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Modeling and analysis of ozone absorption and reaction kinetics in the oxidation of organics in effluents in a stirred tank reactor

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Abstract

The presence of high molecular weight organic compounds such as dyes, pharmaceuticals, and endocrine disruptors in receiving waters is of concern due to their toxicity and carcinogenicity to humans and aquatic organisms. Ozone is a powerful oxidant that can be used to oxidize such compounds in effluents. However, the use of ozone in these applications is somewhat limited at present due to the relatively high cost of ozone and ozonation systems. This is in part due to mass transfer limitations, and the lack of understanding of fundamental factors that contribute to poor utilization of applied ozone. Previous studies have concluded that mass transfer of ozone form the gas to the liquid phase is the main rate limiting step in ozonation. However, with high molecular weight compounds, the diffusion and transport of the compound to the reaction plane, the production of byproducts and secondary reactions, can also influence the overall oxidation kinetics. In this study, the mass transfer and reaction kinetics regimes are modeled based on fundamental principles and applied to analyze the oxidation of a high molecular weight dye in a stirred tank reactor with a bubble diffuser. The oxidation kinetics model for the dye is based on the consideration of two parallel reactions in the reactor. The first step involves a fast decomposition reaction that results in the production of primary products. In the second step, the primary products react further with ozone at a slower rate to produce secondary end products. Depending on the relative rates of reaction and mass transfer, the gas-liquid reactions can occur in the liquid film, the bulk liquid, or a combination of both. The decolorization reaction is moderately fast, and is assumed to occur in the film and the bulk liquid. The second reaction is slow, and is assumed to occur in the bulk liquid only. This paper will present model development, model verification with experimental data, and sensitivity analyses to optimize the performance of stirred tank ozonation systems.

Biography

Dr. A.P. Mathews obtained his PhD degree from the University of Michigan, and is currently a Professor of Civil Engineering at Kansas State University in Manhattan, Kansas.