Topic

Synthesis, characterization and application of Ce-doped Fe2O3 nanoparticle for the removal of methylene blue dye from aqueous solution

# Abstract

Methylene blue (MB) is a hazardous chemical that is widely found in wastewater, and its removal is critical. One of the most common methods to remove MB is adsorption.

# CHAPTER ONE

# INTRODUCTION

## BACKGROUND OF STUDY

The nanoparticle of Zinc oxide (ZnO) are one of the most studied material. Doping of the ZnO nanoparticle is one effective way to improve the properties for various applications. In particular, doping ZnO with transition metal is of interest in tailoring it’s optical properties(Daksh & Agrawal, 2016). Doping is an important approach for Fe2O3 modification. As one of rare earth metals, Cerium(Ce) has attracted much attention due to its outstanding advantages: 4f electron transition and abundant energy levels (Shen et al., 2021).

Dyes are considered one of the most problematic groups of pollutants because they can be easily identified by the human eyes once they are released to the water bodies but are not easily removed. Furthermore, most synthetic dyes are properly non-degradable even with sunlight (Mogharabi et al., 2012). Recently, there has been an increase in public awareness and concern regarding environmental pollution. Most organic chemicals and pathogens, which are present in aqueous waste effulents discharged from industrial or domestic sources, should essentially be treated or removed prior to the final discharge to the water courses. Hence, a promising treatment techniques is required to overcome such challenge for a safe disposal. Oxidation of such dyes from aqueous industrial discharges is considered a difficult technique since dyes show resistance to various oxidants, chemical, UV light and heat besides being non-biodegradable (Kargi & Ozmıhc, 2004), (Gupta et al., 2011), (Saleh & Gupta, 2012), (Tony et al., 2011).

Conventionally, various techniques were applied for wastewater treatment such as coagulation, reverse osmosis, biological treatment techniques and adsorption methods (Ashour et al., 2014; Tony et al., 2018), waters, which include photodecomposition (Kapdan & Kargi, 2002; Mulugeta & Belisti, 2014), electrolysis (Qingdong et al., 2017), adsorption (Ahmadi, Rahdar, et al., 2019; Ahmadi & Kord Mostafapoor, 2017), oxidation (Ahmadi et al., 2018; Ahmadi, Igwegbe, et al., 2019) and other processes. However, those methods are not widely recommended as they are expensive, transferring the pollutants phase, or they are not effective with high organic loads (Rahman et al., 2009; Tony & Mansour, 2019). Amongst the different physical and chemical processes, adsorption is an effective technique, which is successfully used for the removal of colors from wastewaters (Elnasri et al., 2013; Rahdar et al., 2018). The adsorption method is widely used due to its simplicity, low cost, and removal of color and other pollutants with great efficiency (Samadi et al., 2013). Adsorption can be either physisorption (which involves fairly weak intermolecular forces), or chemisorption (which involves basically the formation of a chemical bond between the sorbent molecule and the surface of the adsorbent (Karine, 2001). Activated carbons have been used successfully to remove organic and mineral pollutants (Han et al., 2006; Igwegbe et al., 2015) but they are hardly regenerated (Ahmadi & Kord Mostafapour, 2017). Nanoparticles are referred to as particles with a diameter of less than 100 nm (Igwegbe et al., 2018). Nanoparticles have been revealed to have a high potential in adsorbing organic compounds especially colors from wastewater and sewage tanks due to their high surface to volume ratio than other adsorbents (Rahdar, Igwegbe, et al., 2018).

Methylene blue dye-containing effluent from various industries such as textile, rubber, plastic, paper-making are established to be carinogenic and also create toxic effects on living organisms (Kumar et al., 2014). Methylene blue is a cation color with a complex aromatic structure, which is used for colouring cotton and silk (Srivastava, 2008). This compound can cause impaired respiration. Further, direct exposure to it causes permanent damage to human and animal eyes; it also local burns, nausea and vomiting, mental disorders, and Methemoglobinemia (Mulugeta & Belisti, 2014; Rafatullah et al., 2010).

In the present work Cerium-doped Fe2O3 nanoparticles with different concentration were prepaped with co-precipation method. Structural and adsorbing properties were studied for the prepared particles. Then Cerium-doped Fe2O3 nanoparticle were efficiently used to adsorbed organic dye Methylene blue. These organic dye are released in to water streams by textile, food, printing industries etc. The dye polluted water is harmful for aquatic life and is carcinogenic to human beings (Phuruangrat et al., 2018).



* 1. AIM AND OBJECTIVES

### 1.2.1 AIM OF STUDY

The aim and objective of this work is the investigation of the effectiveness of Ce-doped ZnO Nanoparticle on the removal of Methylene from aqueous solution and the applicability of Linear adsorption isotherm and Kinetic models on the process.

1.2.2 Specific objectives of Study

The specific objective of this work includes:

1. To synthesis and characterize the Ce-doped Fe2O3 nanoparticle by varoius technique such as X-ray diffraction (XRD), Ultra Violet Spectroscopy and Fourier Transform infrared Spectroscopy (FTIR).
2. Evaluate the effectiveness of Ce-doped Fe2O3 nanoparticles in removing methylene blue dye through adsorption experiments. This includes determining the removal efficiency at different initial dye concentrations and contact times and utilize UV-Vis spectroscopy to quantify the amount of methylene blue adsorbed onto the nanoparticles.
3. Investigate the influence of experimental parameters such as initial methylene blue concentration and contact time on the adsorption capacity of the Ce-doped Fe2O3 nanoparticles.
4. Applying linear adsorption isotherms (e.g., Langmuir, Freundlich) to understand the interaction between the dye and the nanoparticles.
5. Based on the findings, propose potential areas for future research to further explore and improve the Ce-doped Fe2O3 nanoparticle system for methylene blue removal or its application for the removal of other pollutants.
   1. JUSTIFICATION AND SIGNIFICANCE OF THE STUDY

# CHAPTER TWO

# Literature review

## 2.1 Adsorption

## 2.2 Factor Affecting Adsorption Capacity

## 2.3 Kinetic Model

## 2.4 Adsorption Isotherm

## 2.5 Adsorption Thermodynamics

# Chapter three

## 3.1 Material and Reagent used

## 3.2 Apparatus and Equipment

## 3.3 Chemicals

## 3.4 Synthesis of Cerium doped Iron (Fe2O3) Nanoparticle