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Synergistic effects of Fe_2O_3 supported on dendritic fibrous SBA-15 for superior photocatalytic degradation of methylene blue

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ABSTRACT

Environmental pollution caused by dye effluent has attracted much attention, and thus developing photocatalysts with superior photodegradation performance is an imperative task. A series of Fe supported on dendritic fibrous SBA-15 (Fe/DFSBA-15) catalysts with various Fe contents were prepared using a microemulsion coupled with ultrasonic-assisted impregnation methods. The findings revealed that the structural stability of DFSBA-15 was unaffected by the amount of Fe loaded. As the Fe loading increased, the size of Fe_2O_3 nanocrystals increased while the catalysts' surface area decreased. The bandgap energy of the catalyst decreased with increasing Fe loading and became constant after reaching an optimal Fe loading of 10 wt%. The one-factor-at-a-time study revealed that 10Fe/DFSBA-15 degraded 94.72 % of methylene blue (MB) within 180 min at 1.5 g/L catalyst dosage, pH 8, and 10 mg/L of concentration, owing to Si-O-Fe coordination, modest Fe_2O_3 crystallite size, homogeneous metal distribution, slower recombination rate, and low bandgap energy. The advantageous features of 10Fe/DFSBA-15 resulted in accelerating the photodegradation rate, where 10Fe/DFSBA-15 is found as the optimal catalyst. The addition of Fe particles to the DFSBA-15 largely improved their photocatalytic activity toward MB degradation, making it a potential candidate for removing pollutants from aqueous solutions.

1. Introduction

Methylene blue (MB) is a heterocyclic aromatic compound and is generally used in many applications, including textiles, bio-pigments, cosmetics, pulp, and paper, owing to its inexpensive cost, water solubility, and good color ability [1,2]. However, MB effluent was reported to be ecologically hazardous, carcinogenic, discolored, and has a foul odor. Thus, it causes a significant danger to human health upon ingestion as it can harm the nerves, eyes, and respiratory system and reduce nausea, vomiting, diarrhea, and gastritis infections [3]. Additionally, MB reduces sunlight penetration and water oxygen levels, negatively impacting aquatic ecosystems' capacity to function, and presents an environmental risk to the marine ecosystem [4]. Therefore, it is essential to create cutting-edge plans to eliminate such dangerous pollutants from water sources. Among others, photocatalytic degradation has attracted significant consideration owing to its ecologically beneficial, high energy-saving, and sustainable technology [5,6]. Interestingly, the final product of the photocatalytic degradation reaction is carbon dioxide and hydrogen, with no secondary pollutants. Accordingly, the photocatalytic degradation approach is a safer and cleaner technology for green environmental management, minimizing negative environmental effects [7].

Silica structures are extensively studied as the photocatalyst's

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