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Kinetics of the pollutant photocatalytic conversion in a Photo-CREC-Air Reactor

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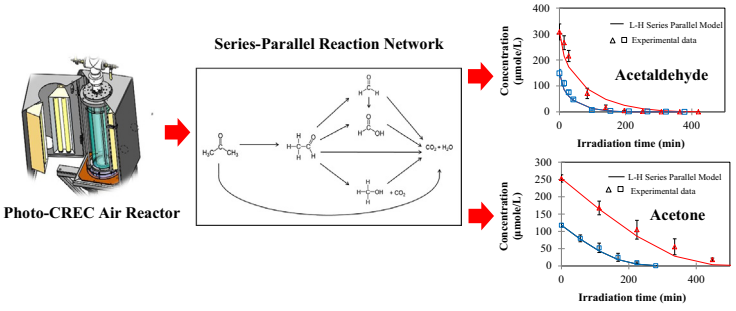
HIGHLIGHTS

- A kinetic model for VOC photodegradation in air using supported TiO_2 is developed.
- Adsorption and photoreaction are incorporated using a "series-parallel" network.
- Independent adsorption constants are calculated with equilibrium experiments.
- The kinetics is simplified in order to avoid over-parameterization.
- The proposed kinetics is in agreement with a photon density distribution on TiO_2.

GRAPHICAL ABSTRACT



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ABSTRACT

This research reports the kinetic studies for acetone and acetaldehyde photoconversion in the gas phase utilizing a scaled-up Photo-CREC-Air unit with TiO_2. The inclusion of intermediate species in the reaction network is required for the kinetic modeling of a wide range of oxygenate pollutant concentrations. The proposed "in parallel-series" reaction network encompasses a Langmuir-Hinshelwood (L-H) kinetics including species adsorption and intrinsic reaction parameters. The estimated kinetic parameters provide a successful prediction of various measurable chemical species. It is shown that the proposed kinetic model can be simplified, under low initial model pollutant concentrations. This is critical to avoid model overparameterization. The proposed kinetic model while being restricted to two model pollutants (acetone and acetaldehyde) and one specific photoreactor (e.g. 55.1 L Photo-CREC-Air), provides a framework to establish the photodegradation kinetics of other organic species in air, for larger photoreactor scales.

1. Introduction

Heterogeneous photocatalysis is an efficient technique for Volatile Organic Compound (VOC) removal from air. The commercial application of this technique, among other factors, depends on the photocatalytic performance of the photoreactor and photocatalyst. Photoreaction rates, adsorption constants, and reaction kinetic constants are key kinetic parameters to be established in order to evaluate the performance of photocatalytic units [1,2].

Abbreviations: AAS-ACM, Air Assisted Spray – Automatized Coating Method; CREC, Chemical Reaction Engineering Centre; L-H, Langmuir-Hinshelwood; PCO, photocatalytic oxidation; PTEF, photochemical thermodynamic efficiency factor; UV, ultra violet; VOC, Volatile Organic Compound.

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