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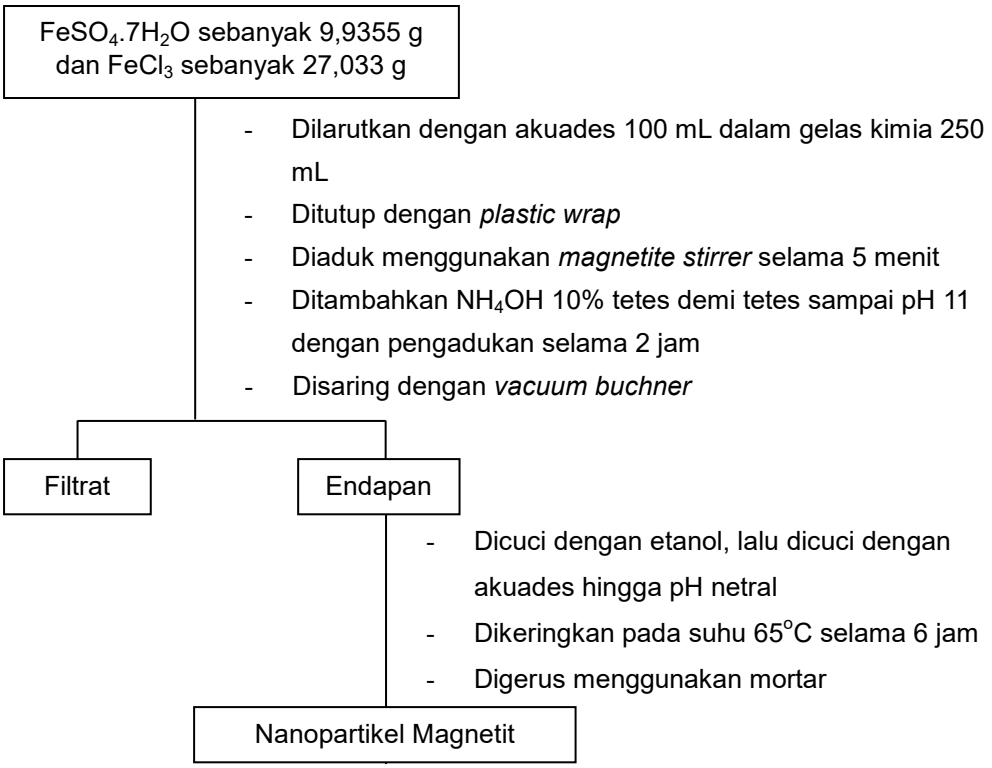
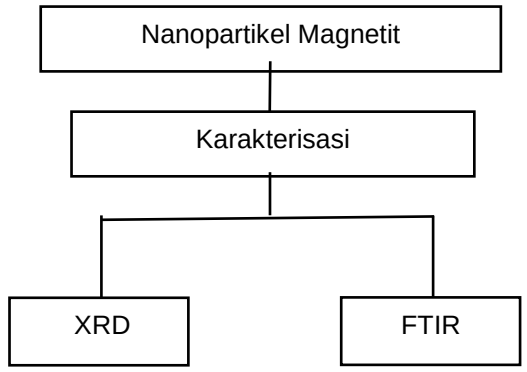
Lampiran 1. Bagan Kerja

