THE AMERICAN UNIVERSITY IN CAIRO
الجامعة الأمريكية بالقاهرة

Effect of pH on the removal efficiency of phenol in oil refinery wastewater using cobalt ferrite nano-composites

June 2022

Presented By: **Amira T. Mohamed**

CONTENTS

Problem definition

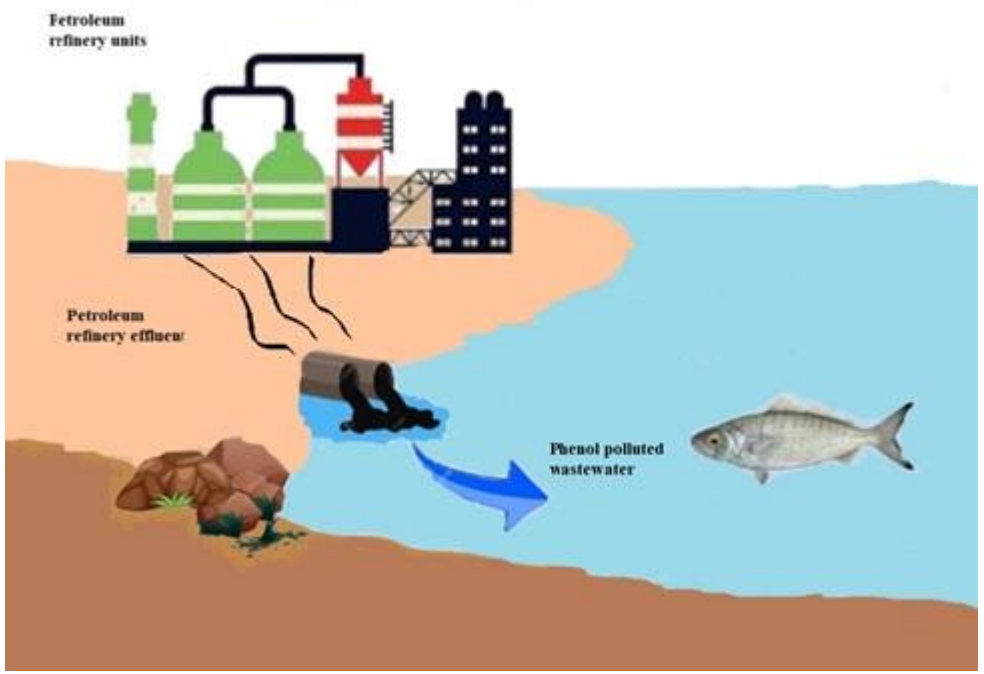
Problem definition

- Refineries generate process and non-process wastewater with volumes almost equal to 0.4-1.6 times the volume of oil processed (Coelho A, 2006).

- Polluted wastewater from refineries contains phenol levels ranging from 20 to 200 mg/l (world bank, 1999).

Problem definition

- 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 RM, 1987).



Objectives

Objectives

- Synthesising the nano-composites.
- Studying the effect of pH on phenol photo-catalytic degradation on a batch system.

Introduction

Introduction

Table 1: Phenol characteristics

Property	Value
Molecular formula	C_6H_5OH or C_6H_6O
Molecular Weight	94.11
Colour	White crystal
Solution Colour	Colourless when pure(otherwise pink or red)
Flash point	$80\,^0c$
Freezing point	$40\,^0c$
Density	1.04-1.07 g/cm^3
Odour	Sweet- tarry
Taste	Sweetish- sharp taste
Corrosivity	Caustic
pH	6 Approximately

(Adapted from Pubchem, 2021)

Impact of phenol

- On aquatic life:
  - Growth rate.
  - Reproduction.
  - Metabolism.
- On humans:
  - Irritating effect on skin.
  - Delay of puberty in girls.
  - Heart, kidneys and liver problems.
  - Carcinogenic effects

Petroleum refinery effluent

Table 2 : Characteristics of petroleum refinery wastewater

Property	Range	Maximum allowed
BOD	150-250 mg/l	30 mg/l
COD	300-600 mg/l	150 mg/l
Phenol	20-200 mg/l	0.5 mg/l
Oil level	100-300 mg/l in desalter water Up to 5000 mg/l in tank bottoms	10 mg/l
Benzene level	1-100 mg/l	0.05 mg/l
Heavy metals	0.1-100 mg/l for chrome 0.2-10 mg/l for lead	0.5 mg/l for chrome 0.1 mg/l for lead

(Adapted World bank, 1999)

