Ammonia formation in N_2-seeded H-mode discharges on JET and ASDEX-Upgrade

A. Drenik[a], D. Alegre[b, c], S. Brezinsek[d], M. Cavedon[a], A. de Castro[c], T. Dittmar[d], I. Jepu[e], M. Köppen[d], U. Kruezi[e, i], T. Loarer[f], R. McDermott[a], A. Meigs[e], G. Meisl[a], M. Oberkofler[a], M. Panjan[g], E. Pawelec[h], R. A. Pitts[i], S. Potzel[a], G. Primc[g], T. Reichbauer[a], M. Resnik[g], V. Rohde[a], M. Seibt[a], G. De Temmerman[i], A. Widdowson[e], R. Zaplotnik[g], the ASDEX-Upgrade team*, the EUROfusion MST1 team** and the JET contributors***

[a]Max-Planck-Institut für Plasmaphysik, 85748 Garching b. München, Germany
[b]Departamento de Ingeniería Energética, UNED, C/ Juan del Rosal 12, 28040 Madrid, Spain.
[c]Laboratorio Nacional de Fusión, CIEMAT, Avda Complutense 40, 28040 Madrid, Spain
[d]Forschungszentrum Jülich GmbH, IEK - Plasmaphysik, 52425 Jülich, Germany
[e]Culham Centre for Fusion Energy, Abingdon, Oxon, OX14 3DB, United Kingdom
[f]CEA IRFM, EURATOM Assoc, F-13108 St Paul Les Durance, France
[g]Jožef Stefan Institute, Jamova 39, SI-1000 Ljubljana, Slovenia
[h]University of Opole, Institute of Physics, Oleska 48, Opole, Poland
[i]ITER Organization, Route de Vinon-sur-Verdon, CS 90 046, 13067 St Paul Lez Durance Cedex, France
**See the author list of "A. Kallenbach et al, 2017 Nucl. Fusion 57 102015"*
***See the author list "H. Meyer et al 2017 Nucl. Fusion 57 102014"*
****See the author list of "X. Litaudon et al 2017 Nucl. Fusion 57 102001"*
aleksander.drenik@ipp.mpg.de

Fusion devices with metallic plasma-facing components will require impurity seeding to reduce divertor heat loads to technologically feasible levels. In burning plasma discharges in ITER, ~70% of power entering the scrape-off layer will need to be dissipated in this way. Among the candidate impurities, experiments in present all-metal devices show that nitrogen (N) provides for the best plasma performance, notably as a result of efficient divertor compression. However, N-seeding leads to in-vessel ammonia formation. On ITER, where N is planned as a seeding gas option, the need to regenerate pumping cryopanels to high temperature to recover tritiated ammonia would have a significant impact on the machine duty cycle if the quantities were too high. In order to develop reliable estimates of ammonia production for ITER, data from present-day fusion devices are required. This paper presents the recent results of studies of its formation during N_2-seeded plasmas on ASDEX-Upgrade (AUG) and JET.

The experiments were performed as series of identically set-up N_2-seeded H-mode discharges. Constant seeding rates and heating powers were used to allow for a straightforward study of the evolution of the nitrogen inventory. Ammonia formation was detected with residual gas analysis (RGA) and divertor spectroscopy. The peak concentration of ammonia in the residual gas at AUG was found to be of the order of 1 % in the inner divertor. The amount of detected ammonia exhibited a pronounced build-up behaviour and legacy effects. Similar trends of radiated power, divertor temperature, confinement enhancement, as well as the core N density from charge-exchange spectroscopy confirm that the rate of ammonia formation is chiefly proportional to the density of N in the divertor plasma, and that the latter is strongly affected by the wall inventory. Spatially resolved residual gas analysis (at AUG) and divertor spectroscopy indicate higher concentrations of ammonia near recessed areas, which would suggest that a significant part of the net ammonia production occurs on areas not accessible to the plasma, via surface reactions between neutral N and H atoms.