisions with faster highly charged ions [8].

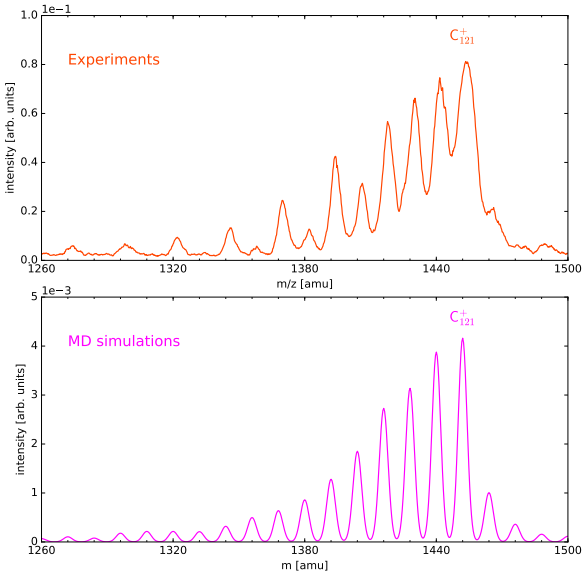

Figure 1. Zoom-in the mass spectra of the species produced in the collision of 3 keV Ar^+ ions with clusters of C_{60} molecules

References

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