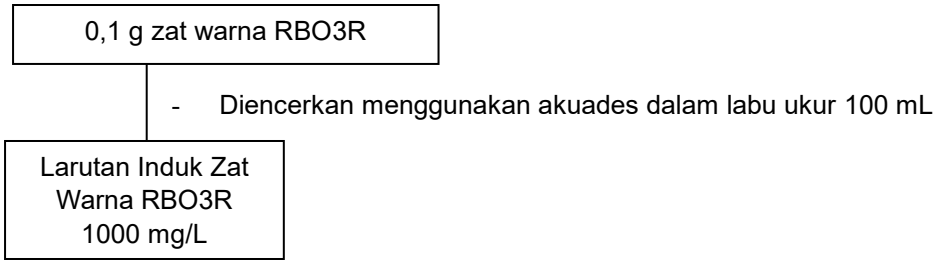
1. Sintesis Nanopartikel Magnetit



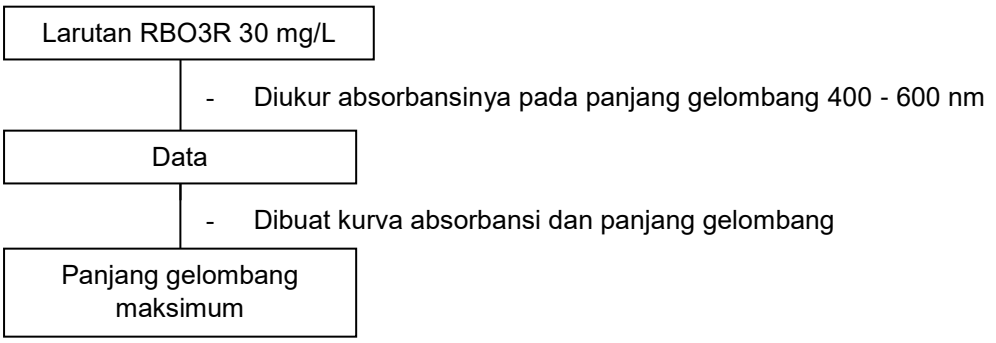
2. Karakterisasi Nanopartikel Magnetit



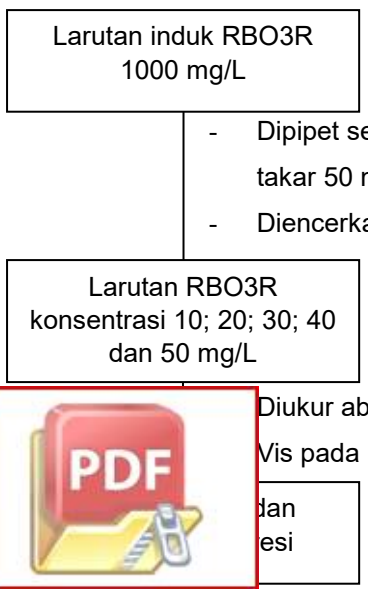
3. Pembuatan Larutan Induk RBO3R 1000 mg/L



4. Penentuan Panjang Gelombang Maksimum



5. Pembuatan Kurva Kalibrasi Larutan Standar Zat Warna RBO3R



6. Penentuan pH optimum

Larutan RBO3R 30 mg/L

- Dipipet 25 mL ke dalam 6 buah erlenmeyer
- Diatur pH 4, 5, 6, 7, 8 dan 9
- Ditambahkan magnetit sebanyak 0,1 g
- Diaduk menggunakan *magnetic stirrer* selama 60 menit
- Dipisahkan adsorben dari larutan menggunakan magnet eksternal

Filtrat | Adsorben

- Diukur absorbansinya menggunakan spektrofotometer UV-Vis

Hasil

7. Penentuan Waktu kontak optimum

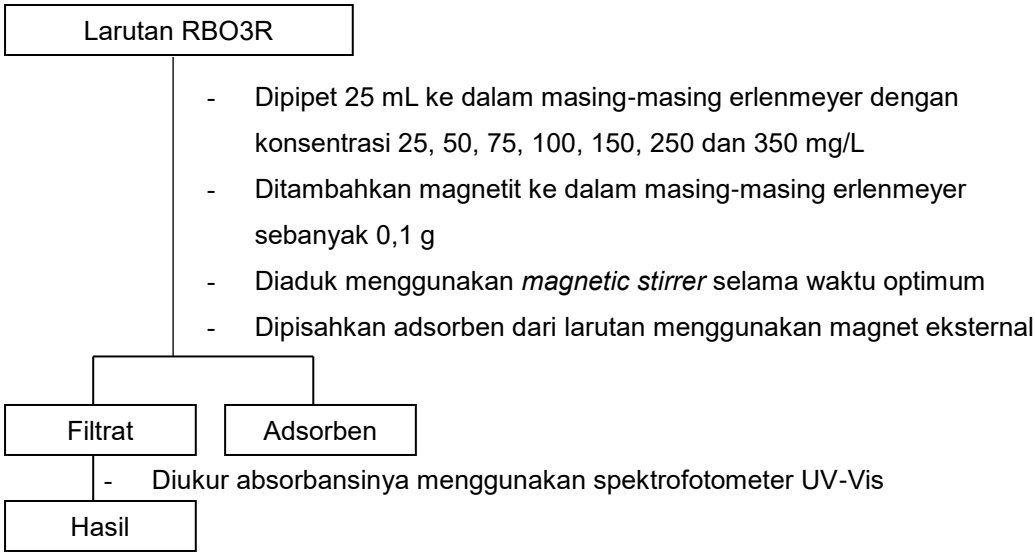
Larutan RBO3R 30 mg/L

- Dipipet 25 mL larutan dengan pH 6 ke dalam 7 buah erlenmeyer
- Ditambahkan magnetit sebanyak 0,1 g
- Diaduk menggunakan *magnetic stirrer* selama 5, 10, 20, 40, 60, 90 dan 120 menit
- Dipisahkan adsorben dari larutan menggunakan magnet eksternal

