Impact of ICRF heating on core impurity transport in NBI-heated LHD plasmas

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The impurity accumulation towards the plasma centre has become a severe concern in magnetic confinement fusion devices, especially in stellarators, because it can cause significant degradation of fusion reactor performance and lead to a radiative collapse of the discharges. Therefore, it is essential to develop an efficient way of controlling the number of impurities in the core plasma, especially removing the impurities from the core plasma. In LHD, we have demonstrated the mitigation of the core impurity accumulation in high-density NBI-heated plasmas by applying an additional electron cyclotron heating (ECH, $P_{\mathrm{ECH}} \sim 1.5$ MW at $f = 154$ GHz) [1, 2]. In this contribution, we report the impact of an additional ion cyclotron resonance frequency (ICRF) heating on the core impurity transport in NBI-heated LHD plasmas. Here, we have utilized the new type of TESPELs containing an inorganic compound [3] (in particular, lithium titanite (Li_2TiO_3: Z=3, 22 and 8), silicon hexaboride (SiB_6: Z=14, 5), sodium chloride (NaCl: Z = 11, 17), and calcium aluminate ($CaAl_2O_4$: Z = 20, 13 and 8)) for studying the behaviours of low- and mid/high-Z impurities simultaneously. Line emissions from the highly ionized impurities derived from the TESPEL were measured basically with EUV/VUV spectrometers. Further, the spatio-temporal behaviours of some of those impurities can be measured using a charge exchange spectroscopy (CXS) technique. The experiments have been performed in high-density (as line-averaged electron density of ~ 5 x 10^{19} m^{-3}) NBI-heated plasmas, where the impurity accumulation has been observed. When the ICRF heating ($P_{\mathrm{ICRF}} \sim$ 3 MW at $f = 38.47$ MHz) was applied just after the TESPEL (tracer impurity) injection, the decay times of the intensities of line emissions from the tracer impurity ions became shorter, compared to the cases without the ICRF heating. However, after the ICRF heating was switched off, the intensities of line emissions from the tracer impurity ions were slightly recovered. This result indicates that ICRF power of more than 3 MW is needed to mitigate core impurity accumulation completely in the high-density NBI-heated LHD plasmas.

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