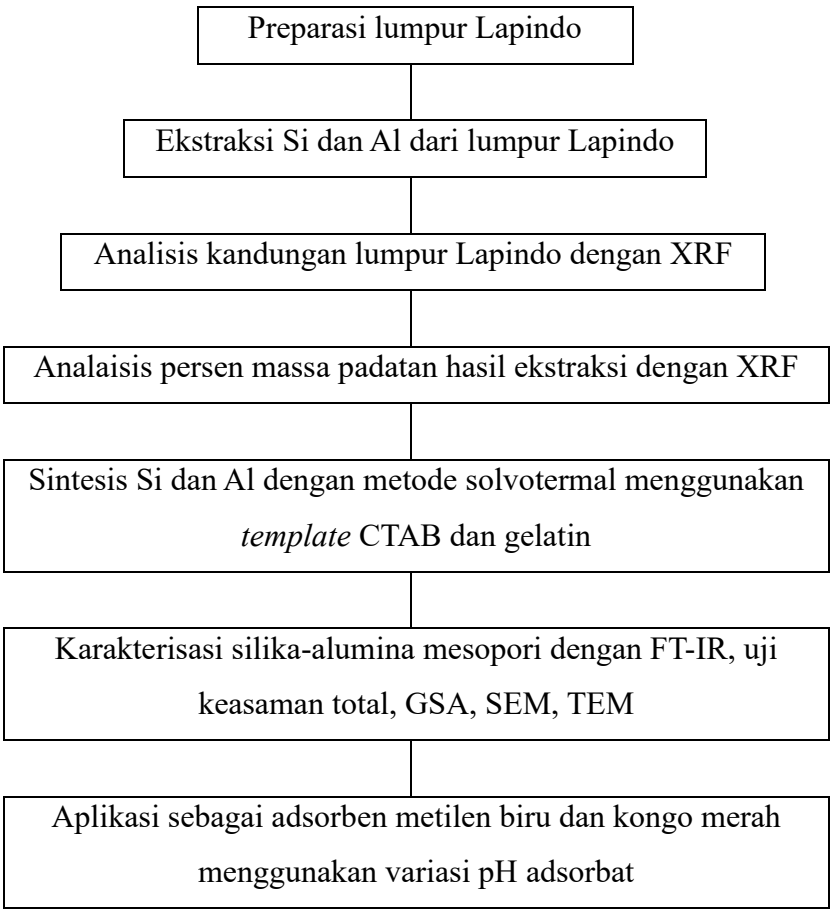
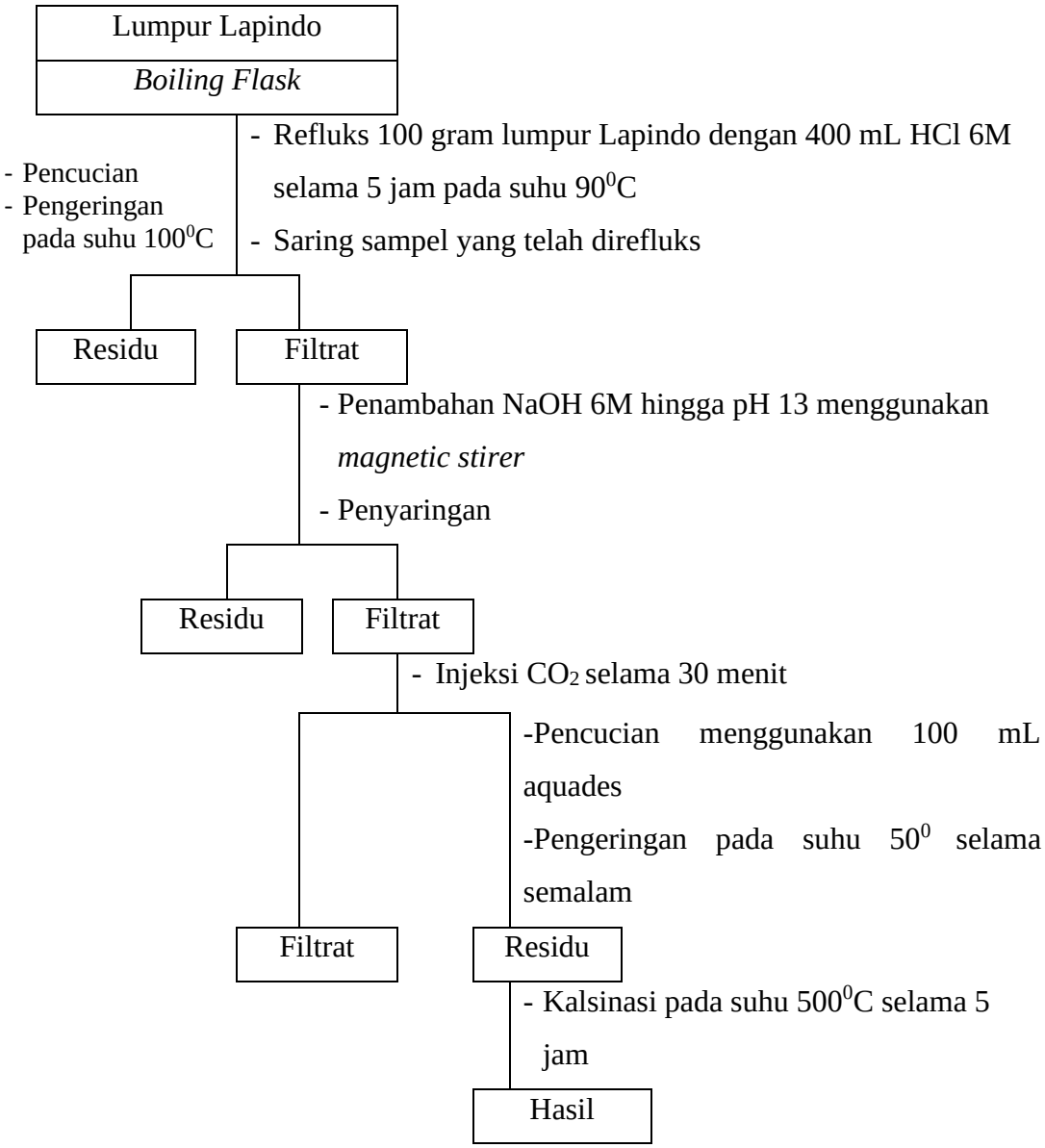
LAMPIRAN-LAMPIRAN