Filtrat | Adsorben

- Diukur absorbansinya menggunakan spektrofotometer UV-Vis

8. Penentuan Kapasitas Adsorpsi



Lampiran 2. Perhitungan

1. Pembuatan Larutan Induk RBO3R 1000 mg/L

$$\frac{mg}{L} = \frac{massa}{L}$$

$$1000\ \frac{mg}{L} = \frac{massa}{0{,}1\ L}$$

$$massa = \frac{1000}{0{,}1}\ mg$$

massa = 100 mg

massa = 0,1 g

2. Pembuatan Larutan Standar RBO3R 10; 20; 30; 40; dan 50 mg/L

a. 10 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000\ mg/L = 50\ mL \times 10\ mg/L$

$V_1 = 0{,}5\ mL$

b. 20 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000\ mg/L = 50\ mL \times 20\ mg/L$

$V_1 = 1\ mL$

c. 30 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000\ mg/L = 50\ mL \times 30\ mg/L$

$= 1{,}5\ mL$

$= V_2 \times C_2$

$/L = 50\ mL \times 40\ mg/L$

V_1 = 2 mL

e. 50 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000$ mg/L = 50 mL x 50 mg/L

V_1 = 2,5 mL

3. Pembuatan Variasi Konsentrasi pada Penentuan Kapasitas Adsorpsi

a. 25 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000$ mg/L = 50 mL x 25 mg/L

V_1 = 1,25 mL

b. 50 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000$ mg/L = 50 mL x 50 mg/L

V_1 = 2,5 mL

c. 75 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000$ mg/L = 50 mL x 75 mg/L

V_1 = 3,75 mL

d. 100 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000$ mg/L = 50 mL x 100 mg/L

= 5 mL

= $V_2 \times C_2$

/L = 50 mL x 150 mg/L

V_1 = 7,5 mL

f. 250 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000$ mg/L = 50 mL x 250 mg/L

V_1 = 22,5 mL

g. 350 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000$ mg/L = 50 mL x 350 mg/L

V_1 = 17,5 mL

h. 500 mg/L

$V_1 \times C_1 = V_2 \times C_2$

$V_1 \times 1000$ mg/L = 50 mL x 500 mg/L

V_1 = 25 mL

Lampiran 3. Dokumentasi Penelitian

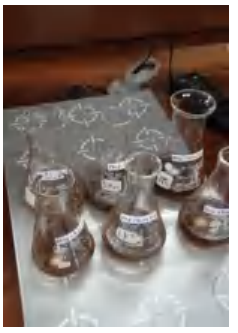
Padatan $FeSO_4.7H_2O$

Larutan $FeCl_3.6H_2O$

Penambahan NH_4OH

Larutan Induk RBO3R 1000 mg/L

Larutan Standar RBO3R 10; 20; 30; 40 dan 50 mg/L



Proses Adsorpsi RBO3R

si

Setelah Adsorpsi

Lampiran 4. Karakterisasi XRD

Name	Formula	Entry No.	FoM
Goethite	Fe H O2	96-900-2159	0.6876
Iron(III) oxide hydroxide (Goethite)	Fe H O2	96-100-8767	0.6832
Goethite	Fe O2	96-901-5697	0.6767
Iron(III) oxide hydroxide (Goethite)	Fe H O2	96-100-8768	0.6764
Goethite	Fe H O2	96-900-2160	0.6755
Goethite	Co0.1 Fe0.9 H O2	96-901-0411	0.6718
Goethite	Fe H O2	96-901-0407	0.6707
Goethite	Fe O2	96-901-6179	0.6694
Goethite	Co0.03 Fe0.97 H O2	96-901-0408	0.6684
(Fe0.99 Cd0.01) O (O H)	Cd0.01 Fe0.99 H O2	96-153-2551	0.6666
Iron(III) oxide hydroxide (Goethite)	Fe H O2	96-100-8769	0.6650
Goethite	Co0.07 Fe0.93 H O2	96-901-0410	0.6637
Goethite	Co0.05 Fe0.95 H O2	96-901-0409	0.6625
Goethite	Fe H O2	96-900-3078	0.6582
Goethite	Fe H O2	96-900-3079	0.6574
Goethite	Fe O2	96-901-6407	0.6573
Goethite	Fe H O2	96-221-1653	0.6433
Goethite	Fe O2	96-901-1413	0.6404
Goethite	Fe H O2	96-900-3077	0.6391
Iron(III) oxide hydroxide (Goethite)	Fe H O2	96-101-1088	0.6376
Lutecium borate	B24 Lu4 O49	96-154-7893	0.6287
Goethite	Fe O2	96-901-6060	0.6260

Search-Match

Settings

Reference database used	COD-Inorg 2023.12.05
Automatic zeropoint adaptation	Yes
Downgrade entries with low scaling factors	Yes
Minimum figure-of-merit (FoM)	0.60
2theta window for peak corr.	0.30 deg.
Minimum rel. int. for peak corr.	0
Parameter/influence 2theta	0.50
Parameter/influence intensities	0.50
Parameter multiple/single phase(s)	0.50

