Catalytic Wet Air Oxidation Of Azo-Dye Orange II: In Search Of An Efficient Catalyst

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Introduction

Catalytic wet air oxidation (CWAO) is an efficient treatment technique for wastewaters from various industries that contain toxic or refractory organic compounds. Effluents from the textile industry, specifically from dying processes, cause serious environmental problems, both in terms of treatment and aesthetic concerns because of their refractory nature, strong color and high COD concentrations. Textile dyes are intentionally designed to exhibit a high degree of chemical, photolytic, and microbial stability, as to fulfill the fastness requirements of consumers [1].

Orange II (also known as Acid Orange 7) is one of the dyes that are commonly used in the textile industry in large amounts in the United States. Choosing a stable, non-selective catalyst with high oxidation properties is essential to the success of a CWAO process. In this paper the selection of an efficient catalyst for the catalytic oxidation of Orange II will be discussed.

Materials and Methods

A stainless steel autoclave reactor with 1L volume operated in batch mode was utilized for this study. It was equipped with an impeller, temperature and pressure control units, gas introduction and vent lines, and a sampling port with a filter to filter out the catalyst and charred residue (if any) from collected samples. Reaction temperatures and pressures were held between 353-403 K and 1-20 atm respectively. Catalysts tested for this study were 35% CuO+65%ZnO, 5-15% CuO+85-95% Al_2O_3, 26% CuO+74% Cu Chromite, 10%Ba_2CO_3+<5%C+30-40% CuO+60-70% ZnO, and 8-15% Al_2O_3+1-5%C+35-45% CuO+40-50% ZnO.

Chemical Oxygen Demand (COD) and color reduction were used as an indicator for the efficiency of catalysts. For all laboratory experiments, reagent grade chemicals were utilized.

Results and Discussion

The mechanism of oxidation of Orange II might be very complicated, with many different intermediate products, and end-products formed. Therefore, lumped modeling will be utilized to determine the order of the reaction and the rate expression. The lumped responses in this study are COD and TOC.

The total decomposition rate for Orange II is expected to be first order with respect to carbon content:

$$-\frac{dC_c}{dt} = k\ C_c$$

Expected intermediates for the oxidation of Orange II are: benzenesulfonic acid, naphthol, 1,2-benzenedicarboxylic acid, 4-hydroxybenzenesulfonic acid, 2-hydroxymethylbenzoic acid, and 1,3-isobenzofurandione. Acetic acid is expected to be the dominant compound in the treated water, along with formic acid, lactic acid, and malic acid.

Significance

This study will help to identify a catalyst that effectively works for the oxidation of Orange II. If the selected catalyst proves to be efficient for the removal of Orange II, knowing the rate expression can be used to design reactors that can effectively be used for the treatment of Orange II containing wastewaters.

References

1. Arslan-Alaton, I., Ferry, J. *Dyes and Pigments* 54, 25-36 (2002).