Lampiran 1. Alur Penelitian

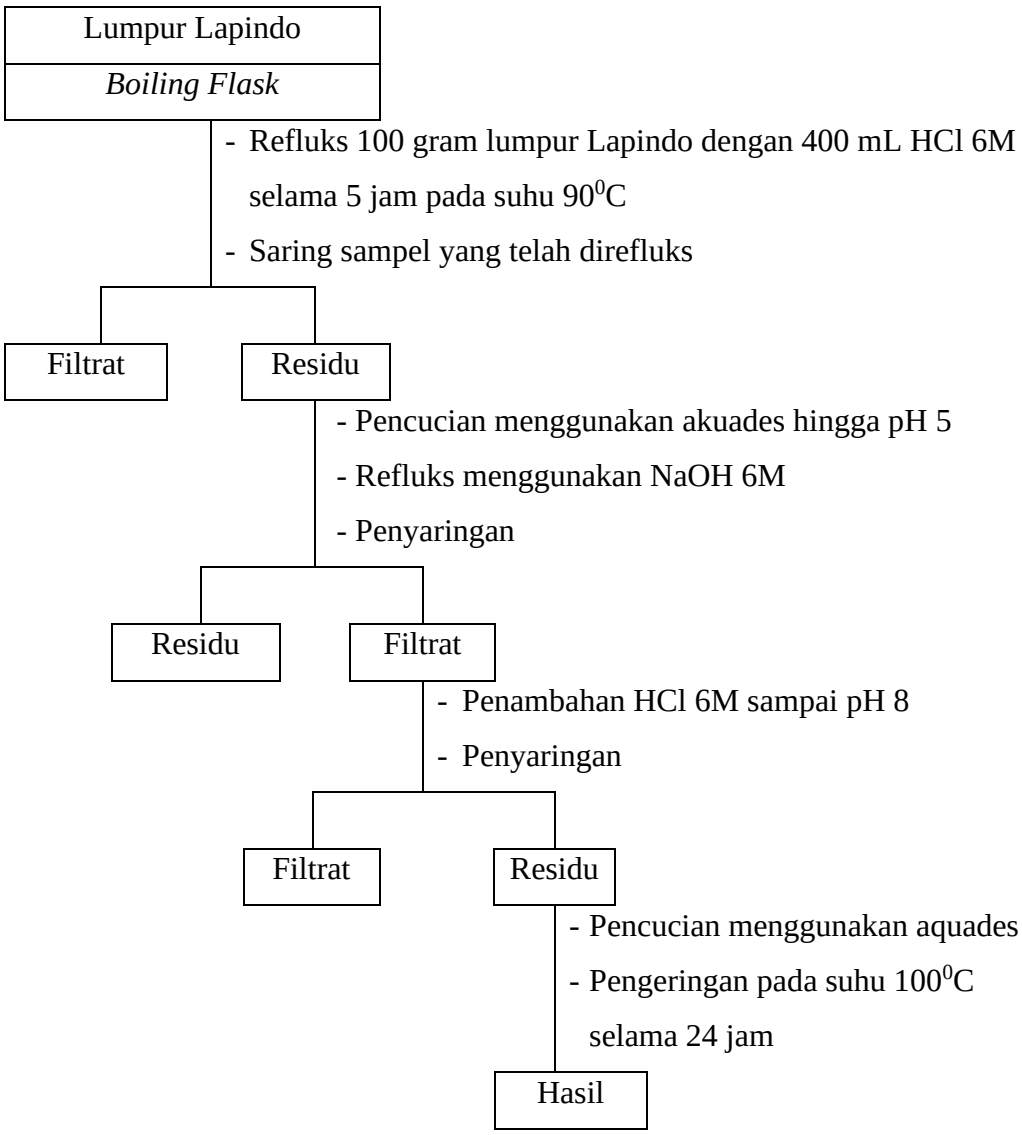


Lampiran 2. Skema Kerja

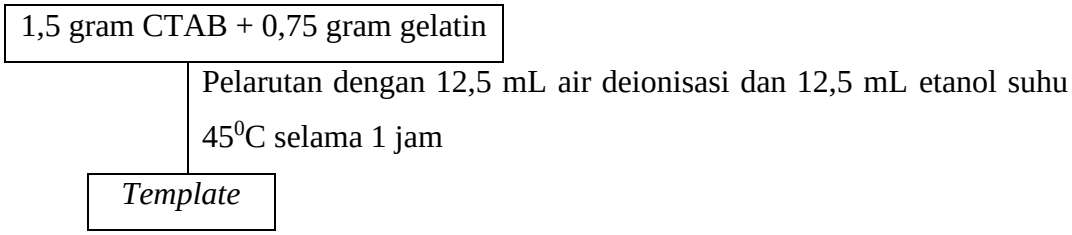
I. Ekstraksi Al_2O_3



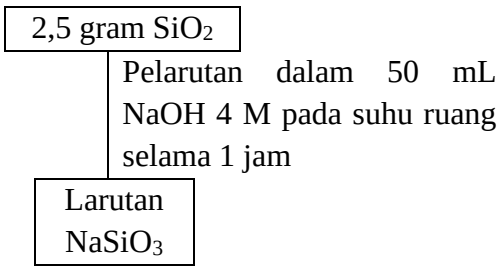
II. Ekstraksi SiO_2

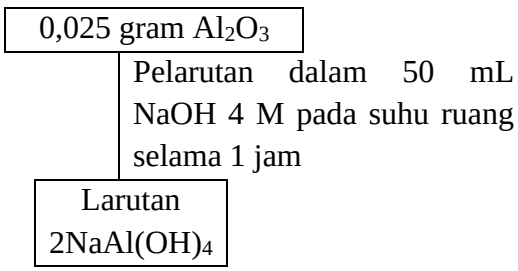


III. Preparasi *template* CTAB + Gelatin

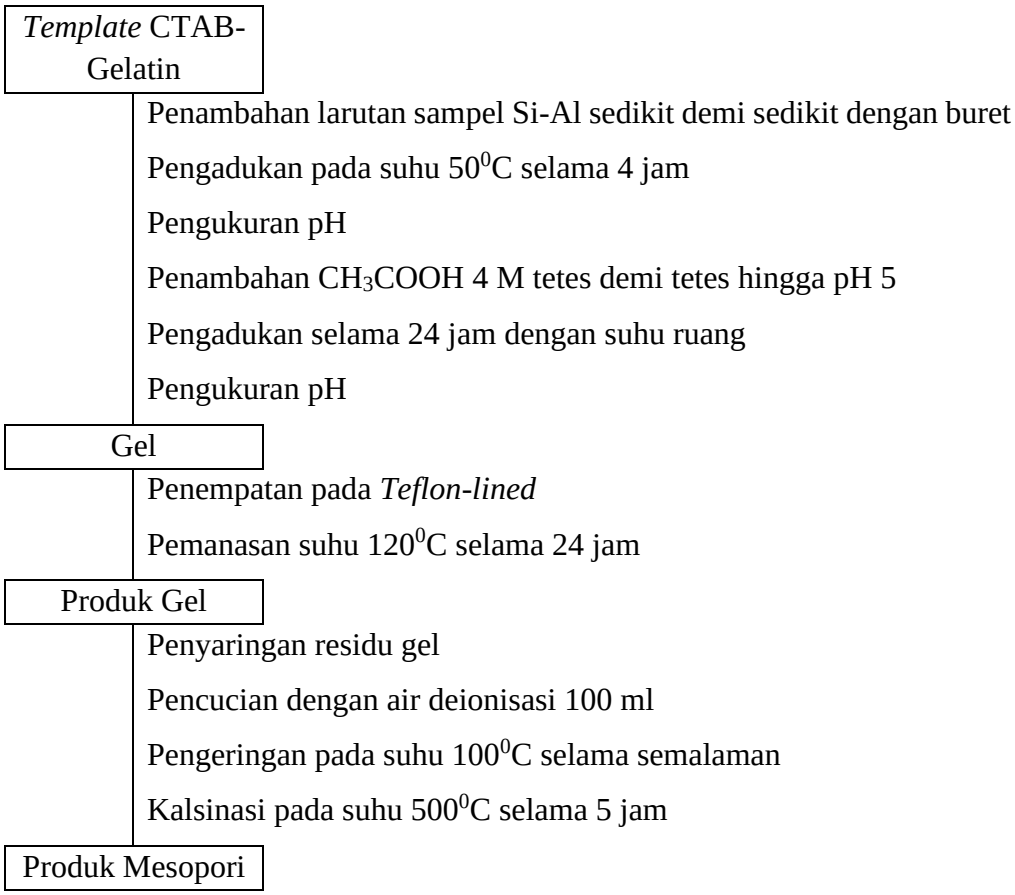


IV. Pembuatan Larutan $NaSiO_3$ dan Larutan $NaAl(OH)_4$





V. Sintesis Adsorben Silika-Alumina Mesopori



VI.Aplikasi sebagai Adsorben Metilen Biru

VI.1 Pembuatan variasi pH pelarut pH asam dan pelarut pH basa

Akuademineral

Gelas beaker

- Penambahan HCl yang telah diencerkan tetes demi tetes sampai mendapatkan pH 3, 4, 5, 6
- Penggojokan

Pelarut pH 3, 4, 5, 6

Akuademineral

Gelas beaker

- Penambahan NaOH yang telah diencerkan tetes demi tetes sampai mendapatkan pH 7, 8, 9
- Penggojokan

Pelarut pH 7, 8, 9

VI.2 Pembuatan Larutan 25 ppm MB

0,1 gam MB

Labu ukur 100 mL

