126d Charge Transfer Reactions Have a Negligible Contribution on Nox Conversion in Nonthermal Plasma Reactor

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Nonthermal pulsed corona discharge plasmas in co-axial wire-cylinder reactors have been extensively investigated and used for conversion of nitrogen oxides (NO_x). When the wire electrode is positively charged, induced plasma channels (positive streamers) propagate from the wire anode to the cylinder cathode. The energetic electrons in the streamer formed during the electric pulse can excite background gas molecules and produce chemically active species, including metastable excited states, radicals, and cations. Studies on the formation of chemically reactive species and their reaction pathways are essential for optimizing nonthermal plasma processing for practical applications.

The contribution of cations to NO_x conversion through charge transfer reactions has been the subject of much debate. However, there is no direct experimental evidence to preclude the contribution of cations to NO_x conversion through charge transfer reactions. In our recent investigations on NO_x conversion in N_2 and Ar, we found that inclusion of charge transfer reactions of N_2^+ and Ar^+ cannot explain the reaction mechanism of NO_x conversion and the effect of CO on NO_x conversion in N_2 and Ar, respectively.

This work shows that the contribution of charge transfer reactions to NO_x conversion in the nonthermal plasma is negligible through the detailed analysis of optical emission spectra induced by pulsed corona discharge in UHP argon, 290 ppm N_2O in argon, 566 ppm NO in argon, and 408 ppm N_2O in nitrogen. In these gas mixtures, if cations like Ar^+ and N_2^+ were responsible for NO_x conversion, they would react with NO_x through charge transfer reactions to form positive ions, such as N_2O^+ and NO_2^+. The N_2O^+ and NO_2^+ produced would then be destroyed through dissociative recombination reactions with electrons, which would be observed by optical emission from an excited NO molecular electronic state, NO(B). However, optical emission of NO(B) is not observed. The reasons that charge transfer reactions are not important in nonthermal plasma are analyzed and explained by the reaction mechanism in the streamer discharge. A previously developed lumped kinetic model is used to investigate NO_x conversion and the effect of CO on NO_x conversion. All experimental data on NO_x conversion and the effect of CO on NO_x conversion in Ar can be adequately modeled without inclusion of charge transfer reactions.