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Lampiran 1. Bagan Kerja

1. Sintesis Nanopartikel Magnetit

$FeSO_4.7H_2O$ sebanyak 9,9355 g dan $FeCl_3$ sebanyak 27,033 g

- Dilarutkan dengan akuades 100 mL dalam gelas kimia 250 mL
- Ditutup dengan *plastic wrap*
- Diaduk menggunakan *magnetite stirrer* selama 5 menit
- Ditambahkan NH_3 10% tetes demi tetes sampai pH 11 selama 2 jam
- Disaring dengan *vacuum buchner*

Filtrat

Endapan

- Dicuci dengan etanol, lalu dicuci dengan akuades hingga pH netral
- Dikeringkan pada suhu 65^oC selama 6 jam
- Dikarakterisasi menggunakan FTIR dan XRD

Nanopartikel Magnetit

2. Karakterisasi Nanopartikel Magnetit

Nanopartikel magnetit

Karakterisasi

XRD | FTIR

3. Pembuatan Larutan Induk RBG6B 1000 mg/L

0,1 g zat warna RBG6B

- Diencerkan menggunakan akuades dalam labu ukur 100 mL

Larutan Induk Zat Warna RBG6B 1000 mg/L

4. Penentuan Panjang Gelombang Maksimum

Larutan RBG6B 30 mg/L

- Diukur absorbansinya pada panjang gelombang 550-650 nm

Data

- Dibuat kurva absorbansi dan panjang gelombang

Panjang gelombang maksimum

5. Pembuatan Kurva Kalibrasi Larutan Standar Zat Warna RBG6B

Larutan induk RBG6B
1000 mg/L

- Dipipet sebanyak 0,5; 1; 1,5; 2 dan 2,5 mL ke dalam labu takar 50 mL
- Diencerkan hingga tanda batas

Larutan RBG6B konsentrasi
10; 20; 30; 40 dan 50 mg/L

- Diukur absorbansinya menggunakan Spektrofotometer UV-Vis pada panjang gelombang maksimum

Kurva kalibrasi dan
persamaan regresi

6. Penentuan pH optimum

Larutan RBG6B 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 *magnetite stirrer* selama 60 menit
- Dipisahkan adsorben dari larutan menggunakan magnet eksternal

Filtrat | Adsorben

Filtrat:

- Diukur absorbansinya menggunakan spektrofotometer UV-Vis

Hasil

7. Penentuan Waktu kontak optimum

Larutan RBG6B 30 mg/L

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

Filtrat | Adsorben

Filtrat:

- Diukur absorbansinya menggunakan spektrofotometer UV-Vis

Hasil

8. Penentuan Kapasitas Adsorpsi

Larutan RBG6B

- Dipipet 25 mL ke dalam masing-masing erlenmeyer dengan konsentrasi 10, 25, 50, 75, 100, 150, 250 dan 350 mg/L
- Ditambahkan magnetit ke dalam masing-masing erlenmeyer sebanyak 0,1 g
- Diaduk menggunakan *magnetite stirrer* selama waktu optimum
- Dipisahkan adsorben dari larutan menggunakan magnet eksternal

Filtrat | Adsorben

Filtrat

- Diukur absorbansinya menggunakan spektrofotometer UV-Vis

Hasil

Lampiran 2. Perhitungan

1. Pembuatan Larutan Induk RBG6B 1000 mg/L

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

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

massa = 1000 mg/L x 0,1 L

massa = 100 mg

massa = 0,1 g

2. Pembuatan Larutan Standar RBG6B 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 x 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 x 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 x 30 mg/L