Methods of refinery wastewater treatment

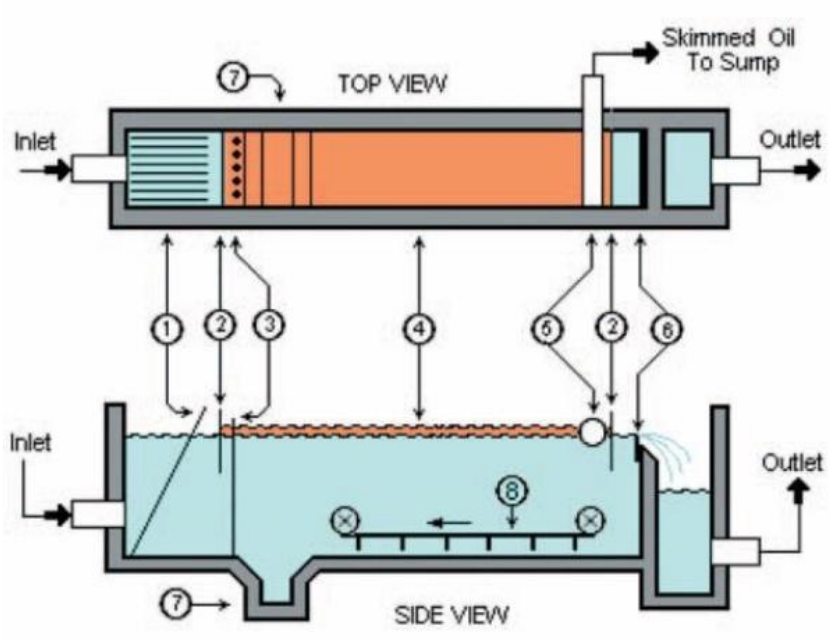
- The refinery wastewater treatment process typically consists of a set of stages depending on the complexity of the refinery and the type of contaminants to be treated (Benyahia, 2006).

- Various treatment methods such as biological, chemical or advanced oxidation methods can be used to treat petroleum refineries wastewater (Hwang & Moore, 2011).

Methods of refinery wastewater treatment

✔ Pre-treatment

Is a typically gravity physical separation process where the untreated wastewater is allowed inside an API separator.



IPIECA. (2010)

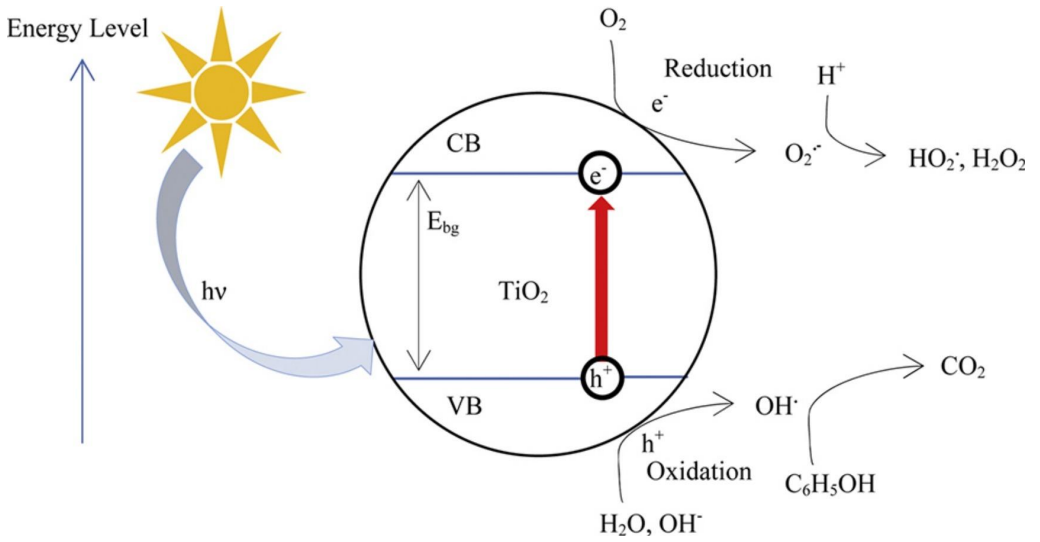
Methods of refinery wastewater treatment

✔ Biological treatment process

A process where attached growth or suspended growth bacteria are used to dissolve organic compounds present in the refinery wastewater (IPIECA, 2010).

Photo-catalytic oxidation

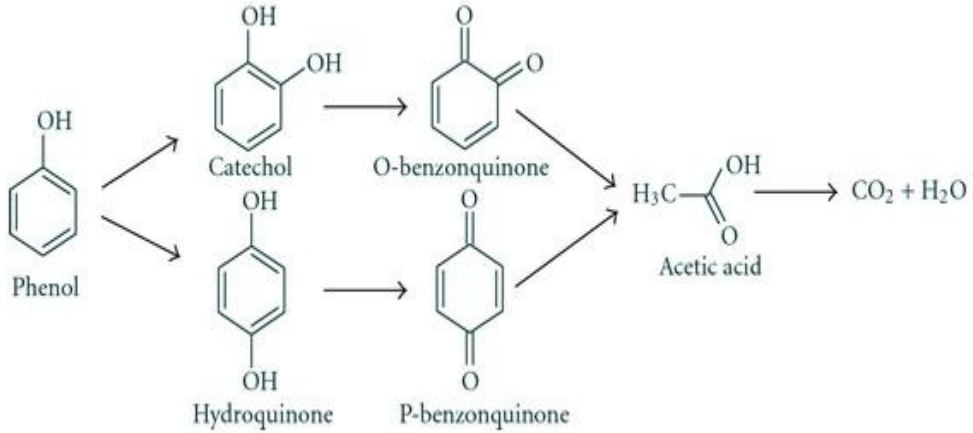
- Photo-catalysis is the excitation of semiconductors using UV light. In semiconductors such as zinc oxide or titanium dioxide when valance band is excited it leads to a free electron in the conduction band and a formation of a positive hole (hv +) in the valence band.



