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Modification of Activated Carbon from *Elaeis Guineensis Jacq Shell* with Magnetite (Fe_3O_4) Particles and Study Adsorption-Desorption on Ni(II) Ions in Solution

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Bandar Lampung, September 3rd – 4th, 2020

OUTLINE OF PRESENTATION

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1. INTRODUCTION

Development industrial progress

Heavy metal contamination in water sources

Elaeis Guineensis Jacq Shell

ACA-Fe_3O_4

Adsorption

Desorption

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Purposes

- Synthesize magnetite activated carbon (ACA-Fe_3O_4) from oil palm shells.
- Study of Ni(II) ions adsorption and desorption on magnetite activated carbon (ACA-Fe_3O_4) includes a study of the effects of adsorbent dosage, pH, determination of kinetic adsorption, and isotherm models.

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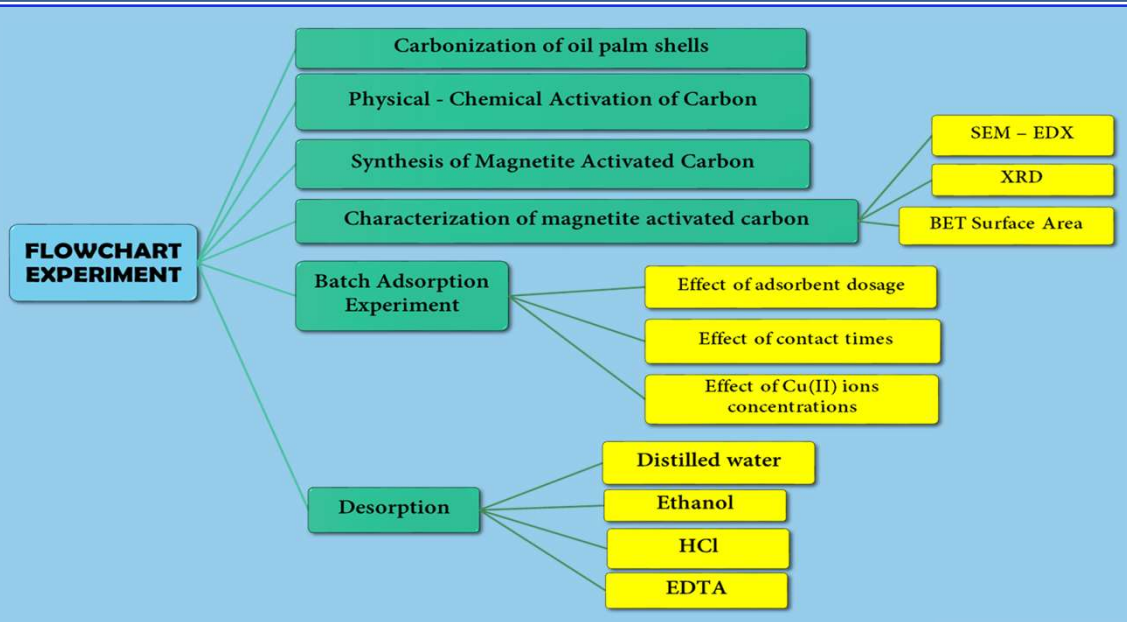

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2. Experimental

Figure 1. Carbonization of oil palm shells
(A) Oil palm shells;
(B) Oil palm shell after being carbonized
(C) Oil palm shell carbon after smoothed and sifted with size 100 – 200 µm

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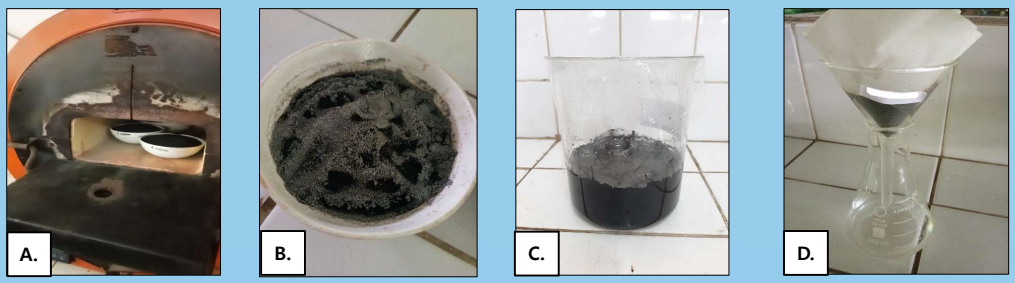