V_1 = 1,5 mL

d. 40 mg/L

$V_1 \times C_1 = V_2 \times C_2$

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

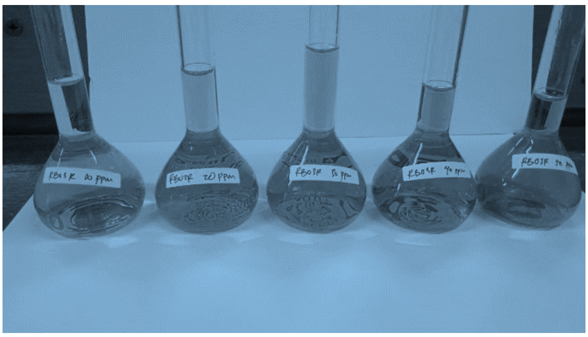
Lampiran 3. Dokumentasi Penelitian

Padatan $FeSO_4.7H_2O$

Larutan $FeCl_3.6H_2O$

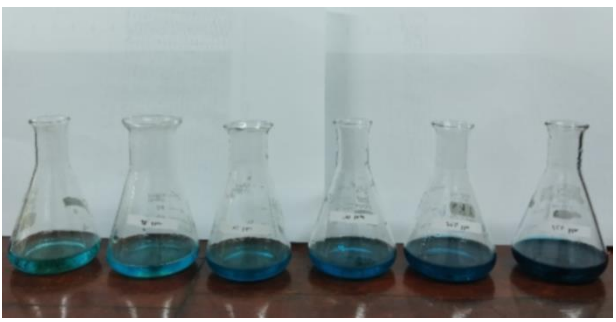
Penambahan NH_4OH

Larutan Induk RBG6B 1000 mg/L

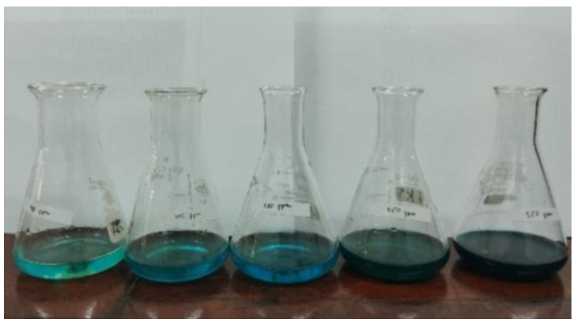


Larutan Standar RBG6B 10; 20; 30; 40 dan 50 mg/L

Proses Adsorpsi RBG6B



Sebelum Adsorpsi



Setelah Adsorpsi

Lampiran 4. Karakterisasi XRD

*** Basic Data Process ***

Group : Standard
Data : fe3o4#azzam

Strongest 3 peaks

no.	peak no.	2Theta (deg)	d (A)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)
1	11	35.4883	2.52750	100	0.80330	38	1435
2	34	62.6600	1.48144	58	0.56000	22	887
3	12	36.4600	2.46234	47	0.60000	18	611

Peak Data List

peak no.	2Theta (deg)	d (A)	I/I1	FWHM (deg)	Intensity (Counts)	Integrated Int (Counts)
1	21.1400	4.19927	26	0.48000	10	389
2	22.1400	4.01181	3	0.00000	1	0
3	23.0800	3.85050	5	0.08000	2	12
4	24.3600	3.65099	3	0.00000	1	0
5	26.0300	3.42042	8	0.06000	3	35
6	27.1400	3.28300	3	0.00000	1	0
7	29.0400	3.07238	5	0.04000	2	8
8	30.1200	2.96463	26	0.52000	10	297
9	33.0800	2.70580	18	0.32000	7	144
10	34.6600	2.58599	29	0.36000	11	260
11	35.4883	2.52750	100	0.80330	38	1435
12	36.4600	2.46234	47	0.60000	18	611
13	37.7300	2.38233	5	0.14000	2	21
14	38.8300	2.31733	5	0.06000	2	21
15	39.1200	2.30082	3	0.00000	1	0
16	39.7000	2.26853	8	0.12000	3	55
17	40.7800	2.21091	8	0.04000	3	22
18	42.2200	2.13877	3	0.00000	1	0
19	43.0500	2.09944	21	0.50000	8	248
20	43.7900	2.06566	8	0.06000	3	24
21	44.9600	2.01459	3	0.00000	1	0
22	46.6800	1.94429	5	0.24000	2	33
23	47.1700	1.92522	11	0.22000	4	77
24	47.9400	1.89608	8	0.04000	3	23
25	50.5600	1.80380	8	0.16000	3	52
26	53.2600	1.71855	18	0.60000	7	323
27	53.9950	1.69688	18	0.23000	7	105
28	54.6600	1.67779	3	0.00000	1	0
29	57.0500	1.61305	32	0.78000	12	497
30	58.1800	1.58438	3	0.00000	1	0
31	58.9000	1.56672	16	0.32000	6	121
32	59.8400	1.54434	3	0.00000	1	0
33	61.2300	1.51257	16	0.26000	6	125
34	62.6600	1.48144	58	0.56000	22	887
35	63.8800	1.45606	13	0.24000	5	154
36	65.3900	1.42604	8	0.14000	3	67