- Penambahan akuademineral sampai batas
- Penggojokan

Larutan stok MB 1000 ppm

2,5 mL MB 1000 ppm

Labu ukur 100 mL

- Penambahan masing-masing variasi pH aquademineral sampai batas
- Penggojokan

MB 25 ppm

VI.3 Penentuan pH adsorbat MB terbaik

20 mL MB 25 ppm
pH 3,4,5,6,7,8,9

Gelas beaker

- Penambahan SAM pada masing-masing beaker sebanyak 0,02 gam
- Shaker 180 rpm selama 30 menit
- Sentrifugasi 4000 rpm selama 60 menit
- Penyaringan
- Pengukuran absorbansi menggunakan spektrofotometer UV-Vis dengan panjang gelombang maksimum 664 nm

Hasil

VI.4 Adsorpsi MB pada adsorbat terbaik dengan variasi waktu

20 mL MB pH 9 25 ppm

Gelas beaker

- Penambahan SAM sebanyak 0,02 gram
- Shaker 180 rpm selama 30 menit
- Sentrifugasi 4000 rpm selama 60 menit
- Penyaringan
- Pengukuran absorbansi menggunakan spektrofotometer UV-Vis dengan panjang gelombang maksimum 664 nm

Hasil

VII.Aplikasi Sebagai Adsorben Kongo Merah

VII.1 Pembuatan variasi pH pelarut pH asam dan pelarut pH basa

