VIETNAM NATIONAL UNIVERSITY – HCMC
**HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY**

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# DISSERTATION INFORMATION

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| Thesis title: | Research on the treatment of persistent biodegradable wastewater using Electro-Fenton technology with $Fe_3O_4/Mn_3O_4$ as a catalyst |
| Major: | Environmental engineering |
| Major code: | 62520320 |
| PhD Student: | Nguyen Duc Dat Duc |
| Advisors: | Assoc. Prof. Dr. Nguyen Tan Phong |
| University: | Ho Chi Minh City University of Technology, VNU - HCMC |

**Major Contributions of This Dissertation:**

$Fe_3O_4/Mn_3O_4$ serves as a promising catalyst for the heterogeneous Fenton process. Its catalytic activity surpasses that of many other materials, such as $Fe_3O_4$ or $Mn_3O_4$. Furthermore, this material boasts durability and strong magnetism, enabling quickly separation from water and reusability's abilities.

Within this thesis, $Fe_3O_4/Mn_3O_4$ is employed as a catalyst for the Electro-Fenton process, targeting the treatment of three varieties of non-biodegradable wastewater: textile wastewater, instant coffee wastewater, and pesticide wastewater. The primary objective is to enhance treatment efficiency, minimize the usage of chemicals, reduce sludge production, facilitate catalyst reusability, and streamline operations.

The research on treating textile dyeing wastewater using this model has identified the following optimal treatment conditions: pH of 3.8, catalyst dosage of 1.1 g/l, a catalyst loading of 1.96 kg/kg COD, current density of 17.0 $mA/cm^2$, electrode distance of 4 cm, air sparging rate of 0.5 liters per minute, duration time of 90 minutes with the utilization of graphite electrodes. The optimal treatment efficiencies for COD and color under these conditions are 93.2% and 99.6%, respectively, resulting in COD concentration of 56 mg/l and color of 16.0 Pt – Co, meeting the QCVN 40:2011/BTNMT standard (column A).

For the treatment of instant coffee wastewater, the optimal operational parameters for this technology are as follows: pH of 3.7, catalyst dosage of 0.5 g/l, a catalyst loading of 1.47 kg/kgCOD, current density of 19.6 $mA/cm^2$, electrode distance of 4 cm, air sparging rate of 0.5 l/min, duration time of 60 minutes, and the usage of graphite electrodes. The obtained treatment efficiencies for COD, color, and TOC are 87.9%, 97.7%, and 93.3% respectively, resulting in COD of 42 mg/l, color of 19 Pt – Co, and TOC of 6.82 mg outputs. These results comply with the QCVN 40:2011/BTNMT standard (column A).

Similarly, for the treatment of pesticide wastewater, the optimal conditions are determined as follows: pH of 3.8, catalyst dosage of 1.3 g/l, a catalyst loading of 4.9 kg/kgCOD, current density of 13.4 $mA/cm^2$, electrode distance of 2 cm, air sparging rate of 0.5 l/min, processing time of 150 minutes, utilizing a boron-doped diamond anode and graphite cathode. The treatment efficiencies for COD and IMI are achieved to be 98.2% and 99.8%, respectively, corresponding to COD of 6 mg/l and IMI of 0.043 mg/l. These results also meet the QCVN 40:2011/BTNMT standard (column B).

This research has been conducted on three types of wastewater, demonstrating that this technology attains high treatment efficiency for non-biodegradable organic matters. Notably, the obtained value of pH has been improved while comparing to conventional electro-Fenton processes. Furthermore, the $Fe_3O_4/Mn_3O_4$ as a catalyst exhibits low solubility (approximately 0.1% after each cycle), high stability, and low leaching ability of material (approximately 0.4% after each cycle).

The research has identified two methods of oxidation for this technology in two different cases; using a graphite anode and a BDD anode. As a result, this method can produce •OH through five different pathways. Two of these pathways involve a Fenton-like reaction, where $H_2O_2$ interacts with $\equiv Mn^{2+}$ or $\equiv Fe^{2+}$ to create •OH. The other two pathways arise from the reaction between $H_2O_2$ and $\equiv Mn^{2+}$ or $\equiv Fe^{2+}$, resulting in the formation of •HOO. These species may continue reacting with $H_2O_2$ to produce •OH.

Additionally, the production of •OH could occur directly on the Boron Doped Diamond electrode.

The Modde 5.0 software has successfully been used to evaluate the quality of the mathematical model, determine the regression equation, and figure out the optimal treatment conditions for using the Electro-Fenton process with $Fe_3O_4/Mn_3O_4$ as a catalyst to remediate in terms of non- wastewater biodegradable wastewater.

Additionally, this thesis proposes the schematic diagrams of wastewater treatment technologies that utilize the Electro-Fenton process with $Fe_3O_4/Mn_3O_4$ as a catalyst to remediate these various sources of wastewater.

In summary, $Fe_3O_4/Mn_3O_4$ material can be employed as a catalyst for the Electro-Fenton technology to treat non-biodegradable wastewater, offering several advantages such as high treatment efficiency, a higher pH value compared to traditional methods, reduced chemical usage, decreased sludge volume, a short treatment time, and the ability to reuse this catalyst.

| Advisors | PhD Student |
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| Assoc. Prof. Dr. Nguyen Tan Phong | Nguyen Duc Dat Duc |