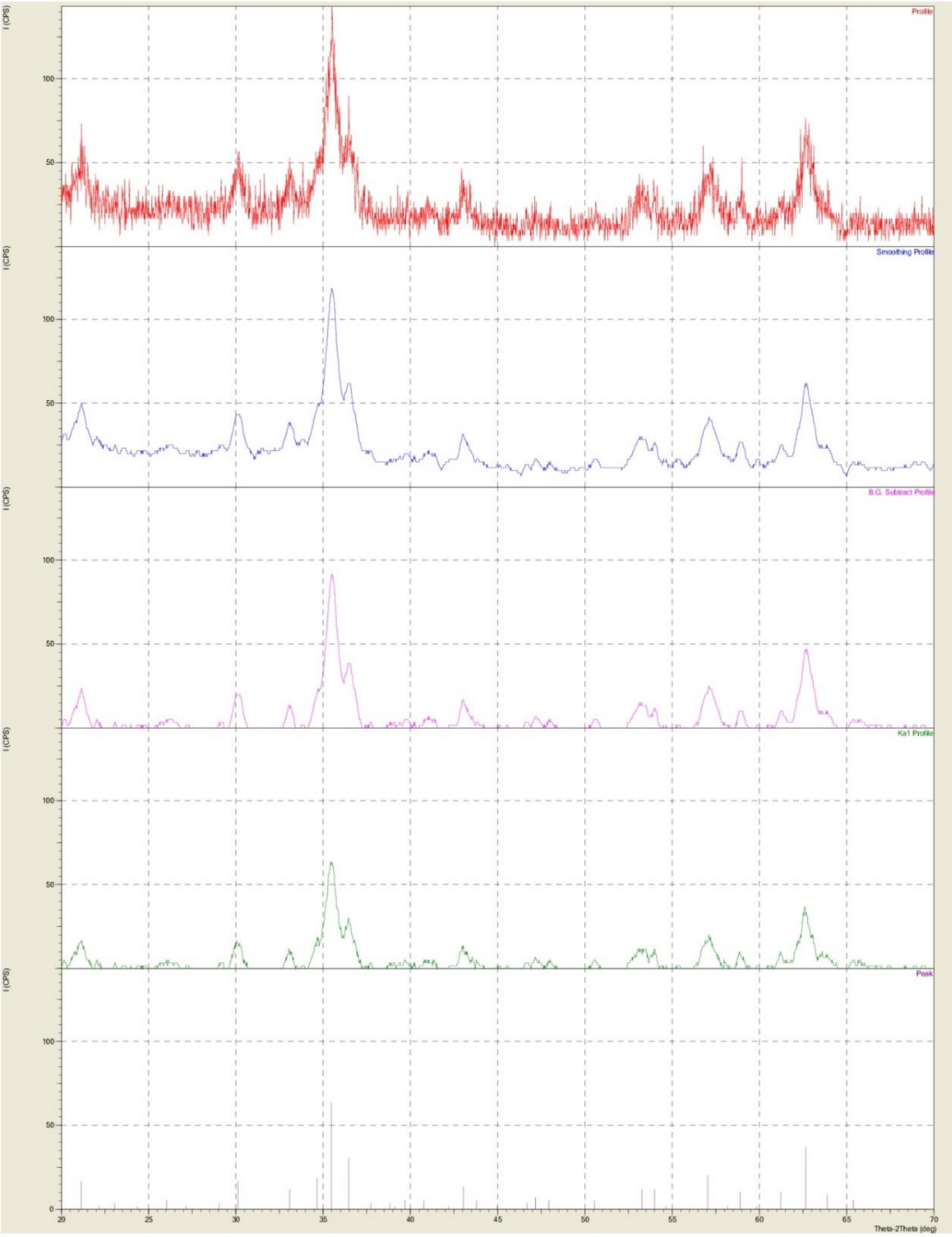
```
        ***  Basic Data Process  ***

# Data Infomation
          Group                  : Standard
          Data                   : fe3o4#azzam
          Sample Nmae            : powder
          Comment                :
          Date & Time            : 12-20-23 12:38:48

# Measurement Condition
    X-ray tube
          target                 : Cu
          voltage                : 40.0 (kV)
          current                : 30.0 (mA)
    Slits
          Auto Slit              : not Used
          divergence slit        :   1.00000 (deg)
          scatter slit           :   1.00000 (deg)
          receiving slit         :   0.30000(mm)
    Scanning
          drive axis             : Theta-2Theta
          scan range             :   20.0000 - 70.0000 (deg)
          scan mode              : Continuous Scan
          scan speed             :    2.0000 (deg/min)
          sampling pitch         :    0.0200 (deg)
          preset time            :    0.60 (sec)

# Data Process Condition
    Smoothing                    [ AUTO ]
          smoothing points       : 31
    B.G.Subtruction              [ AUTO ]
          sampling points        : 49
          repeat times           : 30
    Ka1-a2 Separate              [ MANUAL ]
          Ka1 a2 ratio           : 50 (%)
    Peak Search                  [ AUTO ]
          differential points    : 41
          FWHM threhold          : 0.050 (deg)
          intensity threhold     : 30 (par mil)
          FWHM ratio  (n-1)/n    : 2
    System error Correction      [ NO ]
    Precise peak Correction      [ NO ]
```