Figure 2. Physical - Chemical Activation of Carbon
(A) Carbon is heated at 700°C for 1 hour in furnace
(B) Carbon is separated from ash
(C) Carbon soaked in 10% H_3PO_4 for 24 hours
(D) Activated carbon (ACA) was produce after washed with distilled water to pH 6 and dried in an oven at 100°C for 1 hour

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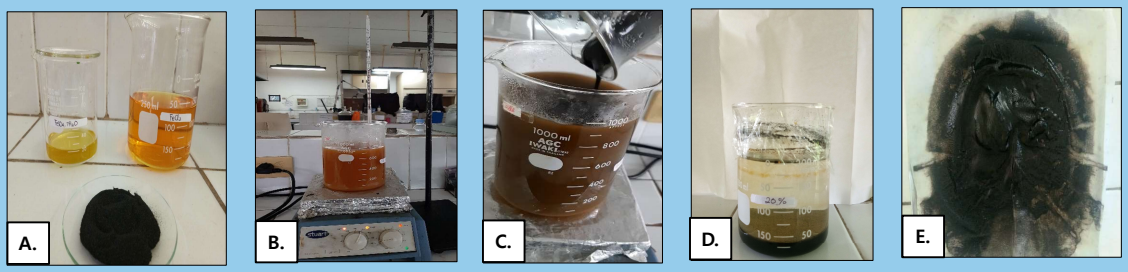

Figure 3. Synthesis of Magnetite Activated Carbon
(A) ACA, $FeCl_3$, and $FeSO_4$ solutions
(B) A mixture of $FeCl_3$ and $FeSO_4$ solutions was stirred for 30 minutes at 60°C
(C) Mixture B is reacted with ACA suspension and water, then NaOH is added to pH 10
(D) The mixture is left for 24 hours
(E) The solid phase (ACA-Fe_3O_4) is filtered, rinsed with distilled water to neutral pH, and dried in an oven at 50°C for 5 hours

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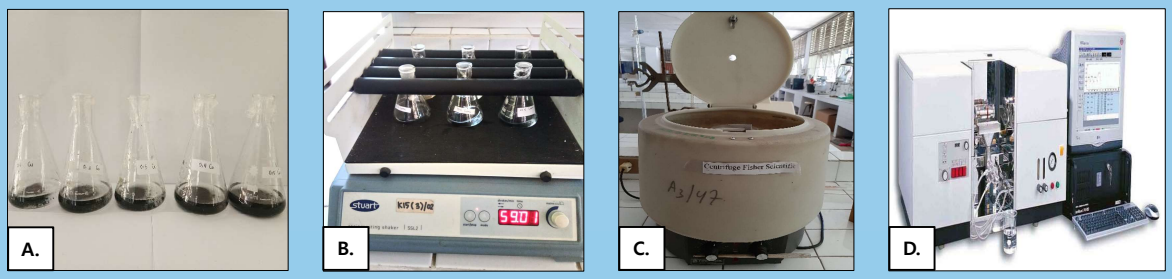

Figure 4. Batch Adsorption Experiment
(A) Magnetite activated carbon (ACA-Fe_3O_4) is inserted into 25 mL of Ni(II) solution
(B) The mixture is stirred for 1 hour using a shaker
(C) Mixed B is left for a moment, then decanted. The filtrate is then centrifuged
(D) The concentration of the filtrate was analyzed using AAS.

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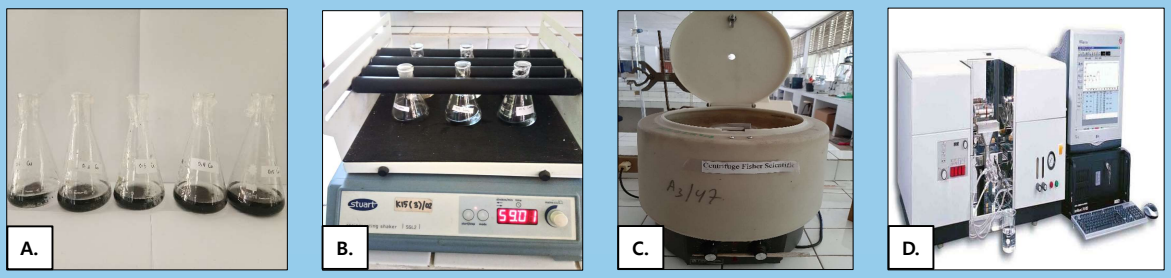

