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S Indrajith, J Kočíšekt, A Domaracka, P Rousseau, B Huber. Energetic processing of hydrocarbons molecular species by ionizing radiation towards the formation of cyclic species. *Journal of Physics: Conference Series*, 2020, 1412 (14), pp.142018. 10.1088/1742-6596/1412/14/142018 . hal-03792743

HAL Id: hal-03792743

<https://hal.science/hal-03792743v1>

Submitted on 9 Jan 2024

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Energetic processing of hydrocarbons molecular species by ionizing radiation towards the formation of cyclic species

S Indrajith^{1*}, J Kočíšek^{2†}, A Domaracka¹, P Rousseau¹ and B A Huber¹

¹Normandie Université, ENSICAEN, UNICAEN, CEA, CNRS, CIMAP, Caen, 14000, France

²J. Heyrovský Institute of Physical Chemistry v.v.i., the Czech Academy of Sciences, Prague, 18223, Czech Republic

Synopsis Here we report on experimental studies of the collisions between butadiene clusters and three different ionizing radiation sources: 70 eV electrons, 270 nm photons and 3 keV Ar⁺ ions. New molecular species are produced by growth mechanism inside of clusters.

Cassini-Huygens mission brought interesting results concerning one of Saturn's biggest satellites, Titan. In fact, it has been shown that this moon's typical orange-brownish haze layers could be due to the presence of aerosols. These aerosols are essential for Titan's climate, radiation balance and atmosphere chemistry. The formation of such aerosols is a complex process ranging from the molecular scale to large particles scale. Polycyclic Aromatic Hydrocarbons (PAHs) and their clusters are important components in terrestrial soot formation. Given this, their presence in Titan's atmosphere can be considered as a nucleation agent, which triggers aerosol formation in Saturn's moon's low temperature atmosphere. However, since it is mainly composed of nitrogen, methane and a small amount of more complex hydrocarbons, understanding the way such PAHs are formed is mandatory [1].

Ionizing radiation sources (photons, electrons and ions) can trigger gas-phase polymerization, ion-molecule reactions and nanoparticle grain surfaces catalysis. These processes contribute to the formation of complex organic synthesis pathways in atmosphere and space. Simple ionization may induce chemical reactions and isomerization processes.

To understand them, simple linear hydrocarbons like butadiene (a non-aromatic molecule) have been chosen to study the formation of more complex cyclic species (aromatic). The irradiation of hydrocarbons clusters has been performed using different radiation sources (electrons, UV photons and ions) (Fig.1). This allowed the de-

*E-mail: suvasthika.indrajith@ganil.fr

†E-mail: jaroslav.kocisek@jh-inst.cas.cz

termination of the balance between ionization induced reactivity and collision induced one. The latter is the typical collision occurring in Titan's atmosphere involving slow and heavy ions (few keV O cations). It has been shown that this triggers reactivity, as observed in C₆₀ clusters [2] or PAH ones [3]. These experiments were performed at ARIBE, the low energy ion beam facility of GANIL in Caen and in J. Heyrovský Institute of Physical Chemistry in Prague.

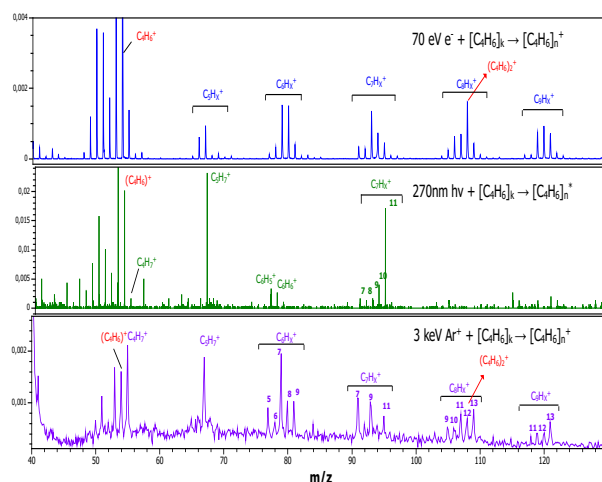


Figure 1. Mass spectra of butadiene clusters in collision with electrons, photons and ions showing growth products between the monomer and the dimer.

References

- [1] Long Z *et al* 2018 *Nature Astronomy* **2** 973
- [2] Delaunay R *et al* 2018 *Carbon* **129** 766
- [3] Delaunay R *et al* 2015 *J. Phys. Chem. Lett.* **6** 1536