< Group: Standard   Data: fe3o4#azzam >



Lampiran 5. Perhitungan Hasil Rendamen dan Ukuran Partikel

Hasil Rendemen

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

$$\% \text{ rendemen} = \frac{22{,}04 \text{ g}}{27{,}033 \text{ g} + 9{,}9355 \text{ g}} \times 100\%$$

$$\% \text{ rendemen} = 60\%$$

Persamaan *Debye-Scherer*

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

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)
35,48	0,80	11,35
36,46	0,60	15,88
62,66	0,56	17,67
Ukuran rata-rata partikel		14,97 nm

Perhitungan:

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

$2\theta = 35{,}48$

$\theta = \frac{35{,}48}{2} = 17{,}74$

$\text{Cos } \theta = 0{,}9524$

$\beta \text{ (FWHM)} = \frac{0{,}80}{180 \text{ rad}} \text{ x } 3{,}14$

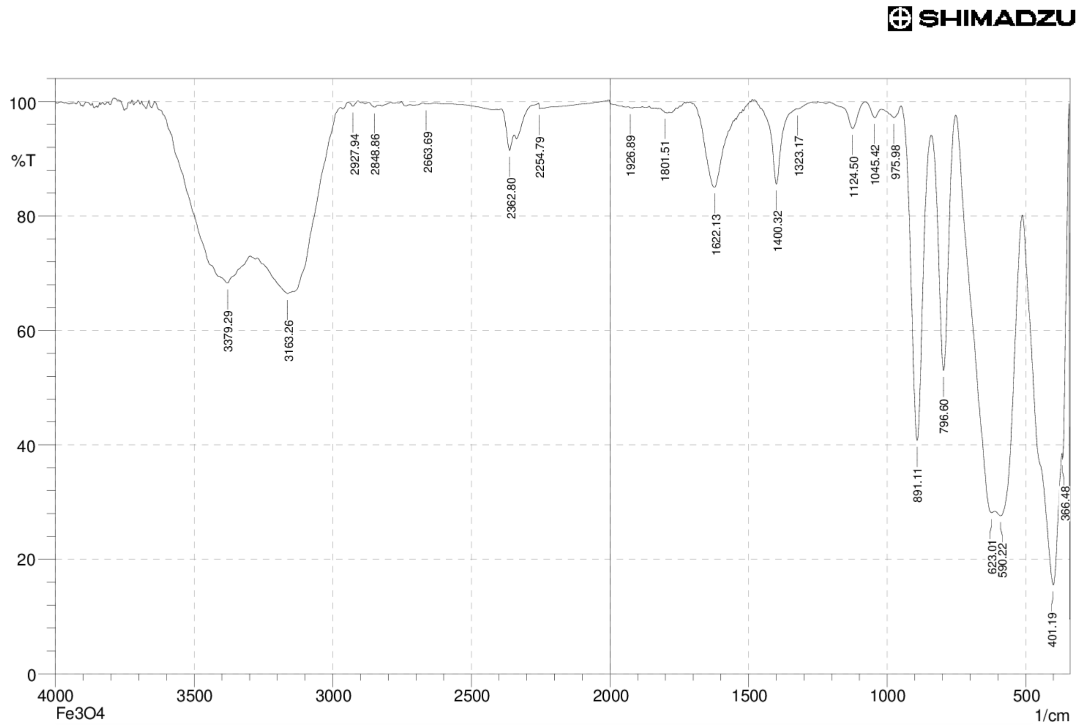
$= 0{,}014 \text{ rad}$

$= \frac{0{,}98 \text{ x } 0{,}154 \text{ nm}}{0{,}014 \text{ x } 0{,}9524}$

$= \frac{0{,}1509}{0{,}0133}$

$= 11{,}35 \text{ nm}$

Lampiran 6. Karakterisasi FTIR Nanopartikel Magnetit



