N, O and $N_2(A)$ metastable densities in the afterglows of N_2 RF discharges with addition of O_2

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Afterglows of N_2 RF flowing discharges with addition of small quantities (0.01-1%) of O_2 in the discharge are characterized by optical emission spectroscopy. The N and O atoms and the $N_2(A)$ metastable molecule densities are determined in early and late afterglows by NO titration for N –atoms and from the measurements of NO and N_2 emission band intensities for O and $N_2(A)$. The experimental set-up of the RF plasmas and afterglows is detailed in [1]. A quartz discharge tube of 6 mm i.d and 30 cm length is connected to a post-discharge quartz tube of 21 mm i.d and 100 cm length. The RF plasma is produced between two rings separated by 2 cm. In conditions of N_2 flow rate Q=1 Slm , pressure p=8 Torr and incident power of 100 Watt, it is observed an early afterglow at the beginning of the downstream 21 mm tube and then a late afterglow [1].
The N-atom density was determined by NO titration for mixtures containing up to 1% O_2. Nearly the same density was obtained in the two afterglows up to 0.1% O_2, of the order of 10^{15}cm^{-3}, slightly higher in the early than in the late afterglow up to, but with a more marked decrease to 3×10^{14}cm^{-3} between 0.1 and 1% O_2. The O-atom density is determined by comparing the NO_β (320 nm) and N_2 (580 nm) bands intensities. It increases with O_2, and can be higher in the late afterglow. For example at 0.2% O_2 into N_2 it reaches 10^{14} cm^{-3} in the early and 3×10^{14}cm^{-3} in the late afterglows. The $N_2(A)$ metastable molecules densities have been determined from the N_2(316 nm) and NO_β(320 nm) intensity ratio. In the early afterglow, the $N_2(A)$ density decreased from 8 to 2×10^{11} cm^{-3} when O_2 increased up to 1%. In the late afterglow it has values of the order of 10^{11} cm^{-3}.
The results are analyzed and interpreted with the help of a self-consistent kinetic model describing the discharge and the afterglow [2,3]. The simulation results are in good quantitative agreement with the experimentally deduced values. The transition from a "mixed" pink afterglow, where vibrationally excited molecules are significantly involved in the formation of several excited state, to the late afterglow, where the dominant role is played by 3-body N atom recombination, is well described, both experimentally and theoretically. It is further shown that the destruction of vibrationally excited molecules by O atoms, in V-T collisions and/or in the NO formation reaction $N_2(X,v\geq13)+O\rightarrow NO+N$, has an important role in the detailed kinetics of the early afterglow. The comparison of the experimentally deduced values using different line ratios provides an estimation of the rate coefficient of this reaction at room temperature.

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