Ling,H. et al. (2015)

Photo-catalysis

- These positive holes can oxidize organic compounds directly leading to its degradation.
- They can also oxidize water to produce free .OH radical which in turn oxidizes the organic compounds leading to its degradation.(Ahmed et al. 2011)



Tao, Y. et al. (2012)

Factors affecting the treatment process

- Temperature: 20 to 80 ˚C
- Catalyst concentration.
- Initial substance concentration.
- Initial pH.
- Irradiation intensity.

Material and methods

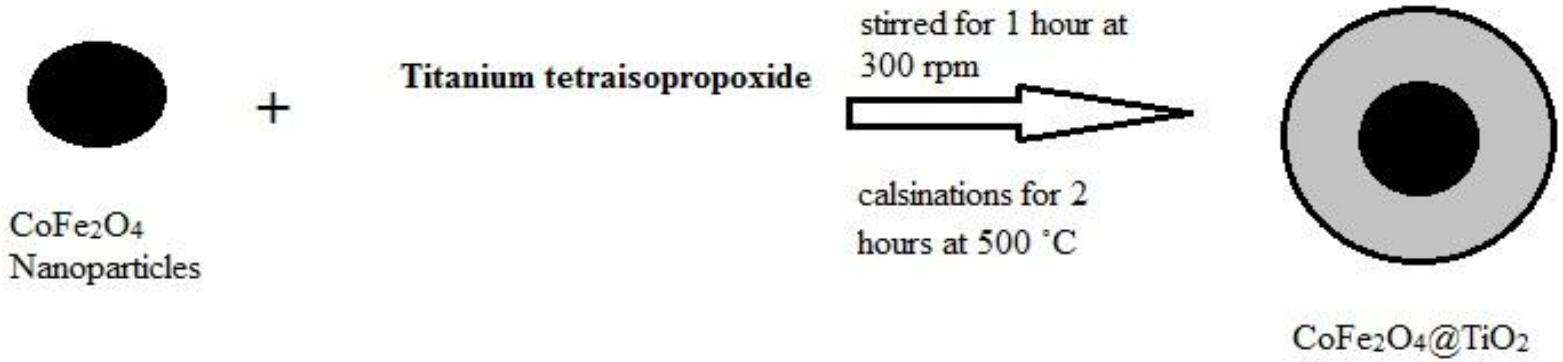
MATERIAL AND METHODS

Synthesis and testing

1. Synthesis and characterization of nano-composites
2. **Performance of nano-composites in a batch system**

1. synthesis and characterization of CNPs

- Synthesis of $CoFe_2O_4@TiO_2$ composite nano-particles



1. synthesis and characterization of CNPs

- **Characterization of nanomaterials:**

1. Transmission Electron Microscopy (TEM) test.
2. X-ray Diffraction (XRD) test.
3. Dynamic light scattering (DLS) test.

2. Performance of nano-composites in a batch system

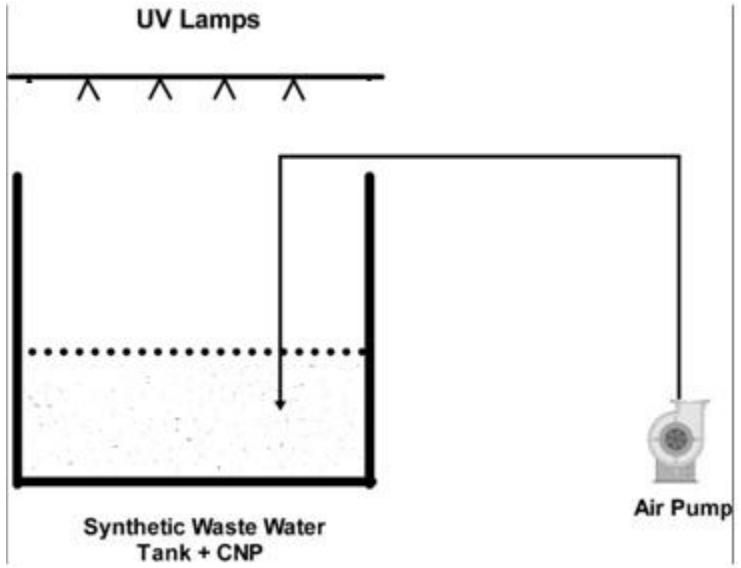


Photo-oxidation experiments

Several combinations of different operating parameters were tested in order to determine optimum operating conditions required to achieve efficient photo-oxidation:

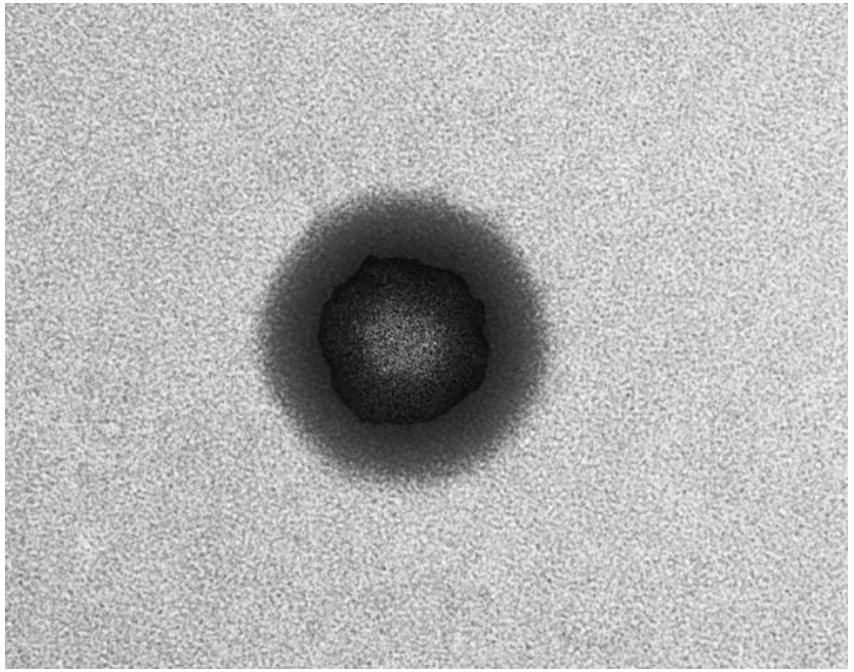
1. CNP doses (0.5 g/l, 1 g/l, 2 g/l and 2.5 g/l).
2. Initial pH (3,5,6,7 and 9).
3. Initial phenol concentrations (50, 100,150, and 200)mg/l.

All experiments were run for 5 continuous hours during which samples were collected every hour.

Results and discussion

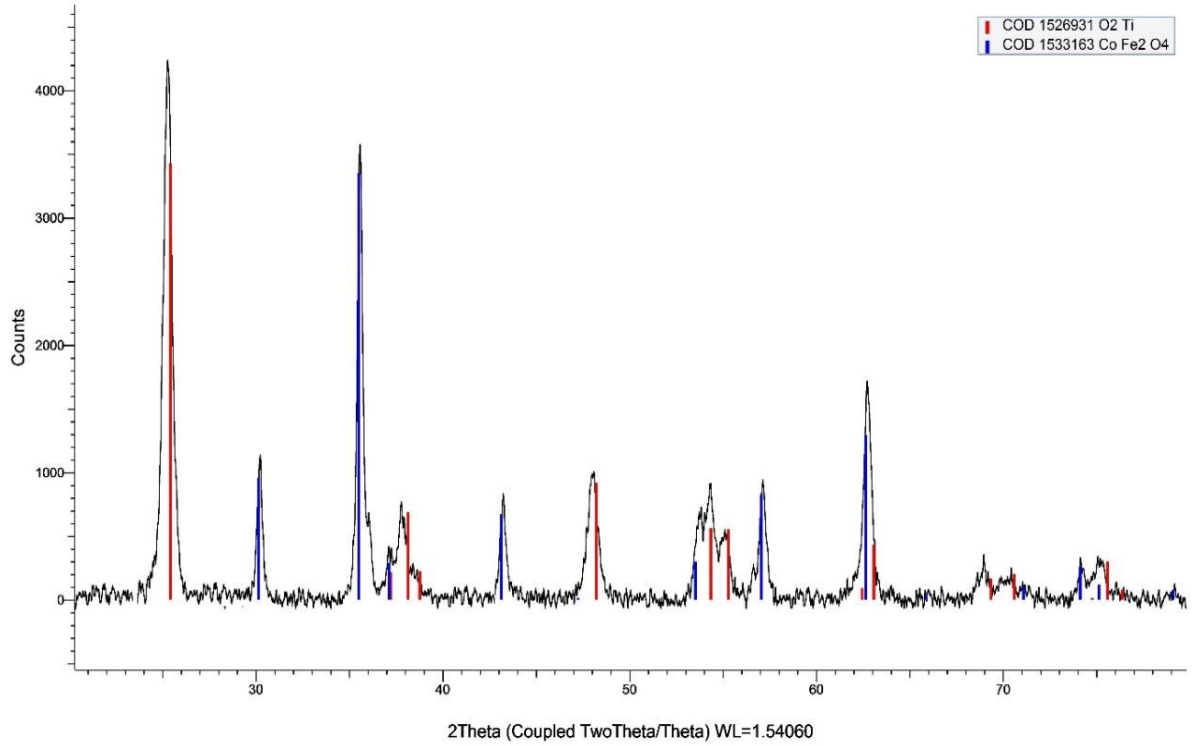
1.Characterization of synthesized material

- TEM image as shown illustrates the formation of $CoFe_2O_4@TiO_2$ composite nano-particles with spherical shape and homogeneity in shape and size.