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	366.48	37.543	5.794	368.4	345.26	5.112	0.521
2	401.19	15.55	31.867	511.14	370.33	63.222	26.747
3	590.22	27.609	11.946	611.43	513.07	38.457	7.443
4	623.01	28.151	5.042	752.24	613.36	38.833	1.728
5	796.6	52.994	42.777	839.03	754.17	10.59	9.006
6	891.11	40.768	55.696	948.98	840.96	16.466	14.827
7	975.98	97.206	1.787	1020.34	948.98	0.615	0.279
8	1045.42	97.168	2.01	1080.14	1020.34	0.406	0.218
9	1124.5	95.282	4.612	1207.44	1080.14	0.95	0.881
10	1323.17	98.69	0.127	1327.03	1274.95	0.173	0.009
11	1400.32	85.587	13.884	1477.47	1328.95	3.058	2.727
12	1622.13	85.042	12.972	1697.36	1554.63	5.242	4.03
13	1801.51	98.064	0.062	1824.66	1799.59	0.167	-0.004
14	1926.89	98.887	0.074	1932.67	1923.03	0.044	0.001
15	2254.79	98.753	0.94	2256.71	2029.11	0.644	0.491
16	2362.8	91.459	4.221	2391.73	2347.37	1.082	0.352
17	2663.69	99.558	0.16	2675.27	2632.83	0.067	0.016
18	2848.86	99.01	0.445	2873.94	2839.22	0.096	0.031
19	2927.94	99.197	0.787	2945.3	2910.58	0.061	0.059
20	3163.26	66.416	1.199	3271.27	3145.9	20.23	0.507
21	3379.29	68.277	11.077	3641.6	3298.28	35.058	11.483

