Reactions Involving Nitrile Anions in the Interstellar Medium: the CRESU Laboratory Apparatus Updates

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Résumé

Almost 30 nitrile molecules, which contain the cyano group (C°N), have been detected in the InterStellar Medium (ISM) so far. Three out of the six negative ions detected in the ISM, C4H, C6H, C8H, CN, C3N, and C5N[1-7] belong to this family. The most prolific source of anions discovered to date is the envelope around the carbon-rich evolved star IRC +10216. This object is the only source where all six anions have been identified, even though anions are also observed in prestellar and protostellar clouds, mostly C6H, the most readily observed anion. Chemical arguments led various authors to suggest that anions may be present in interstellar clouds with abundances high enough to allow their detection[8-10], but few astronomical searches were carried out to try to confirm these suggestions, awaiting relevant laboratory data and highly sensitive instruments.
However usually less abundant than neutrals, negative ions should play a key role in the physics and chemistry of the ISM, especially for the formation of complex nitriles as it was shown recently in some models including reactions involving nitrile anions[8-10]. From a chemical viewpoint, anions are involved in a variety of processes, many of them extremely fast ranging from radiative attachment (A + e– → A + hn), dissociative attachment (AB + e– → A + B), and their corresponding destruction mechanisms, i.e. photo-detachment (A + hn → A + e–) and associative detachment (A + B → AB + e–) respectively but also anion-neutral reactions (A + B → C + D) and ion-ion recombination (A + B+ → A + B)[11]. Associative detachment, which has no counterpart in positive ion reactions, may constitute an efficient and unique chemical bimolecular pathway towards heavier species. To reproduce the observed abundances of the various molecular species in the ISM, the complexity of recent models is increasing, using kinetic rate coefficients and branching ratios as input parameters. However, the temperature dependence prediction of these data continue to be a challenge and less than ten laboratory experimental studies have investigated the temperature dependence of the rate coefficients of reactions involving anion reactants below 200 K.

The cyanoacetylene HC3N, the cyanide anion CN and the cyanoethynyl anion C3N have been detected in various astrophysical environments, and in particular in IRC+10216[2, 12]. Reactions between anions and abundant heavy molecular species are likely to contribute to the growth of molecular anions, through associative detachment or with a lesser efficiency

*Intervenant

through proton exchange[13]. Recently, the temperature dependence of the rate constant k for the HC3N + CN reaction has been studied between 49 and 294 K with the CRESU method. This study concluded to a slight dependence of k versus temperature and the main observed exit channel was the proton transfer corresponding to the C3N anion formation. We present here the results for the HC3N + CN reaction between 49 and 294 K with the same method and the CRESU set-up future updates which allow us to measure the temperature dependence of the rate coefficient and branching ratio for reactions involving various anions.

References

M. Agundez, J. Cernicharo, M. Guélin, C. Kahane, E. Roueff, J. Klos, F.J. Aoiz, F. Lique, N. Marcelino, J.R. Goicoechea, M. Gonzalez Garcia, C.A. Gottlieb, M.C. McCarthy, P. Thaddeus, Astron. Astrophys., 517 (2010) L2.

P. Thaddeus, C.A. Gottlieb, H. Gupta, S. Brunken, M.C. McCarthy, M. Agundez, M. Guelin, J. Cernicharo, Astrophys. J., 677 (2008) 1132-1139.