Akuademineral

Gelas beaker

- Penambahan HCl yang telah diencerkan tetes demi tetes sampai mendapatkan pH 3, 4, 5, 6
- Penggojokan

Pelarut pH 3, 4, 5, 6

Akuademineral

Gelas beaker

- Penambahan NaOH yang telah diencerkan tetes demi tetes sampai mendapatkan pH 7, 8, 9
- Penggojokan

Pelarut pH 7, 8, 9

VII.2 Pembuatan Larutan 25 ppm CR

0,1 gram CR

Labu ukur 100 mL

- Penambahan akuademineral sampai batas
- Penggojokan

Larutan stok MB 1000 ppm

2,5 mL MB 1000 ppm

Labu ukur 100 mL

- Penambahan masing-masing variasi pH aquademineral sampai batas
- Penggojokan

MB 25 ppm

VII.3 Penentuan pH adsorbat CR terbaik

20 mL CR 25 ppm pH 3,4,5,6,7,8,9

Gelas beaker

- Penambahan SAM pada masing-masing beaker sebanyak 0,02 gram
- Shaker 180 rpm selama 30 menit
- Sentrifugasi 4000 rpm selama 60 menit
- Penyaringan
- Pengukuran absorbansi menggunakan spektrofotometer UV-Vis dengan panjang gelombang maksimum 496 nm