Comment;

Fe3O4

Date/Time; 12/13/2023 1:44:09 PM

No. of Scans;

Resolution;

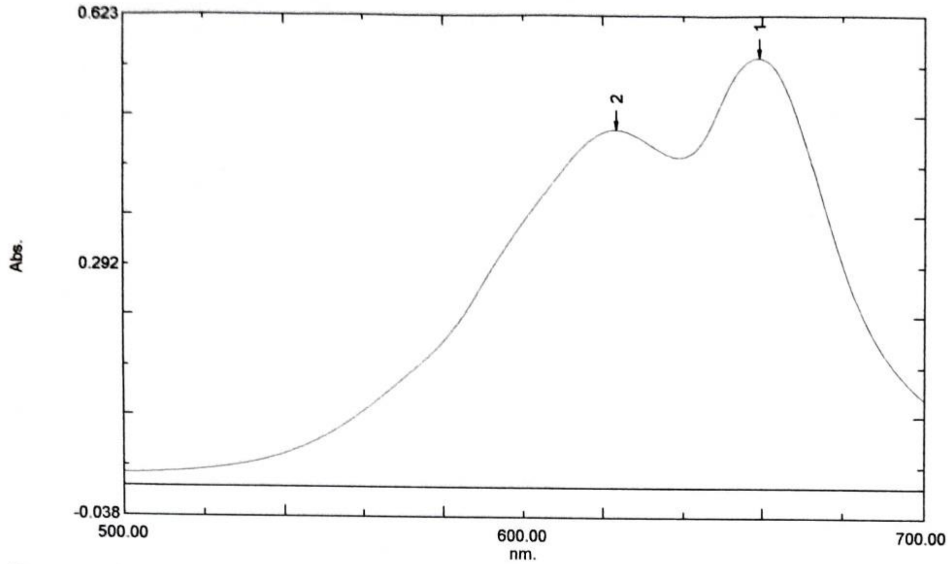
Apodization;

Lampiran 7. Panjang Gelombang Maksimum Zat Warna RBG6B

Spectrum Peak Pick Report

01/11/2024 01:55:23 AM

Data Set: lamdamax RBG6B.spc - RawData



No.	P/V	Wavelength	Abs.	Description
1	●	659.00	0.567	
2	●	623.60	0.473	

[Measurement Properties]
Wavelength Range (nm.): 500.00 to 700.00
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

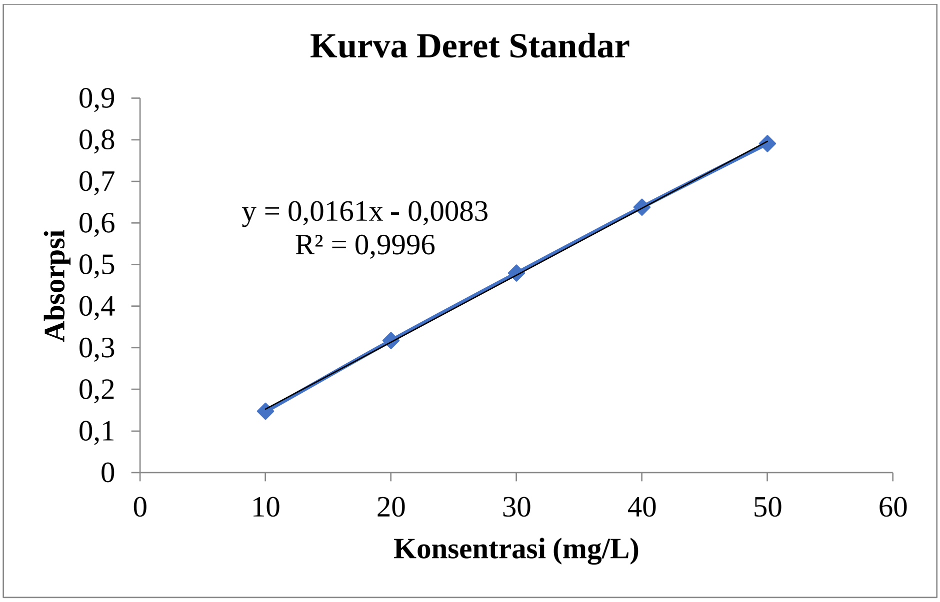
[Attachment Properties]
Attachment: None