Peak List

No.	2theta [°]	d [Å]	I/I0 (peak height)	Counts (peak area)	FWHM	Matched
1	15.10	5.8626	74.86	0.97	0.1200	
2	17.98	4.9295	132.24	0.57	0.0400	
3	21.22	4.1836	322.33	23.70	0.6800	
4	23.08	3.8505	75.13	0.32	0.0400	
5	26.34	3.3809	87.58	0.76	0.0800	
6	30.26	2.9512	218.65	2.84	0.1200	A
7	31.26	2.8591	74.94	1.30	0.1600	
8	33.26	2.6916	273.36	11.82	0.4000	
9	35.68	2.5144	1000.00	77.85	0.7200	A
10	36.64	2.4507	515.84	24.54	0.4400	
11	40.08	2.2479	101.91	2.64	0.2400	
12	41.28	2.1853	120.14	2.60	0.2000	
13	43.28	2.0888	166.00	5.03	0.2800	A
14	53.36	1.7156	269.83	3.50	0.1200	A
15	57.32	1.6061	306.85	6.64	0.2000	A
16	59.06	1.5629	194.20	2.52	0.1200	
17	61.42	1.5083	150.95	0.65	0.0400	
18	62.92	1.4759	466.07	40.31	0.8000	A

Integrated Profile Areas

Based on calculated profile

Profile area	Counts	Amount
Overall diffraction profile	38779	100.00%
Background radiation	16991	43.81%
Diffraction peaks	21788	56.19%
Peak area belonging to selected phases	8015	20.67%
	8015	*20.67%*
	13773	35.52%

Peak Residuals

	Counts	Amount
	209	100.00%
phases	137	65.47%
	72	34.53%

Diffraction Pattern Graphics

Match! Phase Analysis Report

Sample: fe3o4#wahidah

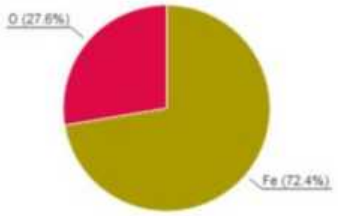
Sample Data

File name	fe3o4#wahidah.txt
File path	D:/Bismillah Jadi Sarjana/DRAFTKU TERSAYANG/Data/XRD Fe3O4
Data collected	Jan 19, 2024 16:48:03
Data range	15.000° - 69.960°
Original data range	15.000° - 69.960°
Number of points	2749
Step size	0.020
Rietveld refinement converged	No
Alpha2 subtracted	No
Background subtr.	No
Data smoothed	Yes
Radiation	X-rays
Wavelength	1.541874 Å

Analysis Results

Phase composition (Weight %)

Elemental composition (Weight %)