Hasil

7.4 Adsorpsi CR pada adsorbat terbaik dengan variasi waktu

20 mL CR pH 3 25 ppm

Gelas beaker

- Penambahan SAM sebanyak 0,02 gram
- Shaker 180 rpm selama 30 menit
- Sentrifugasi 4000 rpm selama 60 menit
- Penyaringan
- Pengukuran absorbansi menggunakan spektrofotometer UV-Vis dengan panjang gelombang maksimum 664 nm

Hasil

VIII. Adsorpsi Amonia Silika-Alumina Mesopori

VIII.1 Preparasi

Cawan Kosong

Furnace

Dioven 100^0C selama 30 menit

Hasil

Pendinginan dalam desikator selama 15 menit

Hasil

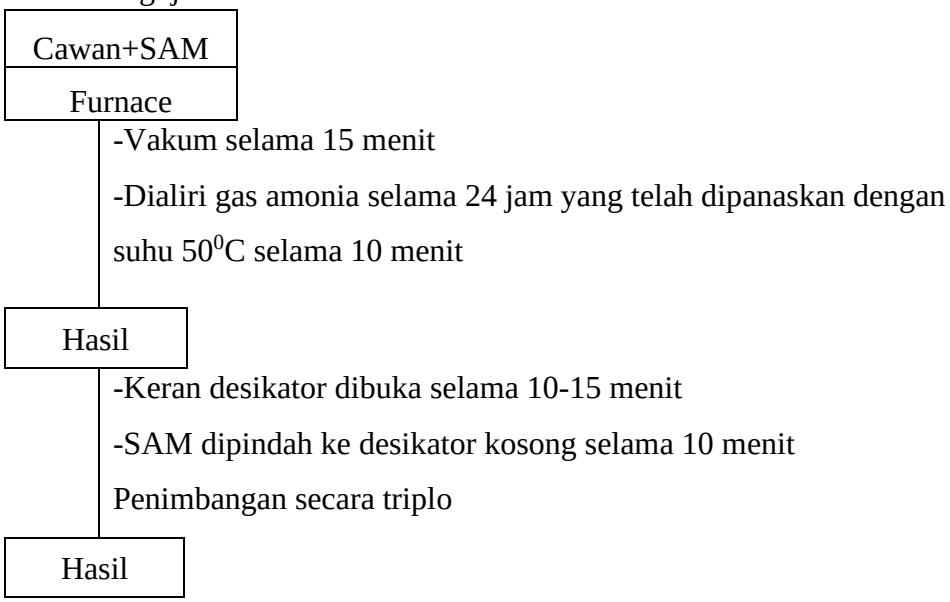
Penimbangan 0,05 gram

Cawan + SAM

Penimbangan secara triplo

Hasil

VIII.2 Pengujian



Lampiran 3. Lampiran Perhitungan

III.1. Pembuatan larutan HCl 6 M

- Konsentrasi molar HCl 37%

$$[\mathrm{HCl}] = \frac{\rho . 10 . kadar}{M}$$

$$[\mathrm{HCl}] = \frac{1{,}19\ {}^{\mathrm{g}}/_{\mathrm{mL}} . 10.37}{36{,}5}$$

$$[\mathrm{HCl}] = 12{,}063\ {}^{\mathrm{mol}}/_{\mathrm{mL}}$$

- Pengenceran untuk membuat 500 mL HCl 6 M

$$M\mathrm{l} . V\mathrm{l} = M2, V2$$

$$12{,}063\ {}^{\mathrm{mol}}/_{\mathrm{mL}} . V\mathrm{l} = 6\ {}^{\mathrm{mol}}/_{\mathrm{mL}} . 500\mathrm{mL}$$