[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 RBG6B

Konsentrasi	Absorbansi
10 ppm	0,147
20 ppm	0,317
30 ppm	0,479
40 ppm	0,638
50 ppm	0,791



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 RBG6B yang diadsorpsi, q_e (mg/g)**
4	30	18,3125	0,1	2,922
5	30	7,875	0,1	5,5312
6	30	2,5	0,1	6,875
7	30	1,375	0,1	7,1562
8	30	7,1875	0,1	5,7031
9	30	14,5	0,1	3,875

Contoh perhitungan RBG6B yang teradsorpsi pada pH 7

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

$$q_e = \frac{(30\ mg/L - 1{,}375\ mg/L)\ 0{,}05\ L}{0{,}1\ g}$$

$$q_e = 7{,}1562\ mg/g$$

Lampiran 10. Penentuan Waktu Optimum Adsorpsi Zat Warna RBG6B 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	11,3125	0,1	4,6719
10	30	8,375	0,1	5,4062
20	30	6,125	0,1	5,9688
40	30	1,8125	0,1	7,0469
60	30	1,1875	0,1	7,2031
90	30	1,625	0,1	7,0938
120	30	1,625	0,1	7,0938

Contoh perhitungan RBO3R yang teradsorpsi pada 60 menit

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

$$q_e = \frac{(30\ mg/L - 1{,}1875)\ 0{,}05\ L}{0{,}1\ g}$$

$$q_e = 7{,}2031\ mg/g$$

Lampiran 11. Data Studi Kinetika Adsorpsi RBG6B 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	4,6719	7,2031	2,5312	0,9287	1,0702
10	5,4062	7,2031	1,7969	0,5860	1,8497
20	5,9688	7,2031	1,2344	0,2106	3,3508
40	7,0469	7,2031	0,1562	-1,8563	5,6763
60	7,2031	7,2031	0	0	8,3297
90	7,0938	7,2031	0,1094	-2,213	12,6872
120	7,0938	7,2031	0,1094	-2,213	16,9163

Dari grafik kinetika orde satu satu semu diperoleh persamaan garis:

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

$$y = -0,0267x + 0,6652$$

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

  $\ln q_e$ = 0,6652
  q_e = 1,94

- K_1 = -Slope
  K_1 = - (-0,0267)
  K_1 = 0,0267
  K_1 = 0,03

Dari grafik kinetika orde satu dua semu diperoleh persamaan garis:

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

$$y = 0,1364x + 0,4009$$

- $1/q_e$ = Slope
  q_e = 1/Slope
  q_e = 1/0,1364
  q_e = 7,33

- $1/K_2.q_e^2$ = Intercept
  K_2 = 1/Intercept . q_e^2
  K_2 = 1/0,4009 x $(7,33)^2$
  K_2 = 0,05

Lampiran 12. Penentuan Kapasitas Adsorpsi RBG6B 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	0,9378	0,1	2,266	0,414	-0,0280	0,355
25	1,688	0,1	5,828	0,290	0,227	0,766
50	11,75	0,1	9,562	1,229	1,070	0,980
75	27,812	0,1	11,797	2,358	1,444	1,072
100	40,812	0,1	14,797	2,758	1,611	1,170
150	87,188	0,1	15,703	5,552	1,940	1,196
250	182,75	0,1	16,812	10,870	2,2618	1,226
350	284,375	0,1	16,406	17,333	2,454	1,215

