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SEMINAR
Imaging Organic Molecules in Motions and Reactions

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Thursday 18 February
11.00am – 12 noon
Science Lecture Theatre S11, Building 25

Abstract

Some reactions of a molecule start from an encounter with other molecules accelerated by phonons, photons, or electrons. The rate of reactions is often discussed from kinetics of the system and dynamics of molecules where the experimental conditions such as pressure, concentration, temperature, and existence of catalysts affect the system. Classic approaches to characterize such behaviours are based on the analysis of thermodynamics, spectroscopy, or microscopy that deal with enormous amounts or assembly of molecules in order to gain enough signal/noise ratios. Scientists have dreamed of capturing the very moment of reactions when the molecules change their structures.

Although the recent development of aberration corrector has substantially improved the spatial resolution limit of transmission electron microscopy (TEM), the attainable resolution is practically determined by the tolerant dose especially for damage sensitive materials. This is indeed the major problem why the individual molecular imaging by TEM is intrinsically difficult to be realized with the real atomic scale.

Recently it has been demonstrated that the motional behaviours of single molecules can be characterized by TEM [1]-[5]. The motional analysis at atomic-level has a great potential to witness various chemical reactions. The bimolecular reactions of fullerene and metallo fullerene molecules in carbon nanotube were studied by TEM, proving that the atomic resolution imaging of chemical reaction is indeed possible with moderate experimental conditions [6]. The motion pictures of the dimerisation process revealed the specific orientations in which two molecules interacted, as well as how bond reorganization occurred after the initial contact of the two molecules. Studies on the concentration, the specimen temperature, the effect of catalyst and the accelerating voltage indicated that imaging the reactions can be achieved under a considerable variety of conditions.

References

[1] Liu, Z. *et al.* Phys. Rev. Lett. 96, 088304 (2006). [2] Koshino M. *et al.* Science 316, 853 (2007). [3] Koshino, M., *et al.* Nat. Nano. 3, 595 (2008). [4] Solin N. *et al.* Chem. Lett. 36, 1208 (2007). [5] Nakamura, E. *et al.* J. Am. Chem. Soc. 130, 7808 (2008). [6] Koshino, M., *et al.* Nat. Chem. **2**, 117, (2010).

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