

Doctoral Defense

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TRANSPORT AND REACTION OF PHOTOCATALYTIC OXIDATION OF VOCs.

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Abstract

The purpose of this work was to measure the effect of transport conditions on the photocatalytic oxidation (PCO) of volatile organic compounds (VOCs) at a relatively large scale, imitating a real indoor environment, and to make clear the relationship between the reaction and transport of PCO processes for VOCs found in indoor environments.

A relatively large-scale experimental system using the oscillating grid technique to generate turbulence at different levels was developed to determine primarily the effect of transport conditions on the effectiveness of TiO₂ to oxidize and thus remove VOCs from the test chamber. Acetone was used as the VOC contaminant. The experimental results showed that the reaction rates remained almost unchanged even when the transport rates were varied from nominally still air to turbulent conditions. This means that the reaction rate is always the controlling factor for the PCO of VOCs.

Further analysis based on the diffusion-reaction modulus $\phi = kL^2/D$, where k is the reaction rate constant, L the transport length scale, and D the diffusivity, was conducted under three flow conditions: infinite molecular diffusion space, turbulent diffusion and diffusion in honeycomb reactors. The results indicated that the reaction rate, not the transport rate, is always the controlling factor for the PCO processes of VOCs in real indoor environments.

A physics-based model is established to calculate the reaction rate of the PCO process. Different from a traditional chemical approach, this model includes many variables in the PCO process, such as UV light intensity, structure and properties of the thin film, temperature and OH* radical concentration, and can be applied to analyze the functions and the relations of these variable. The model results are validated with our and others' experimental data. This physics-based model can be further developed to facilitate and direct future investigations of the PCO of TiO₂.