Index	*Amount (%)*	*Name*
A	100.0	Magnetite
	35.5	*Unidentified peak area*

Formula sum
Fe3 O4

Element	*Amount (weight %)*
Fe	72.4%
O	27.6%(*)
*LE (sum)	27.6%

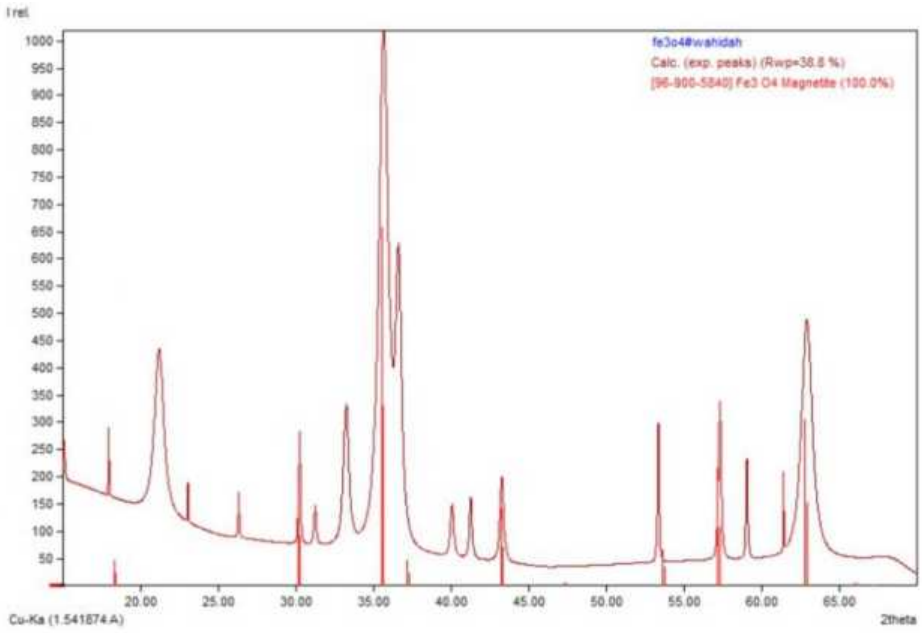
Details of identified phases

A: Magnetite (100.0 %)*

Formula sum	Fe3 O4
Entry number	96-900-5840
Figure-of-Merit (FoM)	0.731573*
Total number of peaks	72
Peaks in range	72
Peaks matched	11
Intensity scale factor	0.66
2theta correction	-0.065°
Space group	F d -3 m
Crystal system	cubic
Unit cell	a= 8.3656 Å
I/Ic	5.66
Calc. density	5.254 g/cm³
Reference	Nakagiri N., Manghnani M. H., Ming L. C., Kimura S., "Crystal structure of magnetite under pressureSample: P = 2.09 GPa", Physics and Chemistry of Minerals **13**, 238-244 (1986)

emally for the calculation of the amounts, the intensity scaling factors as well as the figure-of-merit (FoM), due to natic zero point adaption".

Candidates



Lampiran 5. Perhitungan Hasil Rendamen dan Ukuran Partikel

Hasil Rendemen

$$\% \text{ rendemen} = \frac{\text{berat akhir rendamen}}{\text{berat total bahan mentah}} \times 100\%$$

$$\% \text{ rendemen} = \frac{17{,}86 \text{ g}}{27{,}03 \text{ g} + 9{,}94 \text{ g}} \times 100\%$$

% rendemen = 48,31%

Persamaan *Debye-Scherer*

$$D = \frac{K \lambda}{\beta \cos\theta}$$

Keterangan:

D = Ukuran partikel (nm)

K = Faktor bentuk dari kristal (0,98)

λ = Panjang gelombang dari sinar-X (1,54178 Å)

β = Nilai FWHM (rad)

θ = Sudut Bragg/ sudut difraksi (2θ/2)

2θ(°)	FWHM (°)	D (nm)
35,67	1,03	8,84
36,58	0,76	12,01
62,92	0,88	11,53
n rata-rata partikel		10,79 nm

Perhitungan:

$2\theta = 35{,}67$

$\theta = \frac{35{,}67}{2} = 17{,}8375$

$\text{Cos } \theta = 0{,}9519$

$\beta \text{ (FWHM)} = \frac{1{,}03}{180 \text{ rad}} \text{ x } 3{,}14$

$= 0{,}01796 \text{ rad}$

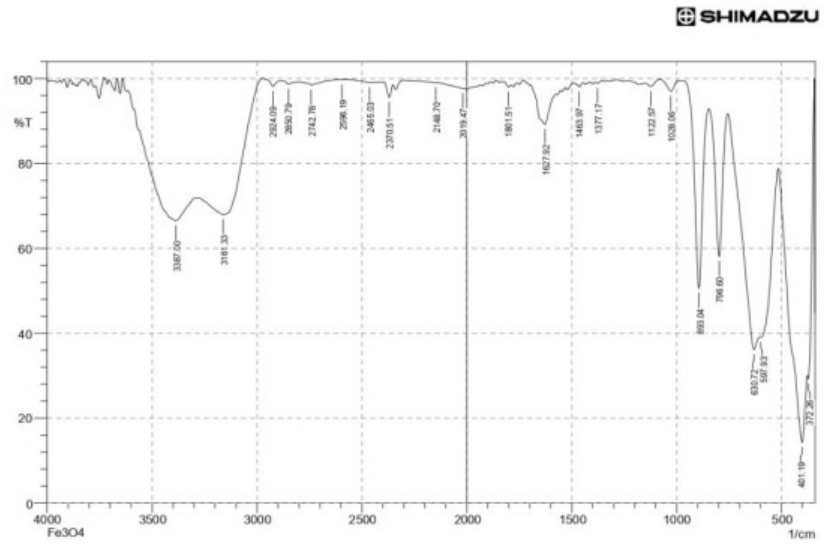
$D = \frac{K \lambda}{\beta \text{ Cos}\theta}$

