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Degradation of Methylorange by Fenton Reagent

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Abstract:
Synthetic dyes play a significant role in various industries, including textiles, paper, food, leather, cosmetics, and pharmaceuticals, with azo dyes being the predominant category. However, their widespread use has led to a pressing environmental issue due to the release of these dyes into wastewater, posing concerns for public health. To address this problem, numerous advanced oxidation processes (AOPs) have been devised, among which Fenton oxidation has gained prominence for its ability to break down these dyes. This review compiles the most recent research findings on the photo-Fenton and electro-Fenton degradation of methylorange (MO).

Keywords: methylorange, photo-Fenton, electro-Fenton, degradation

1. INTRODUCTION

There is a range of physical, chemical, and biological techniques currently at our disposal for treating wastewater released by different industrial sectors. Among these methods, Fenton reactions have established themselves as a verified and economically viable process for the eradication of dyes in wastewater [1]. Methylorange, an azo dye employed in the printing, paper production, textile, pharmaceutical, and food sectors, gives rise to various health issues [2].

2. PHOTO-FENTON DEGRADATION

Numerous studies have explored the photocatalytic degradation of MO dye. For instance, researchers conducted the photodegradation of methylorange using an economical, locally-sourced natural clay as a photocatalyst, utilizing renewable solar irradiation [3]. The most favorable conditions for achieving enhanced degradation (93 %) were determined as follows: [clay] = 1 g/L, pH = 3, with the presence of [oxalic acid] = 10^{-2} M.

P. Mahamallik and A. Pal [4] studied the degradation of methylorange using a heterogeneous photo-Fenton approach, employing Co-SMA (Cobalt II - surfactant-modified alumina) as the catalyst, along with H_2O_2 and visible light. Under the most favorable circumstances, which involved 30 mg/L of MO, 29.92 g/L of Co-SMA, 37.9 mM of H_2O_2, and a pH of 4.31, the highest observed efficacy for MO decolorization reached 94.79 %.

A. M. Domacena and colleagues conducted a study to examine the impact of different additives on the structure and consequent photocatalytic performance of diverse hematite (α-Fe_2O_3) nanostructures [5]. They evaluated the photocatalytic effectiveness of α-Fe_2O_3 powders by decomposing methylorange under a UV-C lamp, employing hydrogen peroxide as an activator. The urchin-like hierarchical structures of α-Fe_2O_3 exhibited the most efficient photocatalytic behavior, achieving a 76.5 % reduction in the initial 2.5 ppm MO concentration after 2 hours of irradiation.

3. ELECTRO-FENTON DEGRADATION

A successful approach to treating aqueous solutions containing methyl orange dye involved electrochemical oxidation, employing the initiation of electro-Fenton reactions with two electrodes: carbon graphite and stainless steel [6]. Under the most favorable operating conditions, a remarkable maximum discoloration rate of 94.5 % was attained.

The degradation of the azo dye methylorange using a heterogeneous electro-Fenton process with a magnetic nano-Fe_3O_4 catalyst was investigated [7]. In a 90-minute electro-Fenton treatment, involving a 500 mL volume and an initial concentration of 50 mg L^{-1} MO solution, an impressive 86.6 % degradation was achieved with the inclusion of 1 g L^{-1} Fe_3O_4. This occurred under a current density of 10 mA cm^{-2} and at a pH of 3.

The effectiveness of a composite comprising reduced graphene oxide (rGO) supported by TiO_2 nanoparticles (TiO_2/rGO) was examined as an electro-Fenton catalyst in the degradation of methylorange [8]. At the cathode composed of TiO_2/rGO, the removal efficiencies for both MO and COD reached 98.40 % and 85.14 %, respectively, following 120 minutes of electrolysis.

4. CONCLUSIONS

The MO removal efficiencies obtained by the presented photo-Fenton processes were 93 %, 94.79 % and 76.5 %, respectively. The removal efficiencies obtained from the electro-Fenton processes were 94.5 %, 86.6 % and 98.4 %, respectively. From the present study, it can be observed that Fenton processes are effective methods for MO removal.

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