Experimental astrochemistry: from ground-based to space-borne laboratories (Foreword)

Michaël De Becker[1,2]*, Hervé Cottin[3,4], Karl Fleury-Frenette[2,5], Serge Habraken[1,2]

[1] Department of Astrophysics, Geophysics & Oceanography, University of Liège, 17 allée du 6 Août, 4000 Liège (Sart-Tilman), Belgium

[2] Liège Space Research Institute (LiSRI), University of Liège, Belgium

[3] Laboratoire Interuniversitaire des Systèmes Atmosphériques, LISA, UMR CNRS 7583, Université Paris Est Créteil, France

[4]Université Paris Diderot, Institut Pierre Simon Laplace, 61 Avenue du Général De Gaulle, 94010 Créteil Cedex, France

[5] Centre Spatial de Liège, University of Liège, Liège Science Park, avenue du Pré Aily, 4031 Angleur, Belgium

Abstract: The investigation of the origin and evolution of molecules in space environments, either in interstellar or interplanetary conditions, constitutes a topic of high importance in modern space sciences. The presence of diversified and complex molecules motivates astrochemists to explore their formation mechanisms along with the physical conditions ruling these physico-chemical processes. Beside theoretical approaches aiming at simulating these processes, experimental techniques are nowadays frequently applied. Both laboratory and space experiment projects allow to reproduce to some extent the adequate conditions to understand some of these processes. The most recent results based on these techniques, and the prospects for future investigations, including the use of space platforms, were the scientific motivation of this workshop. These proceedings summarize a part of the content of this workshop, including abundant references to the relevant bibliography.

1 Scientific context

With the advent of new techniques, it is now possible to make significant progress in the study of molecules of astrochemical interest. Astrochemistry entered an era allowing for studies of physico-chemical processes in conditions reproducing space environments in laboratories, or even to exploit space platforms to investigate such processes in space conditions.

In this context, it was decided in the framework of the working group on "Studies of physico-chemical processes in space conditions", harbored by the "Liège Space Research Institute (LiSRI)", to organize this workshop. The aim was to stimulate meetings and discussions between various actors

*debecker@astro.ulg.ac.be

in the field of experimental astrochemistry. A total of 21 participants were present, coming from Belgium, France, Italy, The Netherlands and Spain. Fifteen contributions were presented (most of them oral). Details on the workshop, including the programme and the abstract booklet, can be found at the following address: http://www.astro.ulg.ac.be/∼debecker/ExAc/.

This workshop aimed at stimulating discussions in the context of experimental astrochemistry, involving both ground-based and space-borne equipments. It addressed notably the following topics:

- the impact of UV and X-ray photons on molecules of astrochemical interest,
- the influence of cosmic rays on molecules in space,
- ground-based laboratories aimed at studying these effects,
- space-borne experiments dedicated to astrochemistry (in operation or in development),
- space platforms likely to harbor astrochemical experiments.

2 Brief summary

When considering experimental devices aiming at simulating space conditions for astrochemical purposes, one has to take into account the very important peculiar physical conditions that will influence molecular species, either in gas phase or in space solid matrices. Among the most valued components of the interstellar or interplanetary medium, one finds solid particles whose composition and size are intimately dependent on the environments considered. These solid particles constitute privileged centers of interest in astrochemistry. In particular, the importance of the carbonaceous component of these solid bodies is emphasized (Dartois et al. 2015).

The chemical material is significantly exposed to agents such as UV and X-ray photons, with an intensity that depends on the astrophysical environment. On the other hand, the energetic processing of molecules notably trapped in ices is considerably influenced by the bombardment of high energy charged particles (cosmic rays) whose origin deserves to be clarified to put astrochemical studies in their adequate astrophysical context (De Becker 2015).

The scientific content of this workshop included two main aspects:

- **Ground-based laboratories.** Modern techniques allow notably to investigate the effect of ultraviolet radiation and cosmic rays on the molecular content of interstellar/interplanetary ice analogs. These effects include the photoprocessing of the molecular material (Cruz-Díaz et al. 2015), or even the simultaneous influence of photons and high energy particles (Palumbo 2015). The thermal processing is also important while investigating the chemical evolution of ice analogs (Martín Doménech et al. 2015). The extensive use of high performance mass spectrometry techniques was also significantly discussed, notably in the context of the study of interstellar and cometary ice analogs (Abou Mrad et al. 2015).
- **Space-borne experiments.** The first results obtained by many projects such as AMINO-EXPOSE, UVolution, EXPOSE-E or OREOcube have been presented and discussed by several participants (see the abstract book on the Workshop web page, and Cottin et al. 2015). Intensive discussions on the use of Cube-sats allowed the participants to debate about the strengths and limitations of these small space platforms in the context of future experimental astrochemical studies.

Acknowledgements

The organizers would like to thank the University of Liège and the LiSRI for fundings related to this workshop. Sylvia Grandjean (AGO Department) and the staff at the Centre Spatial de Liège (CSL) are acknowledged for the logistical support. Finally, the organizers would like to thank Thierry Chantraine, CSL's Director General, for giving access to meeting rooms for this workshop.

Figure 1: The participants visiting the facilities at the Centre Spatial de Liège. In the background, from the left to the right: Pascale Ehrenfreund, Michel Viso, Thierry Chiavassa, Andreas Elsaesser, Hervé Cottin, Nathalie Carrasco, Maria Elisabetta Palumbo, Boris Segret, Emmanuel Dartois, Noël Grand, Euan Monaghan, Rafael Martín-Doménech, Fabien Stalport, Kafila Saiagh. In the foreground, from the left to the right: Michaël De Becker, Karl Fleury-Frenette, Vassilissa Vinogradoff, Serge Habraken.

References

Abou Mrad N., Vinogradoff V., Duverney F. et al., Bull. Soc. Roy. Liège, 84 , 21–32
Cottin H., Saiagh K., Nguyen D. et al. 2015, Bull. Soc. Roy. Liège, 84, 60–73
Cruz-Díaz G.A., Martín Doménech R. & Muñoz Caro G.M. 2015, Bull. Soc. Roy. Liège, 84, 42–52
Dartois E., Alata Y., Engrand C. et al. 2015, Bull. Soc. Roy. Liège, 84, 7–14
De Becker M. 2015, Bull. Soc. Roy. Liège, 84, 15–20
Martín Doménech R. & Muñoz Caro G.M. 2015, Bull. Soc. Roy. Liège, 84, 53–59
Palumbo M.E. 2015, Bull. Soc. Roy. Liège, 84, 33–41