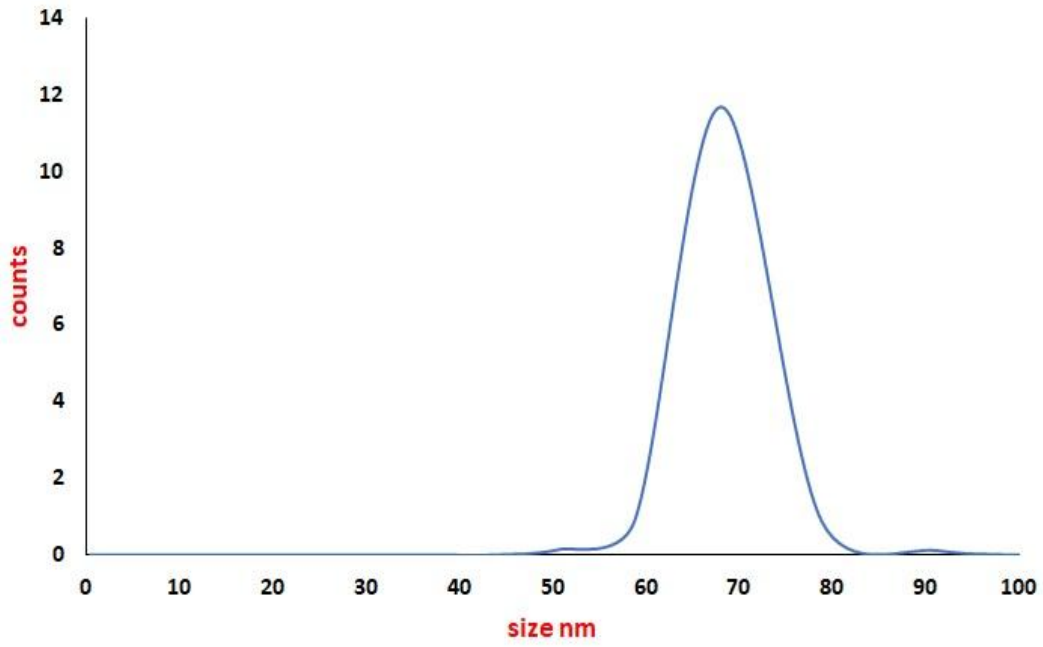
1.Characterization of synthesized material

- XRD curve shows equal amounts of $CoFe_2O_4$ and TiO_2



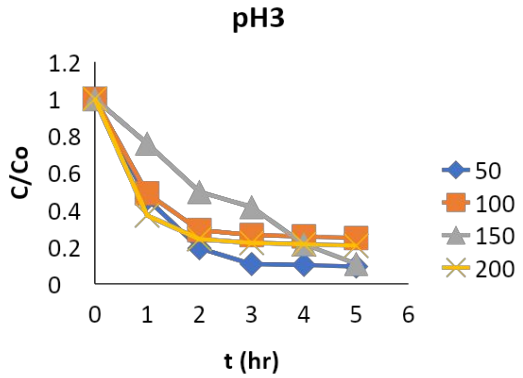
1.Characterization of synthesized material

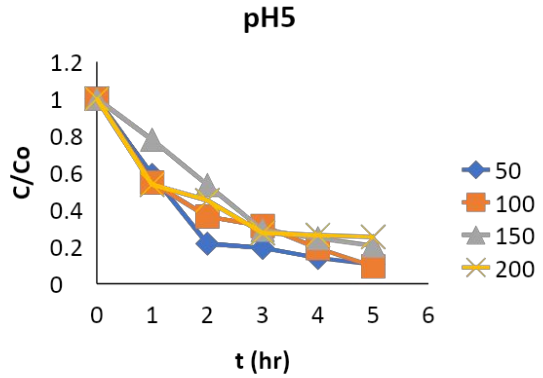
- Dynamic light scattering of $CoFe_2O_4@TiO_2$ illustrates the size control of synthesis method where there is one sharp peak determining a size of 65.5 nm

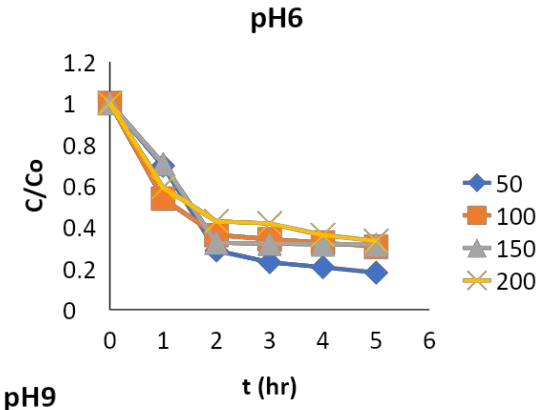


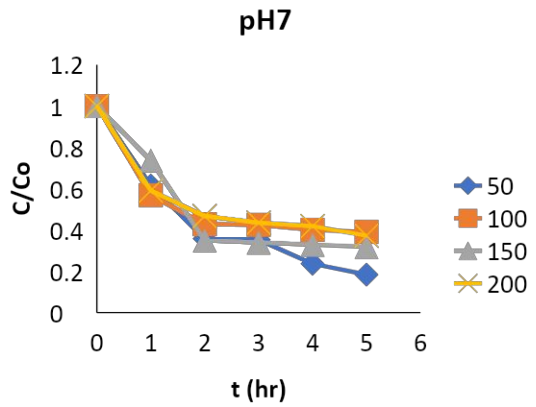
2. Performance of nano-composites in a batch system