$= \frac{0{,}98 \text{ x } 0{,}154 \text{ nm}}{0{,}01796 \text{ x } 0{,}9515}$

$= \frac{0{,}15092}{0{,}01707}$

$= 8{,}84 \text{ nm}$

Lampiran 6. Karakterisasi FTIR Nanopartikel Magnetit



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	372.26	29.3	8.755	376.12	345.26	9.847	1.882
2	401.19	14.307	23.808	514.99	378.05	63.164	19.777
3	597.93	39.118	1.797	601.79	516.92	23.888	2.614
4	630.72	36.206	12.341	754.17	603.72	37.536	4.307
5	796.6	58.101	34.122	844.82	756.1	9.997	6.892
6	893.04	50.661	44.761	966.34	846.75	12.185	10.112
7	1028.06	97.034	2.63	1078.21	991.41	0.572	0.453
8	1122.57	98.139	1.1	1147.65	1078.21	0.34	0.148
9	1377.17	98.85	0.374	1386.82	1357.89	0.113	0.026
10	1463.97	98.061	0.536	1471.69	1444.68	0.179	0.028
11	1627.92	89.213	8.015	1695.43	1575.84	3.631	2.236
12	1801.51	97.997	0.716	1822.73	1789.94	0.216	0.049
13	2019.47	97.62	0.109	2139.06	2013.68	0.912	0.008
14	2148.7	99.031	0.05	2258.64	2139.06	0.388	-0.003
15	2370.51	95.565	3.236	2397.52	2351.23	0.521	0.289
16	2465.03	99.069	0.229	2582.68	2418.74	0.441	0.026
17	2596.19	99.69	0.006	2615.47	2582.68	0.044	0
18	2742.78	98.447	0.911	2796.78	2615.47	0.677	0.246
19	2850.79	98.693	0.675	2873.94	2796.78	0.314	0.087
20	2924.09	98.155	1.594	2972.31	2885.51	0.296	0.216
21	3161.33	67.982	14.53	3275.13	2974.23	33.785	12.462
22	3387	66.546	12.466	3616.53	3296.35	39.218	14.108

Comment;
Fe3O4

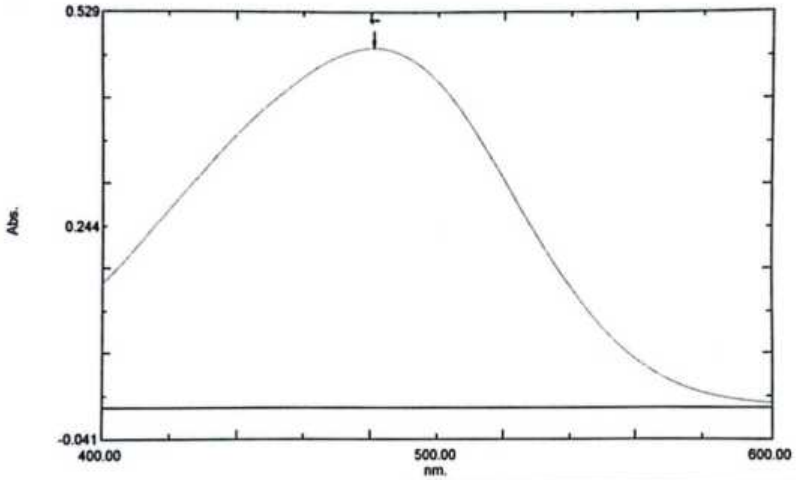
Date/Time; 12/13/2023 1:39:24 PM
No. of Scans;
Resolution;
Apodization;

Lampiran 7. Panjang Gelombang Maksimum Zat Warna RBO3R

Spectrum Peak Pick Report

01/03/2024 01:36:52 PM

Data Set: lamda max Wahidah.spc - RawData



No.	P/V	Wavelength	Abs.	Description
1		480.60	0.481	

[Measurement Properties]
Wavelength Range (nm.): 400.00 to 600.00
Scan Speed: Fast
Sampling Interval: 0.2
Auto Sampling Interval: Enabled
Scan Mode: Single

[Instrument Properties]
Instrument Type: UV-2600 Series
Measuring Mode: Absorbance
Slit Width: 1.0
Accumulation time: 2.0 sec.
Light Source Change Wavelength: 323.0 nm
Detector Unit: Direct
S/R Exchange: Normal
Stair Correction: OFF

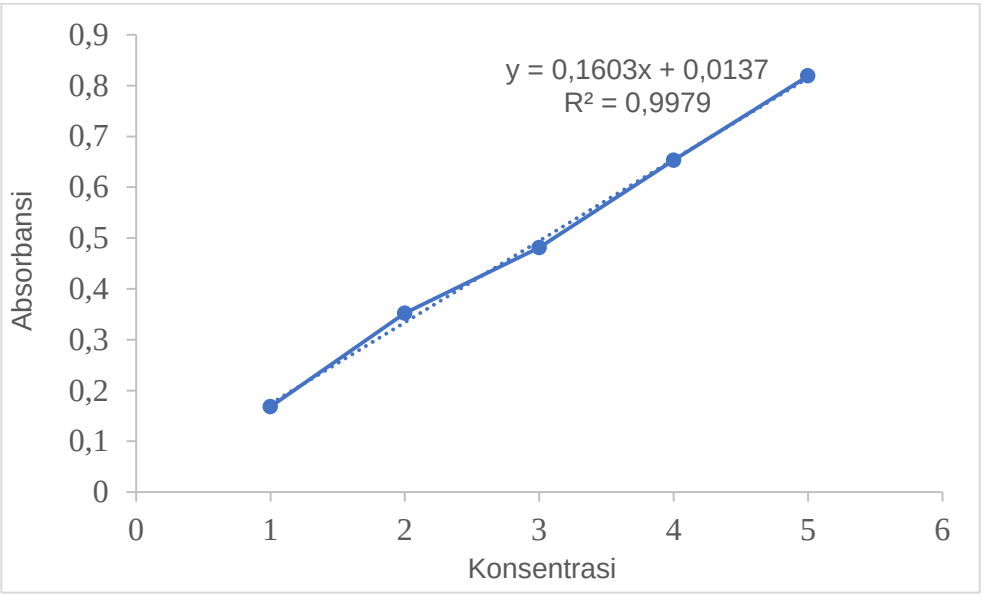
[Attachment Properties]
Attachment: None

