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Photo-Fenton Solar Reactors: Fundamentals and Environmental Applications

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The homogeneous Fenton reaction is a complex chemical system that involves hydrogen peroxide and dissolved iron salts to generate highly reactive hydroxyl radicals in acidic solution. It is also known that the degradation rate of the Fenton system is significantly enhanced when the mixture is irradiated with UV or UV/Visible radiation. This photo-assisted Fenton process, or photo-Fenton process, is probably one of the most widely applied Advanced Oxidation Processes for wastewater treatment in homogeneous phase at ambient temperature.

A proposal for modelling photo-Fenton reactors for water pollution remediation is presented. Reactor models, based on chemical reaction engineering principles and radiative energy transport fundamentals in homogeneous systems, are derived at both laboratory and solar pilot-plant scales.

The proposed methodology is illustrated by presenting an example on the modelling and scaling-up of a solar reactor for degradation of a model pollutant in aqueous solution: the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D). Firstly, in order to apply the photo-Fenton process at pH conditions close to neutrality, different sources of iron were studied: sulphate, oxalate and citrate complexes. The results were evaluated by means of photonic and quantum degradation efficiencies.

Afterwards, a kinetic model derived from a reaction sequence was proposed and its kinetic parameters estimated, using an isothermal, well-stirred tank laboratory photoreactor. For this purpose, a solar simulator was employed.

Finally, the validated kinetic model was utilized to predict the reacting species concentrations during the photo-Fenton degradation in a pilot-plant, nonisothermal solar reactor designed to capture the UV/Visible/IR solar radiation.

This approach has proved to be appropriate to simulate the behavior of the pilot-plant photo-Fenton reactor under different operating conditions.

Keywords: photo-Fenton, solar reactor, water remediation, herbicide.

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