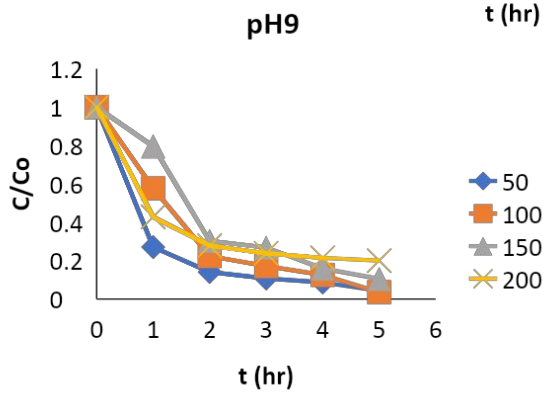
Operating parameters: Phenol degradation under continuous aeration, using CNP dose of 0.5 g/l and different pH levels for different initial phenol concentrations.





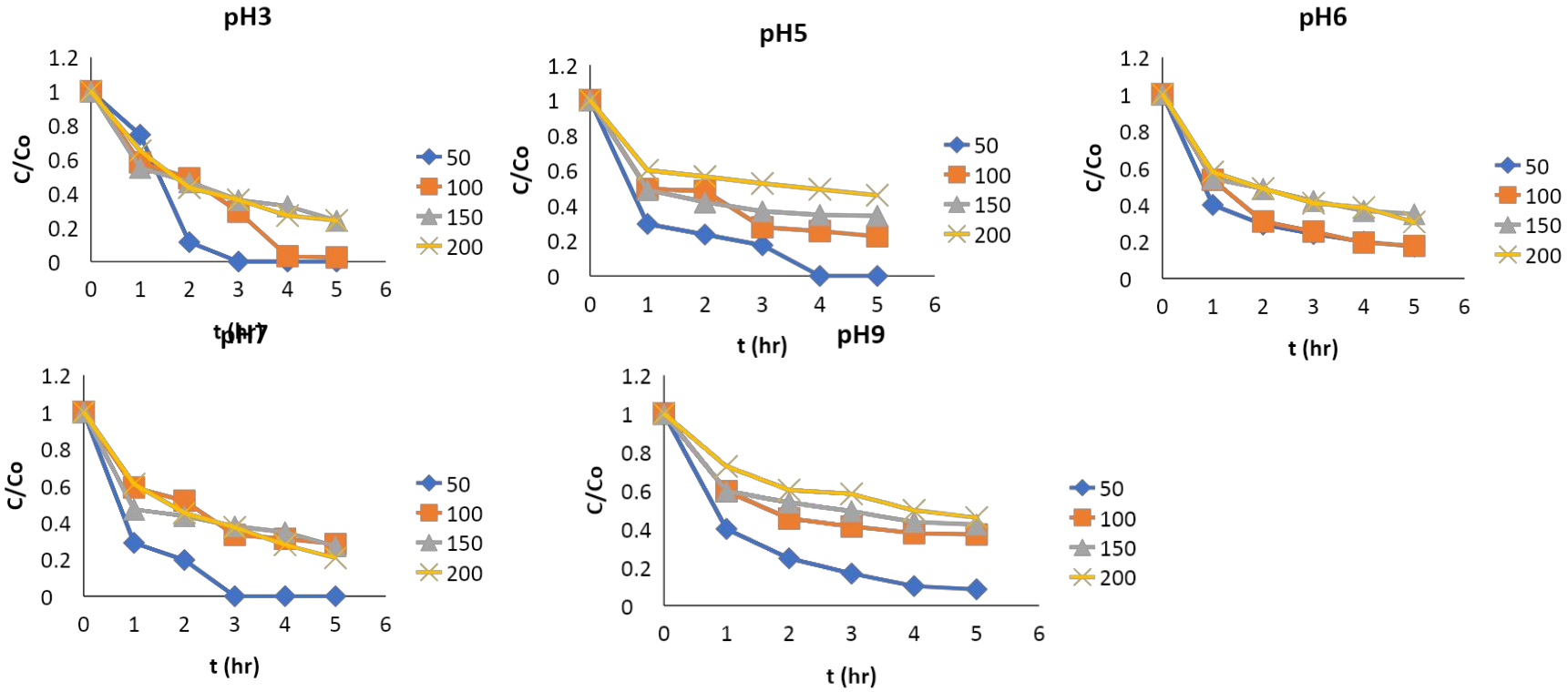