[Operation]
Threshold: 0.0010000
Points: 4
InterPolate: Disabled
Average: Disabled

[Sample Preparation Properties]
Weight:
Volume:
Dilution:
Path Length:
Additional Information: 12/07/2023

Lampiran 8. Data Absorbansi Kurva Standar Larutan RBO3R

Konsentrasi	Absorbansi
10 ppm	0,168
20 ppm	0,352
30 ppm	0,481
40 ppm	0,653
50 ppm	0,819



Lampiran 9. Penentuan pH Optimum Adsorpsi Zat Warna RBO3R oleh Nanopartikel Magnetit

Derajat Keasaman (pH)	Co (Mg/L)	Ce (Mg/L)	Jumlah Adsorben (g)	Jumlah RBO3R yang diadsorpsi, q_e (mg/g)
4	30	1,01	0,1	7,25
5	30	0,91	0,1	7,27
6	30	0,15	0,1	7,46
7	30	0,49	0,1	7,38
8	30	0,63	0,1	7,34
9	30	1,37	0,1	7,16

Contoh perhitungan RBO3R yang teradsorpsi pada pH 6

$$q_e = \frac{(Co\text{-}Ce)\ V}{m}$$

$$q_e = \frac{(30\ mg/L - 1{,}5\ mg/L)\ 0{,}025\ L}{0{,}1\ g}$$

$q_e = 7{,}4625\ mg/g$

Lampiran 10. Penentuan Waktu Optimum Adsorpsi Zat Warna RBO3R oleh Nanopartikel Magnetit

Waktu Kontak (Menit)	Co (Mg/L)	Ce (Mg/L)	Jumlah Adsorben (g)	Jumlah RBO3R yang diadsorpsi, q_e (mg/g)
5	30	1,18	0,1	7,20
10	30	0,96	0,1	7,26
20	30	0,71	0,1	7,32
40	30	0,42	0,1	7,39
60	30	0,26	0,1	7,44
90	30	0,09	0,1	7,48
120	30	0,23	0,1	7,44

Contoh perhitungan RBO3R yang teradsorpsi pada 90 menit

$$q_e = \frac{(Co\text{-}Ce)\ V}{m}$$

$$q_e = \frac{(30\ mg/L - 0{,}09375)\ 0{,}025\ L}{0{,}1\ g}$$

q_e = 7,48 mg/g

Lampiran 11. Data Studi Kinetika Adsorpsi RBO3R oleh Nanopartikel Magnetit

Waktu Kontak (Menit)	q_e (mg/g)	q_t (mg/g)	$q_t - q_e$ (mg/g)	ln ($q_t - q_e$)	t/ q_e
5	7,20	7,48	0,27	-1,30	0,69
10	7,26	7,48	0,22	-1,53	1,38
20	7,32	7,48	0,15	-1,88	2,73
40	7,39	7,48	0,08	-2,49	5,41
60	7,44	7,48	0,04	-3,20	8,07
90	7,48	7,48	0	0	12,04
120	7,44	7,48	0,03	-3,42	16,12

Dari grafik kinetika orde satu satu semu diperoleh persamaan garis:

$$\ln(q_e - q_t) = \ln q_e - K_1.t$$

$$y = -0,03x - 1,17$$

- $\ln q_e$ = Intercept
  q_e = Inv. ln Intercept

  $\ln q_e$ = -1,17
  q_e = 0,31

- K_1 = -Slope
  K_1 = - (-0,03)
  K_1 = 0,03

Dari grafik kinetika orde satu dua semu diperoleh persamaan garis:

