

Basic molecular processes in fusion related problems

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Any direct relevance of molecules and their ions in magnetic fusion devices, with characteristic plasma temperatures in the 10-20 keV range, seems surprising at first sight. However, according to current knowledge and fusion power plant concepts, the outer part of magnetically confined thermonuclear burning plasmas has to be cooled down to low temperatures (1-10 eV), while the molecular and atomic neutral gas is maintained there at low pressures (a few, up to 10-20 Pa). The plasma state near highly exposed parts of the reactor vessel, the so called "divertor targets", is then controlled by a self-sustained, chemically rich cushion of neutral gas. This gas is mostly hydrogenic, but, depending on material choice of plasma facing components (PFC), also containing hydrides formed by plasma wall interactions. The hydrogenic component: H atoms, molecules, molecular ions and isotopomers interact with the divertor plasma, and provide a powerful friction force to the near sonic plasma flow. Access to most favorable near surface plasma conditions ("detached divertor plasmas"), appears to be actively controlled by this strong exchange between the gaseous and the plasma state of matter.

Experimental and computational fusion edge plasma studies have indeed been carried out extensively in the past decade, e.g. also for the ITER divertor design [1]. The status, in particular with respect to the low temperature molecular chemistry, and main consequences from related computational ITER divertor design, will be discussed.

The role of hydrides such as hydrocarbons, perhaps also beryllium hydrides, and their ions, in fusion reactors is different. Once produced by chemical surface erosion processes they are transported into the plasma, fragment there by electron or proton collisions. Molecular spectroscopy and plasma chemistry modelling aim at quantifying the chemical erosion rates, the pathways of radicals in the plasma and the final location of deposits of these (ultimately: tritium containing) hydrides. A hydrocarbon cross section database for fusion plasmas has been compiled [2]. The main reactor chamber in ITER will be made of beryllium (as it is the case already today in JET). The rate of formation of beryllium hydrides (BeH, BeH₂) at PFCs and their fragmentation pathways is subject of dedicated investigations, by basic molecular data studies, by using experimental linear plasma devices ("divertor simulators") and by experiments at JET.

References

- [1] A.K. Kukushkin, H.D. Pacher, V. Kotov *et al.*, Fusion Eng. and Design **86**, 2865 (2011)
- [2] D. Reiter, R.K. Janev, Contrib. Plasma Phys. **50**, 986 (2010)