$$V\mathrm{l} = \frac{6 . 500\mathrm{mL}}{12{,}063}$$

$$V\mathrm{l} = 248{,}69\ \mathrm{mL}$$

III.2. Pembuatan larutan 500 mL NaOH 6 M

- Menentukan jumlah n NaOH padat yang dibutuhkan

$$n = [\mathrm{NaOH}] . V$$

$$n = 6\ {}^{\mathrm{mol}}/_{\mathrm{L}} . 0{,}5\mathrm{L}$$

$$n = 3\ \mathrm{mol}$$

- Menentukan massa NaOH yang dibutuhkan

$$W = n . M$$

$$W = 3\ \mathrm{mol} . 40\ {}^{\mathrm{g}}/_{\mathrm{mol}}$$

$$W = 120\ \mathrm{gram}$$

III.3. Pembuatan 25 mL NaOH 4 M

- Menentukan jumlah n NaOH padat yang dibutuhkan

  $n = [\text{NaOH}].V$

  $n = 4\,{}^{\text{mol}}/_{\text{L}} . 0{,}025\text{L}$

  $n = 0{,}1\ \text{mol}$

- Menentukan massa NaOH yang dibutuhkan

  $W = n\,.M$

  $W = 0{,}1\ \text{mol}\,.\,40\,{}^{\text{g}}/_{\text{mol}}$

  $W = 4\ \text{g}$

III.4. Pembuatan 0,25 L CH_3COOH 4 M

- Menentukan molaritas CH_3COOH 100%

  $$[\text{CH}_3\text{COOH}] = \frac{(kadar \times \rho \times 10)}{M}$$

  $$[\text{CH}_3\text{COOH}] = \frac{\left(100 \times 1{,}05\,{}^{\text{g}}/_{\text{L}} \times 10\right)}{60{,}05\,{}^{\text{g}}/_{\text{mol}}}$$

  $[\text{CH}_3\text{COOH}] = 17{,}5\ \text{M}$

- Menentukan volume CH_3COOH yang dibutuhkan

  $M\text{l} \times V\text{l} = M2 \times V2$

  $17{,}5\,{}^{\text{mol}}/_{\text{L}} \times V\text{l} = 4\,{}^{\text{mol}}/_{\text{L}} \times 0{,}25L$

  $$V\text{l} = \frac{4\,{}^{\text{mol}}/_{\text{L}} \times 0{,}25L}{17{,}5\,{}^{\text{mol}}/_{\text{L}}}$$

  $V\text{l} = 0{,}05714\ \text{L}$

  $V\text{l} = 57{,}14\ \text{ml}$

III.5. Adsorpsi Metilen Biru

III.5.1 Pembuatan Metilen Biru 25 ppm

- Larutan induk 1000 ppm

  1 ppm = 1 mg/L

  1000 ppm = 1000 mg/L

  1 g = 1000 mL

  0,1 g = 100 mL

- Larutan 100 ppm

  M_1V_1 = M_2V_2

  $1000\ \text{ppm} \,.\, V_1$ = $100\ \text{mL} \,.\, 100\ \text{ppm}$

  V_1 = 10 mL

- Larutan 25 ppm

  M_1V_1 = M_2V_2

  $100\ \text{ppm} \,.\, V_1$ = $100\ \text{mL} \,.\, 25\ \text{ppm}$

  V_1 = 25 mL

III.5.2 Pembuatan larutan standar MB

- 10 ppm

  M_1V_1 = M_2V_2

  $100\ \text{ppm} \,.\, V_1$ = $10\ \text{ppm} \,.\, 100\ \text{mL}$

  V_1 = 10 mL

- 8 ppm

  M_1V_1 = M_2V_2

  $10\ \text{ppm} \,.\, V_1$ = $8\ \text{ppm} \,.\, 100\ \text{mL}$

  V_1 = 80 mL

- 6 ppm

  M_1V_1 = M_2V_2

  8 ppm . V_1 = 6 ppm . 100 mL

  V_1 = 75 mL

- 4 ppm

  M_1V_1 = M_2V_2

  6 ppm . V_1 = 4 ppm . 100 mL

  V_1 = 66,67 mL

- 2 ppm

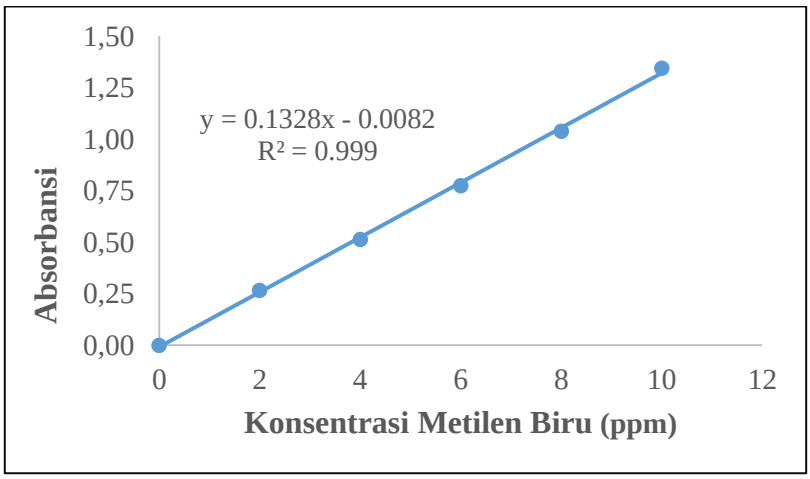
  M_1V_1 = M_2V_2

  4 ppm . V_1 = 2 ppm . 100 mL

  V_1 = 50 mL

III.5.3. Pembuatan kurva kalibrasi standar

Konsentrasi Metilen Biru (ppm)	Absorbansi
2	0,266
4	0,513
6	0,774
8	1,039
10	1,344