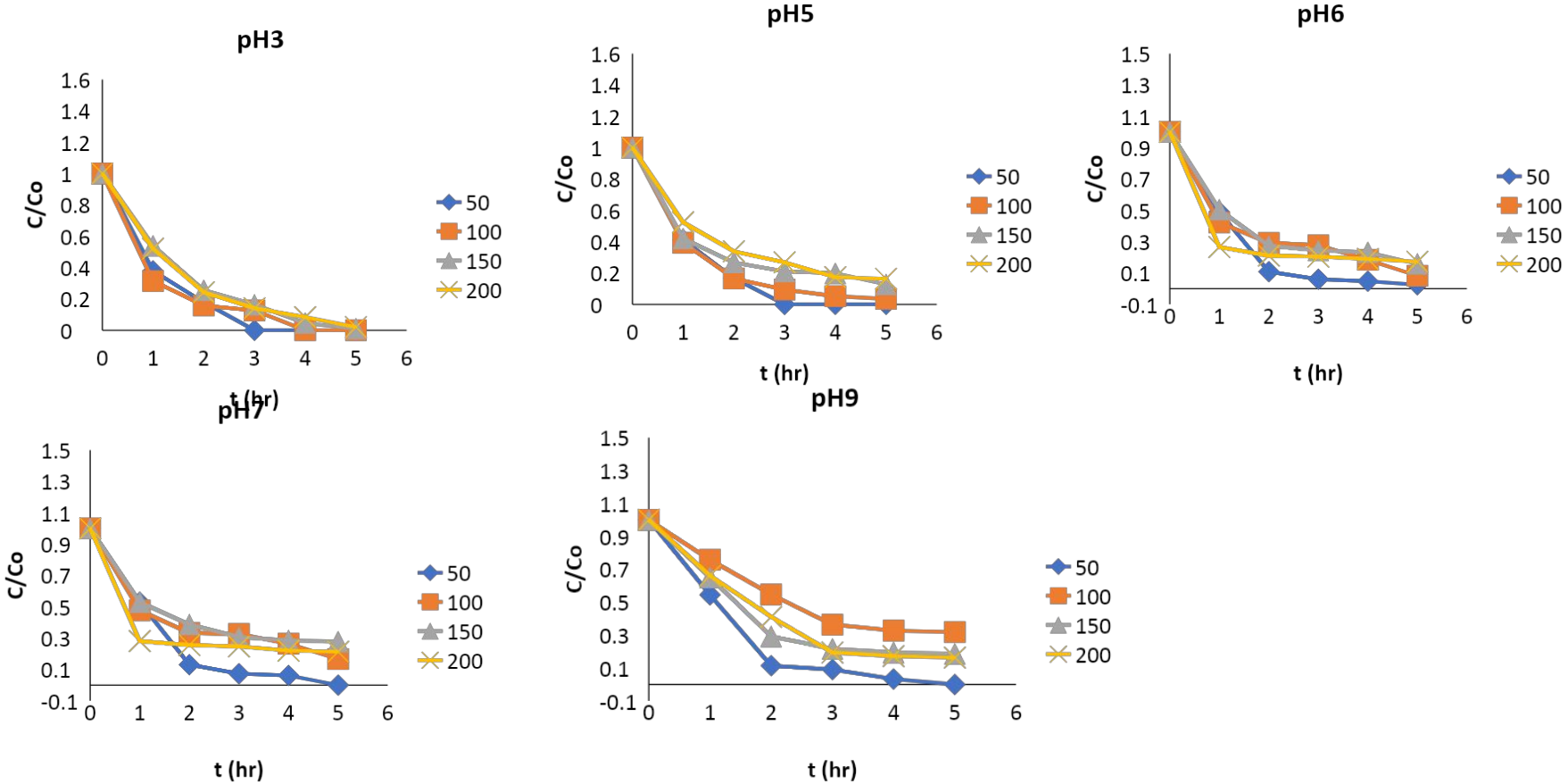
2. Performance of nano-composites in a batch system

Operating parameters: Phenol degradation under continuous aeration, using CNP dose of 1 g/l and different pH levels for different initial phenol concentrations.