$$1/q_t = 1/K_2.q_e^2 + (1/q_e)t$$

$$y = 0,13x + 0,5$$

- $1/q_e$ = Slope
  q_e = 1/Slope
  q_e = 1/0,13
  = 7,5 mg/g

  = Intercept
  = 1/Intercept . q_e^2
  = 1/0,5 x $(7,5)^2$
  = 0,03

Lampiran 12. Penentuan Kapasitas Adsorpsi RBO3R oleh Nanopertikel Magnetit

C_o (mg/L)	C_e (mg/L)	m (g)	q_e (mg/g)	C_e/q_e	Log C_e	Log q_e
10	0,49	0,1	12,38	0,04	-0,31	1,09
25	1,01	0,1	18,50	0,05	0,01	1,27
50	2,37	0,1	24,41	0,10	0,38	1,39
75	6,22	0,1	35,95	0,17	0,79	1,56
100	15,12	0,1	58,72	0,26	1,18	1,77
150	24,63	0,1	81,34	0,30	1,39	1,91
250	182,88	0,1	79,28	2,31	2,26	1,90
350	0,49	0,1	12,38	0,04	-0,31	1,09

Contoh perhitungan RBO3R yang teradsorpsi pada konsentrasi 350 mg/L

$$q_e = \frac{(Co\text{-}Ce)\ V}{m}$$

$$q_e = \frac{(350\ mg/L - 24,63)\ 0,025\ L}{0,1\ g}$$

q_e = 81,34 mg/g

Lampiran 13. Isoterm Adsorpsi Nanopartikel Magnetit

1. Isoterm Adsorpsi Langmuir Bentuk Linear

Berdasarkan model isotermal Langmuir diperoleh persamaan garis:

$$y = 0{,}01x + 0{,}04$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,01 dan nilai *intercept* (b) = 0,04

Nilai kapasitas adsorpsi dapat dihitung sebagai berikut:

$$\frac{1}{qe} = \text{Slope}$$

$$q_e = \frac{1}{\text{slope}} = \frac{1}{0{,}01} = 83{,}33 \text{ mg/g}$$

Intensitas Adsorpsi dapat dihitung sebagai berikut:

$$\frac{1}{Qmaks \,.\, b} = \text{Intercept}$$

$$b = \frac{1}{83{,}33 \text{ mg/g}.\ 0{,}04}$$

$$= 0{,}28 \text{ L mg}^{-1}$$

2. Isoterm adsorpsi Freundlich bentuk linear

Berdasarkan model isotermal Freundlich diperoleh persamaan garis :

$$y = 0{,}29x + 1{,}37$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,29 dan nilai *intercept* (b) = 1,37

Nilai kapasitas adsorpsi dapat dihitung sebagai berikut :

Log k = *intercept*

k = invers log *intercept*

k = invers log 1,37

apat dihitung sebagai berikut :

pe)

3. Isoterm adsorpsi Sips bentuk linear

$$\ln \frac{q_e}{q_m - q_e} = \ln K_s + \frac{1}{n} . \ln C_e$$

Parameter	Nilai
Persamaan	y = 0,74x - 0,95
K_s	0,25
N	0,94
q_{max}	88,65
R^2	0,80

4. Isoterm adsorpsi Langmuir bentuk non-linear (program solver)

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeL (mg/g)	Res^2
50	0,49	12,38	5,17	51,98
75	1,01	18,50	10,08	70,90
100	2,38	24,41	20,94	11,90
150	6,22	35,95	41,50	30,84
250	15,13	58,72	64,55	33,99
350	24,63	81,34	75,91	29,49
500	174,94	81,27	85,56	18,44

$$q_e = \frac{q_m . K_L . C_e}{1 + K_L . C_e}$$

Parameter	Nilai
K	0,28
Qmax	87,33
RSS	688,04

5. Isoterm adsorpsi Freundlich non-linear (program solver)

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeF (mg/g)	Res^2
50	0,49	12,38	10,74	2,68
75	1,01	18,50	15,48	9,00
100	2,38	24,41	23,90	0,25
150	6,22	35,95	39,03	9,54
250	15,13	58,72	61,39	7,12
350	24,63	81,34	78,69	6,99
500	174,94	81,27	91,86	112,25

$$q_e = K_F \cdot C_e^{1/n}$$

Parameter	Nilai
K	30,00
N	0,22
RSS	1404,09

6. Isoterm adsorpsi Sips bentuk non-linear (program solver)

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeS (mg/g)	Res^2
50	0,49	12,38	10,45	3,71
75	1,01	18,50	15,22	10,76
100	2,38	24,41	23,73	0,46
150	6,22	35,95	39,02	9,46
	15,13	58,72	61,41	7,24
	24,63	81,34	78,48	8,19
	174,94	81,27	86,23	24,69

$$q_e = \frac{qm \,.\, Ks \,.\, C_e^{1/n}}{1 + K_s \,.\, C_e^n}$$

Parameter	Nilai
K	0,25
N	0,94
Qmax	88,65
RSS	697,98