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High efficiency NOx synthesis and regulation using dielectric barrier discharge in the needle array packed bed reactor

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Nitrogen, existing in amino acids, chlorophyll, and nucleic acid, is the necessary component of living organisms. Above 99% of the nitrogen is present in the atmosphere as N_2 which has the stable N≡N structure and electron configuration. As a result, the nitrogen fixation process is essential to use N_2 reasonably. Considering the grim situation of world growing population and greenhouse gas emission, the plasma has been considered as a promising technology to develop nitrogen fixation effectively.

In this paper, a needle array packed bed reactor excited by nanosecond pulse voltage is employed to synthesize NO_x efficiently with α-Al_2O_3 and γ-Al_2O_3 packed materials. The pulse width, pulse rising time, pulse repetition rate, and oxygen content are adjusted to regulate the NO_x synthesis results, such as NOx concentration, product selectivity, and energy cost. The discharge power, key reactive species, and the rate coefficient are calculated to provide clear insight into the NOx synthesis pathways. It is found that the NOx can be synthesized efficiently in this needle-tubes array packed bed reactor, the highest NO_x concentration of 1.12% and 0.97% are obtained in unfilled reactor and γ-Al_2O_3 packed bed reactor, respectively, which are nearly two times higher than the results reported in previous works under the same energy cost and the same type of discharge. In addition, increasing pulse width and pulse repetition rate can significantly enhance the NO_x concentrations because of the increased energy input and rate coefficient.

References

[1] D. Z. Yang *et al*, J. Environ. Chem. Eng. **13** 115887 (2025).