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Atmospheric Pressure Air Plasma for Efficient Degradation of Aging-related Body Odors

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Trans-2-Nonenal(T2N), one of the main components responsible for "old person smell," is an endogenous volatile organic compound formed by the oxidation of ω-7 unsaturated fatty acids on the human skin surface. [1] It tends to accumulate more readily in enclosed environments, such as space stations, nuclear submarines, and nursing homes. Studies have shown that T2N can trigger stress responses, increase skin conductance, and activate the sympathetic nervous system. It also exhibits cytotoxicity, posing potential health risks to the skin. At low concentrations, it may cause throat irritation, breathing difficulties, eye inflammation, and chest tightness; at higher concentrations, it can lead to acute toxicity, and long-term exposure may result in nasal tumors and damage to the respiratory tract, ocular mucosa, and skin tissues. [2]

In this study, plasma-catalytic technology was employed for the degradation of T2N, achieving significant removal efficiency. As shown in Figure 1, the degradation efficiency of T2N by pulsed dielectric barrier discharge plasma increased significantly with both applied voltage and treatment time. Under an 8 kV discharge, extending the treatment time from 3 to 10 mins raised the degradation rate from 43% to 99.9%. When the treatment time was fixed at 5 mins, increasing the voltage from 6 to 12 kV improved the degradation efficiency from 47% to nearly complete removal. This positive correlation is primarily attributed to the increase in discharge current peaks and instantaneous power at higher voltages, as well as enhanced multi-channel discharge activation, which collectively intensified the excitation and dissociation reactions of reactive species in the plasma. Furthermore, as shown in Figure 2, the mass degradation per unit energy exhibited a "volcano-shaped" trend. At low voltages, unstable discharges led to large fluctuations in degradation efficiency, while at high voltages, ohmic losses increased significantly, reducing energy utilization efficiency.

MOF-808(Zr), with its excellent porous structure, efficiently adsorbs T2N molecules, intermediate organic byproducts, and active components such as ozone. This adsorption effect not only prolongs the residence time of pollutants in the reactor but also promotes reactions of active species on the MOFs surface, significantly enhancing catalytic degradation efficiency. Experiments demonstrated that the synergistic use of MOF-808 and plasma achieved over 90% degradation of T2N within 2 mins and showed good cycling stability, maintaining superior performance even after six reuse cycles compared to plasma alone. These findings highlight its potential application in indoor air purification.

References

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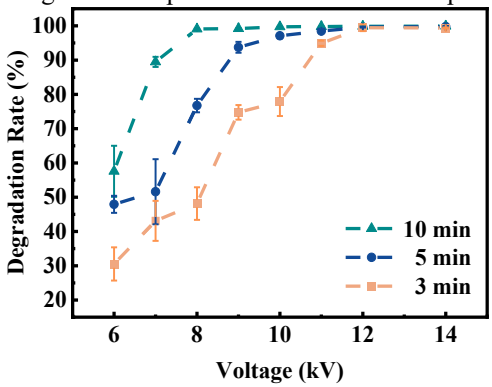

Figure 1. Degradation profiles under various voltages and degradation durations.

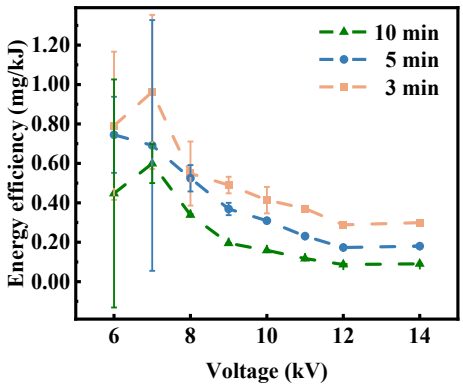

Figure 2. Energy efficiency profiles under various voltages and degradation durations.