Figure 5. Desorption Experiment
(A) ACA-Fe_3O_4 , which had been used in the adsorption process, inserted into eluen (distilled water, ethanol, HCl solution, and EDTA) alternately.
(B) The mixture is stirred for 30 minutes using a shaker
(C) Mixed B is left for a moment, then decanted. The filtrate is then centrifuged
(D) The concentration of the filtrate was analyzed using AAS.

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3. Results and discussion

Characterization

1. SEM - EDX

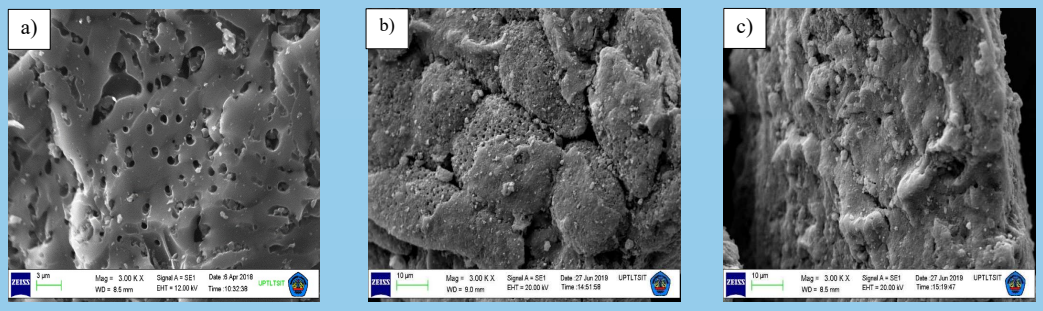

Figure 6. SEM images of a) ACA, b) ACA-Fe_3O_4, and c) ACA-Fe_3O_4 after adsorbing Ni(II) ions at 3000-time magnification

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Characterization

Table 1. Elemental composition on Adsorbents

Sample	Elements (wt %)			
	C	O	Fe	Ni
ACA	80.74	19.26	-	-
ACA-Fe_3O_4	33.01	46.81	20.18	-
ACA-Fe_3O_4-Ni	43.75	50.64	5.50	0.11

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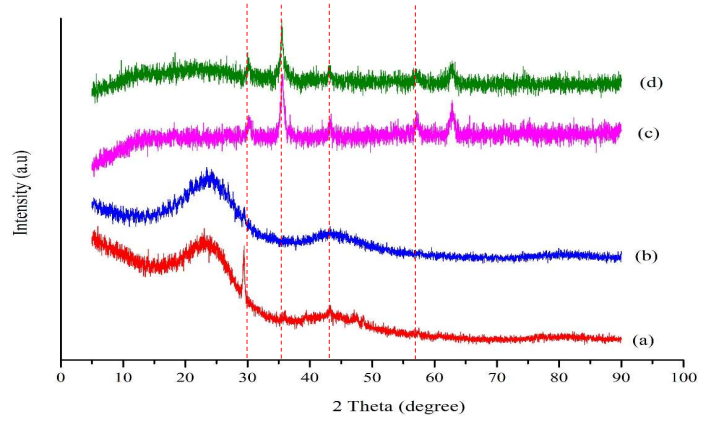
Characterization

2. XRD ANALYSIS



Peaks that appear in area 2Θ of 30.21; 35.52; 43.07; and 57.16˚ which are typical peaks of magnetite

Figure 7. Diffractogram of a) AC b) ACA, c) magnetite, and d) ACA-Fe_3O_4

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Characterization

Table 2. The results of the characterization using the BET (*surface area*) method on ACA and ACA-Fe_3O_4

Adsorbent Surface Characteristics	Adsorbent	
	ACA	ACA-Fe_3O_4
Total surface area ($m^2.g^{-1}$)	415.116	300.090
Total pore volume ($cm^3.g^{-1}$)	0.229	.201
BJH surface area ($m^2.g^{-1}$)	17.136	20.089
BJH pore volume ($cm^3.g^{-1}$)	0.0	0.064
Average pore diameter (nm)		0.134

