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NITROGEN FIXATION AS NO_X ENABLED BY A THREE-LEVEL COUPLED ROTATING ELECTRODES AIR PLASMA COMBINED WITH NANO-SIZED TIO_2

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A novel three-level coupled rotating electrodes air plasma with nano-sized TiO_2 photocatalysts is developed for evaluation of nitrogen fixation. Factors influencing NO_x concentration and energy cost, including gas flow rates, N_2 fractions, relative humidity levels, blade numbers at each rotating electrode and rotating speed, are examined. Gas flow rates prove to have no effect on the rotational temperature of N_2 337.1 nm and the emission intensities of N_2^+ and N_2, but specific energy input (SEI) and species' residence time can be shorter with higher air flow rates, resulting in lower NO_x concentration and energy cost. The addition of H_2O also has a positive effect on both NO_x concentration and energy cost. Optical emission spectrum (OES) shows that air + H_2O plasma has stronger 336 nm (NH) and 309 nm (OH) emission lines than air plasma, indicating that NH and OH are the key species in NO_x enhancement. Final results show that the exceptional synergistic effect between TiO_2 and three-level coupled rotating electrodes air plasma significantly increases the NO_x concentration by 68.32% (from 4952 to 8335 ppm) and reduces the energy cost by 40.55% (from 2.91 to 1.73 MJ mol^{-1}) at gas flow rate of 12 l min^{-1} and relative humidity level of 12%, which beats the ideal thermodynamic energy limit $\sim$2.5 MJ mol^{-1} for the thermal gas-phase process. A possible mechanism for enhanced NO_x production with TiO_2 is discussed: Highly energetic electrons in plasma contribute to the formations of the electron–hole pairs and oxygen vacancy (V_o) on the TiO_2 catalyst surface, which may facilitate the dissociative adsorption of O_2 molecules to form superoxide radical groups (like O_2^-) and H_2O molecules to form surface hydroxyl groups (like OH·), and thus, improving energy efficiency.