III.5.4. Perhitungan konsentrasi adsorpsi (Ct) untuk semua variasi pH MB

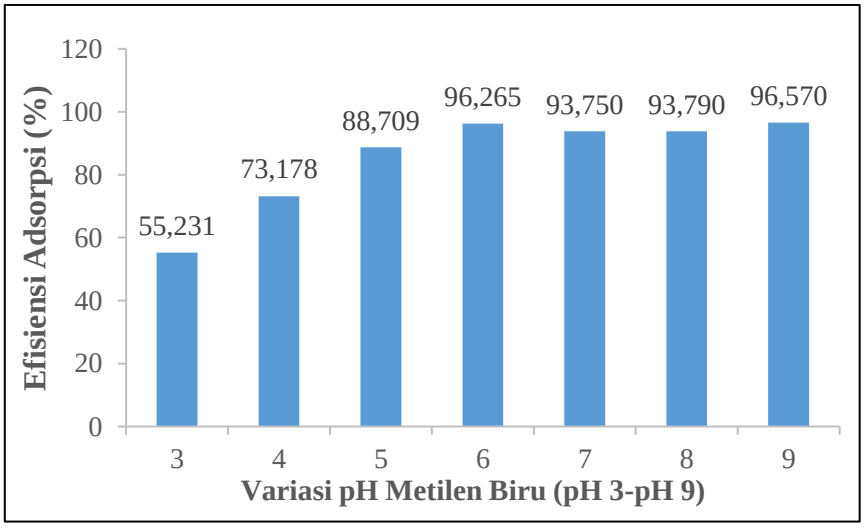
$y = 0{,}1328x - 0{,}0082$

$x = \frac{y + 0{,}0082}{0{,}1328}$

Massa adsorben = 0,02 g

Volume adsorben = 0,02 L

pH	C_0 (ppm)	Absorbansi/y	Ct/x (ppm)	%EA
3	25	1,493	11,302	54,793
4	25	0,891	6,771	72,916
5	25	0,370	2,850	88,598
6	25	0,117	0,943	96,229
7	25	0,201	1,578	93,689
8	25	0,200	1,568	93,729
9	25	0,106	0,857	96,570



III.5.5 Perhitungan konsentrasi adsorpsi (Ct) tiap variasi waktu (t) pada MB pH 9

$y = 0{,}1328x - 0{,}0082$

$x = \frac{y + 0{,}0082}{0{,}1328}$

Massa adsorben = 0,02 g

Volume adsorben = 0,02 L

Waktu (menit)	C_0 (ppm)	Absorbansi/y	Ct/x (ppm)	%EA
15	25	0,122	0,983	96,068
30	25	0,109	0,880	96,480
45	25	0,108	0,872	96,510
60	25	0,103	0,840	96,641
75	25	0,100	0,815	96,741

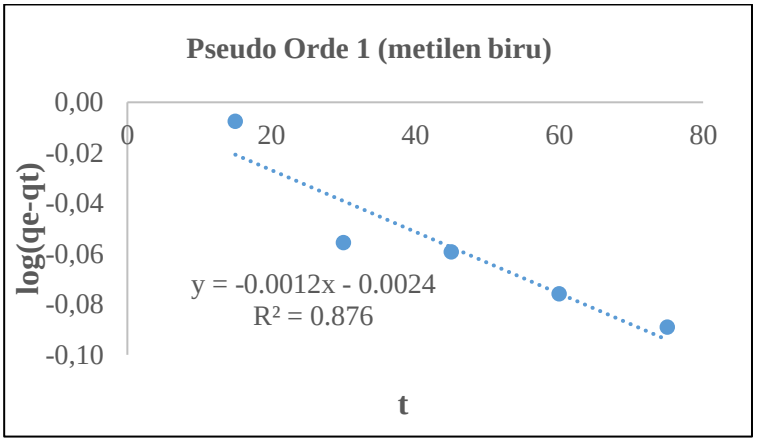
III.5.6 Perhitungan kinetika adsorpsi SAM pada MB pH 9

- Tabel data kinetika adsorpsi

T (menit)	C_0 (ppm)	Ct (ppm)	Qe ($mg.g^{-1}$)	Qt ($mg.g^{-1}$)	Qe-Qt ($mg.g^{-1}$)	log(Qe-Qt)	t/Qt (menit.g. mg^{-1})
15	25	0,983	25	24,017	0,983	-0,007	0,625
30	25	0,880	25	24,120	0,880	-0,056	1,244
45	25	0,872	25	24,128	0,872	-0,059	1,865
60	25	0,840	25	24,160	0,840	-0,076	2,483
75	25	0,815	25	24,185	0,815	-0,089	3,101