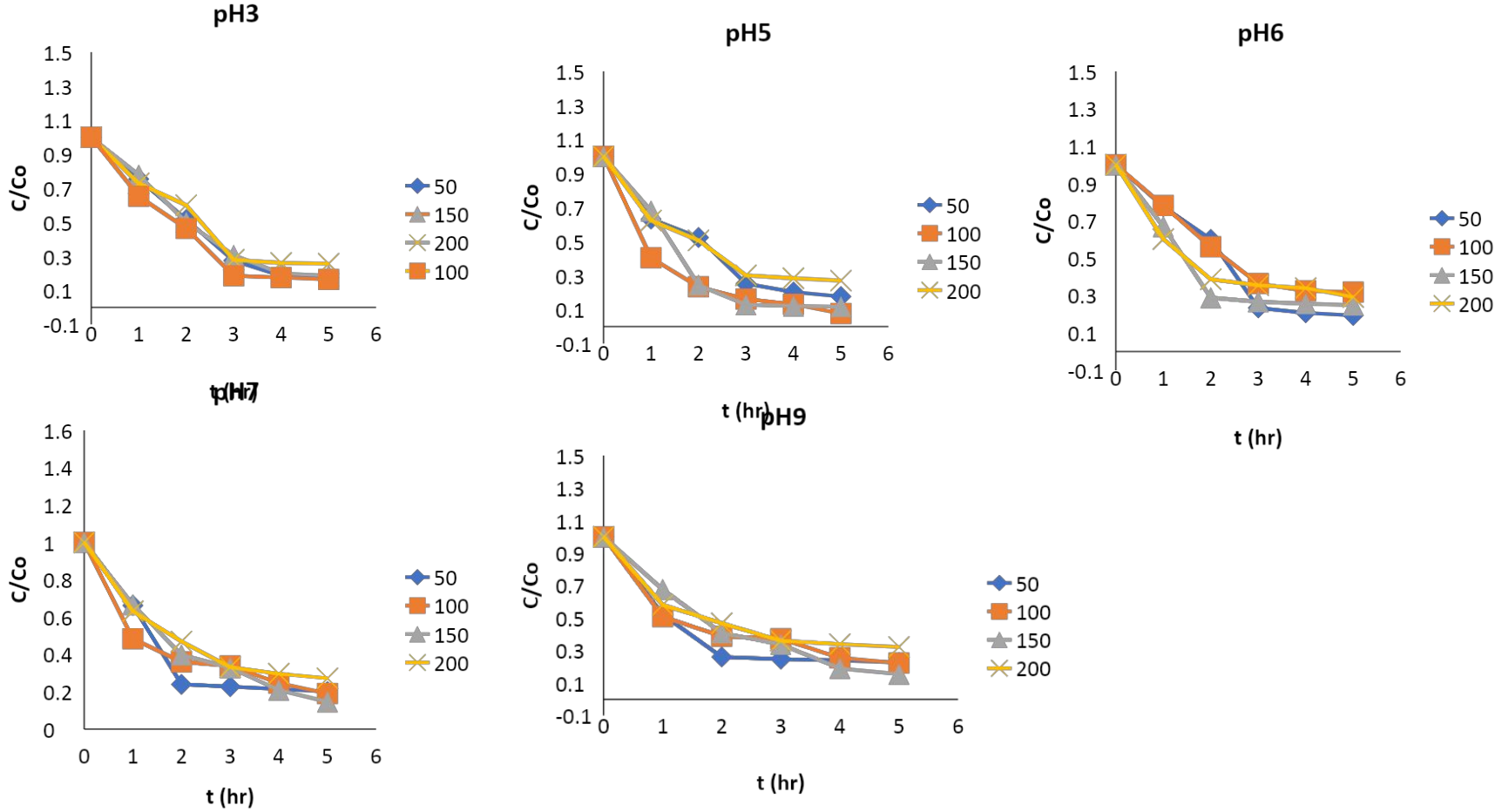
2. Performance of nano-composites in a batch system

Operating parameters: Phenol degradation under continuous aeration, using CNP dose of 2 g/l and different pH levels for different initial phenol concentrations.



2. Performance of nano-composites in a batch system

Operating parameters: Phenol degradation under continuous aeration, using CNP dose of 2.5 g/l and different pH levels for different initial phenol concentrations.



Conclusions

This research was accomplished through :

1. synthesis of nano-composites.

2. Performance of nano-composites in a batch system.

Conclusions

1. Characterization of the synthesized materials showed:

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

Conclusions

2. Analysis showed that:

- CNP dosage varies according to initial phenol concentration and initial pH between 0.5 g/l to 2 g/l.
- An initial pH of 3 showed the highest degradation rates for different initial phenol concentration.

References

- Coelho A, Castro AV, Dezotti M, Sant'Anna GL. Treatment of petroleum refinery sourwater by advanced oxidation processes. *J Hazard Mater*. 2006;137(1):178-184. doi:10.1016/j.jhazmat.2006.01.051
- World Bank - 1999 - Pollution prevention and abatement handbook, 1998.pdf. http://documents.worldbank.org/curated/en/758631468314701365/pdf/multi0page.pdf. Accessed December 20, 2019.
- Bruce RM, Santodonato J, Neal MW. Summary review of the health effects associated with phenol. Toxicol Ind Health. 1987;3(4):535-568. doi:10.1177/074823378700300407.
- Benyahia - Refinery wastewater treatment a true technologica.pdf.
- Hwang S, Moore I. Water network synthesis in refinery. Korean J Chem Eng. 2011;28:1975-1985. doi:10.1007/s11814-011-0087-4.
- Ahmed et al. - 2011 - Advances in Heterogeneous Photocatalytic Degradati.pdf. https://eprints.qut.edu.au/41752/1/41752.pdf. Accessed November 30, 2019.
- Bacri et al. - 1990 - Ionic ferrofluids A crossing of chemistry and phy.pdf.
- SyarifahNazirah_21_3_14.pdf. http://www.ukm.my/mjas/v21_n3/pdf/SyarifahNazirah_21_3_14.pdf. Accessed February 4, 2020.

References

- Qia S, Maoa Y, Lva M, et al. Pathway fraction of bromate formation during O 3 and O 3 / H 2 O 2 processes in drinking water treatment. In: ; 2016.
- Kritsevskaja M. Ozone in Drinking Water Treatment. :10.
- Collivignarelli M, Pedrazzani R, Sorlini S, Abbà A, Bertanza G. H2O2 Based Oxidation Processes for the Treatment of Real High Strength Aqueous Wastes. *Sustainability*. 2017;9(2):244. doi:10.3390/su9020244
- Ahmed et al. - 2011 - Advances in Heterogeneous Photocatalytic Degradati.pdf. https://eprints.qut.edu.au/41752/1/41752.pdf. Accessed November 30, 2019.
- Bacri et al. - 1990 - Ionic ferrofluids A crossing of chemistry and phy.pdf.
- Fraser S. -2014- Distillation in Refining. https://www.sciencedirect.com/science/article/pii/B9780123868763000041

Thank you