Contoh perhitungan RBG6B yang teradsorpsi pada konsentrasi 10 mg/L

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

$$q_e = \frac{(10\ mg/L - 0,938)\ 0,05\ L}{0,1\ g}$$

$$q_e = 2,266\ mg/g$$

Lampiran 13. Isoterm Adsorpsi Nanopartikel Magnetit

1. Isoterm Adsorpsi Langmuir Bentuk Linear

Berdasarkan model isotermal Langmuir diperoleh persamaan garis:

$$y = 0{,}0589x + 0{,}405$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,0589 dan nilai *intercept* (b) = 0,405

Nilai kapasitas adsorpsi dapat dihitung sebagai berikut:

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

$$q_e = \frac{1}{\text{slope}} = \frac{1}{0{,}0589} = 16{,}98 \text{ mg/g}$$

Intensitas Adsorpsi dapat dihitung sebagai berikut:

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

$$b = \frac{1}{185{,}185 \text{ mg/g. } 0{,}405}$$

$$= 0{,}145 \text{ L mg}^{-1}$$

2. Isoterm adsorpsi Freundlich bentuk linear

Berdasarkan model isotermal Freundlich diperoleh persamaan garis :

$$y = 0,3096x + 0,5725$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,3096 dan nilai *intercept* (b) = 0,5725

Nilai kapasitas adsorpsi dapat dihitung sebagai berikut :

Log k = *intercept*

k = invers log *intercept*

k = invers log 0,5725

k = 1,773 mg/g

Intensitas adsorpsi dapat dihitung sebagai berikut :

$\frac{1}{n}$ = kemiringan (*slope*)

$\frac{1}{n}$ = 0,3096

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 = 0,7787x – 1,5745
K_s	0,19895
N	0,58557
q_{max}	17,79889
R^2	0,9588

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeL (mg/g)	Res^2
10	0,9375	2,265625	2,093066	0,029777
25	1,6875	5,828125	3,4224216	5,787409
50	11,75	9,5625	10,691269	1,27412
75	27,8125	11,796875	13,46006	2,766183
100	40,8125	14,796875	14,324458	0,223178
150	87,1875	15,703125	15,453808	0,062159
250	182,75	16,8125	16,035611	0,603557
350	284,375	16,40625	16,234891	0,029364

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

Parameter	Nilai
K	0,15384
Qmax	16,606
RSS	10,7757

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeF (mg/g)	Res^2
10	0,9375	2,265625	5,395615	9,796836
25	1,6875	5,828125	6,126563	0,089065
50	11,75	9,5625	9,319293	0,05915
75	27,8125	11,796875	11,22703	0,324719
100	40,8125	14,796875	12,19733	6,75764
150	87,1875	15,703125	14,37207	1,771696
250	182,75	16,8125	16,86511	0,002768
350	284,375	16,40625	18,55652	4,62366

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

Parameter	Nilai
K	5,471409
N	0,216145
RSS	23,42553

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeS (mg/g)	Res^2
10	0,9375	2,265625	4,845528	6,655902
25	1,6875	5,828125	6,14859	0,102698
50	11,75	9,5625	11,06758	2,265262
75	27,8125	11,796875	13,01831	1,49191
100	40,8125	14,796875	13,76177	1,071439
150	87,1875	15,703125	14,98114	0,521262
250	182,75	16,8125	15,86436	0,898974
350	284,375	16,40625	16,2677	0,019197

$$q_e = \frac{qm \cdot Ks \cdot C_e^{1/n}}{1 + K_S \cdot C_e^{n}}$$

Parameter	Nilai
K	0,19895
N	0,58557
Qmax	17,79889
RSS	13,0266