The reduced surface area on magnetite activated carbon is due to the presence of magnetite particles that attach to the surface of the activated carbon

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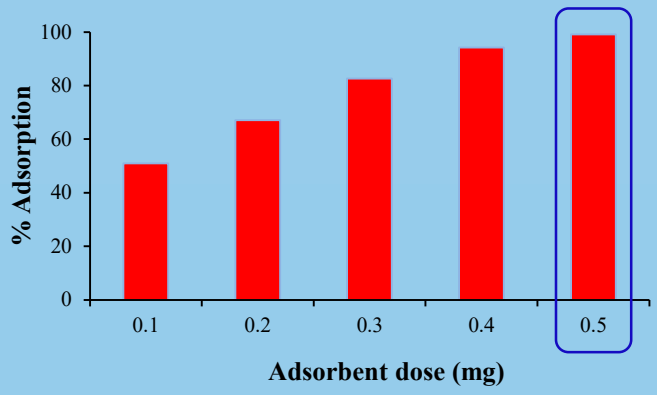
Adsorption

1. Effect of adsorbent dosage



The more the dose was used, the more active sites of the adsorbent can adsorb Ni(II) ions.

Figure 8. Effect of adsorbent dose on the adsorption percentage of Ni(II) ions in solution

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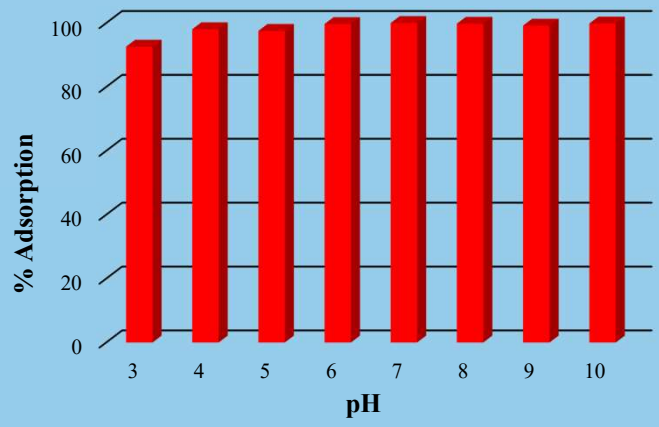
Adsorption

2. Effect of pH



The change of pH has no significant effect on the adsorption of Ni(II) ions

Figure 9. Effect of pH on the adsorption percentage of Ni(II) ions in solution

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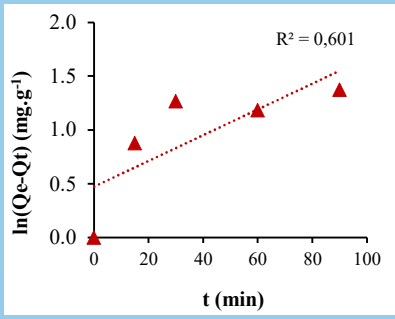
3. Adsorption kinetics

Adsorption



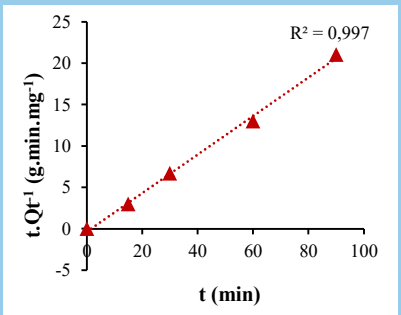


Figure 10.
Graph of pseudo a) first-order and b) second-order for adsorption Ni(II) on ACA-Fe_3O_4

Table 3. Pseudo-first-order and second-order rate constant of ACA and ACA-Fe_3O_4

	Pseudo first order		Pseudo second order	
	k_1 (min^{-1})	R^2	k_2 ($g.mmol^{-1}.menit^{-1}$)	R^2
ACA-Fe_3O_4	0,012	0,602	9,543	0,997

The adsorption of Ni(II) ions on ACA-Fe_3O_4 tends to follow the ***pseudo-second-order*** adsorption kinetics

