PCCP
Dynamic Article Links View Online
Cite this: *Phys. Chem. Chem. Phys.*, 2011, **13**, 15747–15748
www.rsc.org/pccp

EDITORIAL

Low temperature spectroscopy and irradiation effects on Solar System ices – Kuiper belt objects as a case study

Ralf I. Kaiser,*[a] Weijun Zheng,[b] Yoshihiro Osamura[c] and Agnes H. H. Chang[d]

DOI: 10.1039/c1cp90129j

Since their discovery in 1992,[1] Kuiper Belt Objects (KBOs)—small planetary bodies beyond the orbit of Neptune and 'precursors' to short periodic comets[2]—have received considerable attention from the planetary sciences, astronomy, and physical chemistry community.[3,4] At the low temperatures of KBOs of 30–50 K, a chemical modification of their surface ices such as water, nitrogen, carbon monoxide, carbon dioxide, methanol, and possibly ammonia[5] is predominantly induced *via* non-equilibrium chemistry through ionizing radiation from solar wind particles, solar wind photons, and galactic cosmic ray (GCR) particles.[6,7] Laboratory experiments simulating the interactions of ionizing radiation with icy surfaces at ultralow temperatures offer a remarkable opportunity for understanding the chemical processing of primitive bodies and allow for an establishment of a 'chemical' time-line dating back to the origin of our Solar System. Since prebiotic molecules like amino acids and their precursors can be synthesized in these ices as well,[8] those studies also explore scenarios where in our Solar System astrobiologically important molecules might have been synthesized since the formation of the Solar System 4.6 billion years ago.

The symposium 'Kuiper Belt Objects – Laboratory Studies, Models, and Observations' at the Pacifichem 2010 in Honolulu, Hawaii, focussed on the interplay between laboratory spectroscopy, theoretical investigations, and fundamental laboratory studies on specific molecular processes, which lead to a chemical modification of KBO surfaces with the overall goal to extract generalized concepts on the chemical processing of KBO surfaces and related bodies in the outer Solar System. Four 'radiation' sources are considered ranging from high energy electrons and MeV nuclei (simulating GCR particles) *via* solar photons to thermal chemistry of open shell reactants like hydroxyl radicals and hydrogen atoms at low temperatures. In detail, Zheng *et al*. (DOI: 10.1039/c1cp20528e) demonstrated that an investigation of the chemistry of (suprathermal) oxygen atoms, formed in the decomposition of water molecules upon interaction with energetic electrons in the track of galactic cosmic ray particles (GCRs) yields vital laboratory data on the interacting of non-equilibrium species with water-rich KBO ices. Kim *et al*. (DOI: 10.1039/c1cp20658c) proposed that non-equilibrium effects of triplet carbon monoxide in nitrogen-rich ices lead to the formation of the diazirinone molecule (N_2CO), which was recently characterized for the very first time spectroscopically.[9] These results were amplified by Pilling *et al*.'s study (DOI: 10.1039/c1cp20592g) on the processing of water–carbon dioxide ices by heavy MeV particles of the galactic cosmic radiation field. Non-equilibrium effects are also induced *via* the photolysis of water-bearing ices as outlined by Kinugawa *et al*. (DOI: 10.1039/c1cp20595a) and Andersson *et al*. (DOI: 10.1039/c1cp21138b) utilizing sophisticated time-of-flight spectroscopy of the photofragments produced at 157 nm. Oba *et al*. (DOI: 10.1039/c1cp20596j), Hidaka *et al*. (DOI: 10.1039/c1cp20645a), and He *et al*. (DOI: 10.1039/c1cp21601e) showed nicely that reactions of hydroxyl radicals and hydrogen atoms can also result in a rich chemistry on KBO surfaces. Finally, Kayi *et al*. (DOI: 10.1039/c1cp20656g) demonstrated *via* electronic structure calculations that the astrobiologically relevant glycine amino acid is thermodynamically less stable by 31–37 kJ mol^{-1} compared to its methylcarbamic acid isomer thus raising questions of a possible photon-induced isomerization of both structures.

We hope that the timeliness of this topic in light of the currently operating *New Horizon Mission* (NASA) on its way to (ex-planet) Pluto and the Rosetta Mission (ESA) launched in 2004, which is currently on its route to comet 67P/Churyumov-Gerasimenko, triggers further laboratory, spectroscopy, and theoretical investigations on the stability and chemical processing of ices of Kuiper belt objects in the next decade.

[a] *Department of Chemistry, University of Hawaii at Manoa, 2545 McCarthy Mall, Honolulu, HI 96822-2275, USA. E-mail: ralfk@hawaii.edu*
[b] *State Key Laboratory of Molecular Reaction Dynamics, Institute of Chemistry, Chinese Academy of Sciences, No. 2, North 1st Street, ZhongGuanCun, Beijing 100190, P. R. China*
[c] *Kanagawa Institute of Technology, Atsugi 243-0292, Japan*
[d] *Department of Chemistry, National Dong Hua University, Hualien, 974, Taiwan*

References

1 J. Luu, B. G. Marsden, D. Jewitt, C. A. Trujillo, C. W. Hergenrother, J. Chen and W. B. Offutt, *Nature*, 1997, **387**, 573–575.
2 D. Jewitt, *Physics World*, 1999, **12**, 37–41.
3 W. Romanishin, S. C. Tegler, T. W. Rettig, G. Consolmagno and B. Botthof, *Proc. Natl. Acad. Sci. U. S. A.*, 2001, **98**, 11863–11866.
4 T. Owen, *Space Sci. Rev.*, 2008, **138**, 301–316.
5 A. Delsanti, F. Merlin, A. Guilbert-Lepoutre, J. Bauer, B. Yang and K. J. Meech, *Astron. Astrophys.*, 2010, **520**, A40.
6 R. I. Kaiser, *Chem. Rev.*, 2002, **102**, 1309–1358.
7 J. F. Cooper, E. R. Christian, J. D. Richardson and C. Wang, *Earth, Moon, Planets*, 2003, **92**, 261–277.
8 B. N. Khare, E. L. O. Bakes, D. Cruikshank and C. P. McKay, *Adv. Space Res.*, 2001, **27**, 299–307.
9 X. Zeng, H. Beckers, H. Willner and J. F. Stanton, *Angew. Chem., Int. Ed.*, 2011, **50**, 1–5.