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Decolouration of reactive dyes with ozone in a semi-batch and a continuous stirred tank reactor

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ABSTRACT

The aim of the thesis was to model and interpret the behaviour of ozone when utilised to decolourise reactive dye solutions in textile dyeing applications. The purpose of ozonating the dye solutions is to remove dyes from the waste streams produced in order to conserve the water and eliminate the impact associated with these industrial processes.

In order to explain the decolourisation process, ozonation experiments were conducted in a continuously stirred tank reactor (CSTR) and a semi-batch reactor (SBR). Experimental results at both steady state and unsteady state were obtained from both reactors.

Stoichiometry revealed that many dye molecules were decoloured per ozone molecule consumed (58 mole of dye solution per one mole ozone). This suggests that decolouration was taking place via a radical chain reaction. Different coloured dyes had different rates of decolouration. This implied the rates were not totally mass transfer controlled. It was found that the higher the initial dye concentration, the lower the rate of decolouration. This was an unexpected result when needed to be explained using the model. The effect of different gas-phase ozone concentrations appeared to be negligible.

For the SBR, there was a difference (what do you mean??) between the results of experiments. These occurred when the dye was added before the solution was pre-ozonated and when it was not. The former gave more consistent results and showed slightly higher initial rates. Because, for the CSTR, there are wide ranges of steady states as a function of residence time, the major benefit of using the CSTR rather than an SBR is that one can explore different regions of the reaction space. Thus, in doing modelling, one is in a position to assess the kinetic model against a wider variety of conditions.

A mathematical model was developed to describe the kinetic behaviour of the reactive dye degradation by ozone. The basis for the model took into account the phenomena observed as a consequence of exploring the implications of the experimental results described above. The model had three unknown constants and these were estimated by regressing on all the SBR data simultaneously. The fit between experimental and model data was found to be good. As a final verification of the model, it was used to predict the CSTR unsteady/steady-state data. Again, the fit was found to be good (R^2 =0.9897 Model versus experimental) thus suggesting the kinetic model captured all the important aspects of the

reaction kinetics. This model thus becomes potentially important for the design of future facilities for the degradation of a reactive dye by ozone.