Effect of pH on the removal efficiency of phenol in oil refinery wastewater using Cobalt Ferrite Nano-composites

Ahmed S. ElGendy

Associate Professor

Department of Construction Engineering

The American University in Cairo, 11835, Egypt

Amira T. Mohamed

Graduate student

Environmental Engineering Program

The American University in Cairo, 11835, Egypt

Presenting author email: amirataha@aucegypt.edu

Phenolic compounds have the tendency to persist in the environment over a long period making them a main source of concern because of their toxic characteristics towards humans and animals (Bruce et al., 1987).

Petroleum refineries are among the top industries that produces significant quantities of high phenol concentration wastewater. Photo-catalysis is a promising and effective method to treat phenol present in oil refineries effluent. In this study, the photo-catalyst used is recommended to be in the Nano size in order to provide better dispersion leading to higher phenol degradation

Composite nano-particles were synthesised and showed a successful formation of cobalt ferrite core surrounded by titanium dioxide shell, with an average size 65.5nm.

The study aimed to determine the effect of initial pH on the removal efficiency of phenol using a lab scale batch reactor. The removal efficiency of phenol was tested for different initial phenol concentrations at different initial pH levels. It was found that; removal efficiency of phenols using CNPs is significantly affected by the initial pH. Accordingly an initial pH of 3 showed the highest degradation for different initial phenol concentrations. It was found also that the removal efficiency of phenol decreases with increasing initial pH of the solution.

Introduction

Phenol is a toxic compound that can cause several health problems to both humans and animals (Anku et al., 2017). Petroleum refineries are among the top industries that produce significant quantities of high phenol concentration wastewater. The Polluted wastewater from refineries contains phenol levels ranging from 20 to 200 mg/l (*World Bank., 1999*).

Photo-catalysis is a high efficiency treatment technique used to degrade organic contaminants (Szklo & Schaeffer, 2007). In photo-catalysis, organic compounds are degraded using a semiconductor photo-catalyst such as TiO_2 or ZnO in the presence of air and UV light (Ahmed et al., 2011) .

Material and methods

In this research composite nano-particles were synthesised and characterized in order to confirm the physio-chemical properties of the obtained nano-particles.

The obtained composite nano-particles were then tested using a batch reactor in order to determine the removal efficiency of phenol at different initial pH of the solution for different initial phenol concentrations. The reactor used was a polysilicate glass reactor designed to carry 100 ml of solution. UV light source was installed on top of the reactor.

Synthetic wastewater was prepared by spiking deionised water with phenol salt C_6H_5OH purchased from sigma Aldrich Company. The targeted phenol concentrations were in the range between 50 to 200 mg/l in

order to simulate actual phenol concentration in petroleum refinery effluent Four values of initial phenol concentrations were tested 50, 100,150, and 200 mg/l. (*Al Hashemi et al., 2015*).

Initial pH level of the solution was adjusted using hydrochloric acid or sodium hydroxide based on the required pH value. Five different initial pH values were tested 3,5,6,7 and 9. pH values were selected based on the average range of pH level for petroleum refinery effluent which ranges from 4.3- 10 (*Elmobarak et al., 2021*).

To determine the removal efficiency of phenol experiments ran for five continuous hours with a sample being collected every one hour.

UV-Vis spectrophotometer model 1650PC manufactured by Shimadzu corporation (Japan), was used to measure light absorbance from tested samples.

Results and discussion

Obtained composite nano-particles showed homogeneity in shape and size as well as an average size of 65.5 nm. It was noticed that for different initial phenol concentration removal efficiency is generally higher at lower initial pH levels.

The data obtained showed that the highest degradation rates were obtained at initial pH=3 for different initial phenol concentrations

Results show that initial pH adjustment is an important step to achieve higher removal efficiency, especially at higher initial phenol concentration. Degradation rate is higher at lower pH and it decreases as pH increases. This is caused by the higher redox potential.

Conclusions

Characterization of the synthesized materials showed a successful formation of cobalt ferrite core surrounded by titanium dioxide shell. Characterization also showed an average size of 65.5 nm for catalyst particles within the nanoscale (<100 nm).

Adjusting initial pH affects photo-catalytic degradation of phenol at different initial phenol concentrations. An initial pH of 3 showed the highest degradation rates for different initial phenol concentration.

References

Ahmed, S., Rasul, M. G., Martens, W. N., Brown, R., & Hashib, M. A. (2011). Advances in Heterogeneous Photocatalytic Degradation of Phenols and Dyes in Wastewater: A Review. *Water, Air, & Soil Pollution*, *215*(1–4), 3–29. https://doi.org/10.1007/s11270-010-0456-3

Al Hashemi, W., Maraqa, M. A., Rao, M. V., & Hossain, M. M. (2015). Characterization and removal of phenolic compounds from condensate-oil refinery wastewater. *Desalination and Water Treatment*, *54*(3), 660–671. https://doi.org/10.1080/19443994.2014.884472

Anku, W. W., Mamo, M. A., & Govender, P. P. (2017). Phenolic Compounds in Water: Sources, Reactivity, Toxicity and Treatment Methods. *Phenolic Compounds - Natural Sources, Importance and Applications*. https://doi.org/10.5772/66927

Bruce, R. M., Santodonato, J., & Neal, M. W. (1987). Summary review of the health effects associated with phenol. *Toxicology and Industrial Health*, *3*(4), 535–568. https://doi.org/10.1177/074823378700300407

Elmobarak, W. F., Hameed, B. H., Almomani, F., & Abdullah, A. Z. (2021). A Review on the Treatment of Petroleum Refinery Wastewater Using Advanced Oxidation Processes. *Catalysts*, *11*(7), 782. https://doi.org/10.3390/catal11070782

World Bank. (1999). *Pollution prevention and abatement handbook, 1998.* Retrieved 20 December 2019, from http://documents.worldbank.org/curated/en/758631468314701365/pdf/multi0page.pdf

Szklo, A., & Schaeffer, R. (2007). Fuel specification, energy consumption and CO2 emission in oil refineries. *Energy*, *32*(7), 1075–1092.