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Study on the Emission Characteristics and Control Strategies of Dioxins during Municipal Solid Waste Pyrolysis

With the rapid expansion of urbanization, the generation of municipal solid waste (MSW) has been steadily increasing, posing serious environmental and resource management challenges. Pyrolysis technology, which converts organic fractions of MSW into valuable products such as syngas, bio-oil, and char, has gained attention as a promising approach for waste-to-energy conversion. Compared to conventional incineration, pyrolysis offers advantages such as lower energy consumption and fewer secondary pollutants. However, under high-temperature conditions, the formation of toxic and persistent dioxins—notably polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs)—remains a significant environmental concern.

Dioxins can be generated during the cooling of pyrolysis gases and in the solid residues, with their formation influenced by multiple factors such as feedstock composition, pyrolysis temperature, heating rate, gas atmosphere, and reactor configuration. Due to the multiphase and heterogeneous nature of pyrolysis reactions, the mechanisms of dioxin formation are highly complex and nonlinear, making it challenging to predict emissions and develop effective control strategies. A thorough understanding of the emission behavior and pathways of PCDD/Fs is therefore essential to ensure the environmental safety and sustainability of MSW pyrolysis systems.

This study focuses on the emission characteristics and control mechanisms of dioxins during the pyrolysis of municipal solid waste. Controlled pyrolysis experiments and real-time emission monitoring are conducted to quantify the impact of process parameters—such as temperature, chlorine content of the feedstock, and catalyst addition—on dioxin formation and speciation. Gas chromatography–mass spectrometry (GC-MS) and other advanced analytical techniques are used to investigate the transformation pathways of dioxin precursors and to identify key influencing factors.

Based on the findings, multi-level control strategies are proposed, including process optimization, catalytic inhibition, and end-of-pipe treatment technologies. The outcomes of this research are expected to provide theoretical insights and technical guidance for controlling persistent organic pollutants in waste pyrolysis systems, thereby supporting the development of cleaner, low-emission, and resource-efficient urban waste treatment solutions.