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Degradation and mineralization of methylene blue by dielectric barrier discharge non-thermal plasma reactor

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HIGHLIGHTS

- Non-thermal plasma degradation and mineralization of methylene blue in water.
- Confirmation of mineralization by TOC and infrared gas analyzers.
- Improved performance with the addition of Fe^{+2} via Fenton type reaction.
- High energy efficiency for the dye removal (67 g/kW h).
- Confirmation of first order kinetics for the dye removal.

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ABSTRACT

Advanced oxidation process based on dielectric barrier discharge at the gas water interface was used for the oxidative decomposition of dye contaminated wastewater. The advantage of plasma treatment over conventional physical methods of pollutants removal is the mineralization of pollutant, whereas in physical methods, pollutants may be transferred from one form to another. The effect of various parameters like applied voltage, gas flow rate, concentrations of dye, addition of Na_2SO_4 and Fe^{2+}, formation of H_2O_2 and change in pH were investigated for methylene blue degradation. The high degradation yield up to 67 g/kW h was achieved during the present study. Hydrogen peroxide, a powerful oxidant formed during the reaction was confirmed and addition of Fe^{+2} improved the performance, possibly due to Fenton type reactions. It has been observed that dye degradation followed first order kinetics.

1. Introduction

The wastewater, especially from paper and textile industries is highly colored due to the presence of dyes and hazardous compounds. For treatment of water from these industries, various physico-chemical treatments, such as membrane filtration, ion exchange, activated carbon adsorptions have been proposed [1]. Thought on a large scale, many physico-chemical methods were tested for the treatment of wastewater from textile industry, in general, mineralization was not achieved. These methods may transfer the pollutant to another phase against the desired mineralization [2]. Bio-treatment of effluents containing organic dyes is not effective due to their resistance to aerobic degradation, whereas, in anaerobic degradation, carcinogenic aromatic amines may be formed as by-products [3]. In this context, advanced oxidation processes (AOPs) show specific advantages over conventional treatments like *in situ* generation of strong oxidants and may eliminate the problems associated with bio-resistant organic compounds [4].

Oxidation of pollutant in AOPs proceeds via generation of powerful and non-selective hydroxyl radicals that may oxidize majority of the organic pollutants present in the water body [4,5]. Hydroxyl radical has the higher oxidation potential (E_0: 2.8 V) and only next to fluorine (E_0: 3.06 V). The main advantage with AOPs is the ability to mineralize the organic pollutants to CO_2 and H_2O. Various advanced oxidation processes have been investigated for the degradation of organic pollutants in water [6]. These techniques generate strong oxygen-based oxidizers that are expected to mineralize the pollutants [7–9]. However, in many cases, mineralization is not achieved that impose secondary problems with partially oxygenated products; hence there is a need to develop suitable AOPs to reduce toxicity.

Non-thermal plasma (NTP) has been reported as an efficient technique for the removal of pollutants in air, but this technique was not applied until now for the removal of water pollutants on

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