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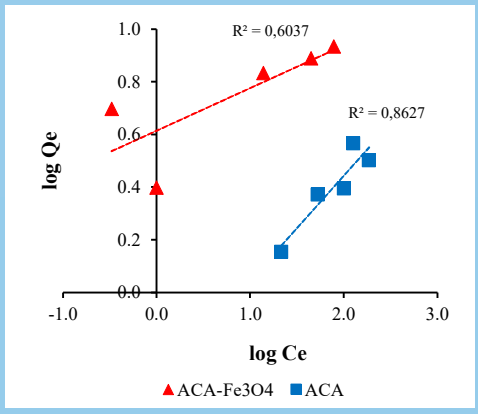
4. Adsorption isotherms

Adsorption



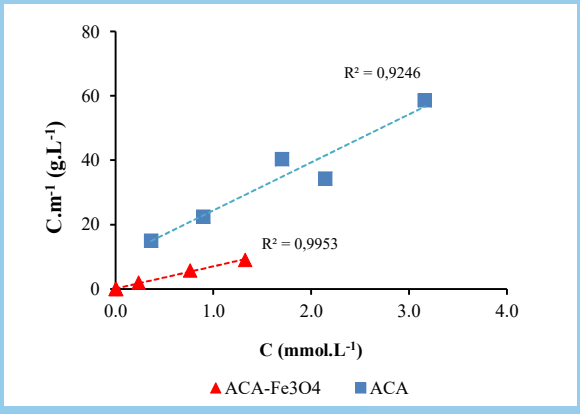


Figure 11. a) Freundlich and b) Langmuir adsorption isotherms of Ni(II) cations by ACA and ACA-Fe_3O_4

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Adsorption

Isotherms parameters

Table 4. Isotherm parameters of Ni(II) ions sorption in solution by ACA and ACA-Fe_3O_4

Model		Adsorbent	
		ACA	ACA-Fe_3O_4
Langmuir			
	q_m in mg g^{-1}	3.933	8.495
	K_L in L mol^{-1}	1564.5	37650
	R^2	0.925	0.995
Freundlich			
	K_F in (mg g^{-1})(L mg^{-1})$^{1/n}$	2.251	0.243
	n	2.514	6.177
	R^2	0.863	0.604

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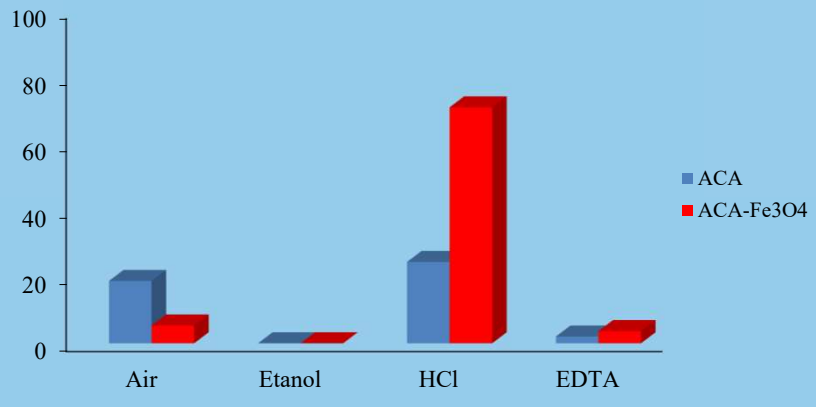
Desorption

5. Desorption Test



Desorption using HCl eluents in this study produced the best desorption rates for Ni(II) ions in ACA and ACA-Fe_3O_4 which was 24.42 and 70.84% respectively

Figure 13. Desorption of Ni(II) ions with several types of eluents

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4. CONCLUSION

- Activated carbon obtained from oil palm shells coated with magnetite (ACA-Fe_3O_4) was a very effective adsorbent in the treatment of wastes containing Ni(II) ions in water resources.
- The adsorption of Ni(II) ions on ACA-Fe_3O_4 tends to follow the pseudo-second-order kinetics and the Langmuir adsorption isotherm model.
- Desorption process with HCl as eluent was produced the best desorption rate of 70.84%.

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Acknowledgements

We be grateful to the Directorate of Research and Community Service, Directorate-General for Research and Development, Ministry of Research, Technology and Higher Education of the Republic of Indonesia for funding this work with the number of contract: 179/SP2H/AMD/LT/DRPM/2020. We also give thanks to the Technical Service Unit of the Integrated Laboratory and the Technology Innovation Center–University of Lampung (UPT Laboratorium Terpadu dan Sentra Inovasi Teknologi–Universitas Lampung) for its hospitality.

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