- Model pseudo orde 1

T (menit)	log(Qe-Qt)
15	-0,007
30	-0,056
45	-0,059
60	-0,076
75	-0,089



$$\frac{dQt}{dt} = k\,(Qe - Qt)$$

$$\log\,(Qe - Qt) = \log Qe - kt/2{,}303$$

$$\text{Slope} = \frac{-k}{2{,}303}$$

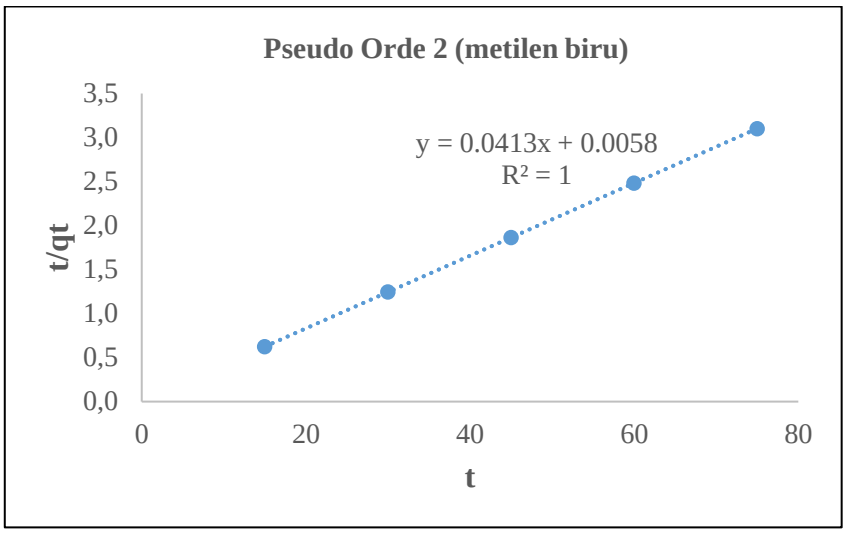
$$-0{,}0012 = \frac{-k}{2{,}303}$$

$$k = 2{,}303 \times 0{,}0012$$

k =0,0027636 g.mg^{-1}.menit^{-1}

- Model pseudo orde 2

t	t/qt
15	0,625
30	1,244
45	1,865
60	2,483
75	3,101



$$\frac{dQt}{dt} = k(Qe - Qt)^2$$

$$\frac{t}{Qt} = \frac{1}{k.\,Qe^2} + \frac{t}{Qe}$$

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

$$0{,}0413 = \frac{1}{Qe}$$

$$Qe = \frac{1}{0{,}0413}$$

$$Qe = 24{,}213$$

$$\text{Intersep} = \frac{1}{k.\,Qe^2}$$

$$0{,}0058 = \frac{1}{k \times (24{,}213)^2}$$

$$k = \frac{1}{0{,}0058 \times 586{,}273}$$

$$k = 0{,}2941 \text{ g.mg}^{-1}\text{.menit}^{-1}$$

III.6. Adsorpsi Kongo Merah

III.6.1 Pembuatan Kongo Merah 25 ppm

- Larutan induk 1000 ppm

  1 ppm = 1 mg/L

  1000 ppm = 1000 mg/L

  1 g = 1000 mL

  0,1 g = 100 mL

- Larutan 100 ppm

  M_1V_1 = M_2V_2

  $1000\ \text{ppm} \,.\, V_1$ = $100\ \text{mL} \,.\, 100\ \text{ppm}$

  V_1 = 10 mL

- Larutan 25 ppm

  M_1V_1 = M_2V_2

  $100\ \text{ppm} \,.\, V_1$ = $100\ \text{mL} \,.\, 25\ \text{ppm}$

  V_1 = 25 mL

III.6.2 Pembuatan larutan standar CR

- 20 ppm

  M_1V_1 = M_2V_2

  $100\ \text{ppm} \,.\, V_1$ = $20\ \text{ppm} \,.\, 100\ \text{mL}$

  V_1 = 20 mL

- 16 ppm

  M_1V_1 = M_2V_2

  $20\ \text{ppm} \,.\, V_1$ = $16\ \text{ppm} \,.\, 100\ \text{mL}$

  V_1 = 80 mL

- 12 ppm

  M_1V_1 = M_2V_2

  16 ppm . V_1 = 12 ppm . 100 mL

  V_1 = 75 mL

- 8 ppm

  M_1V_1 = M_2V_2

  12 ppm . V_1 = 8 ppm . 100 mL

  V_1 = 66,67 mL

- 4 ppm

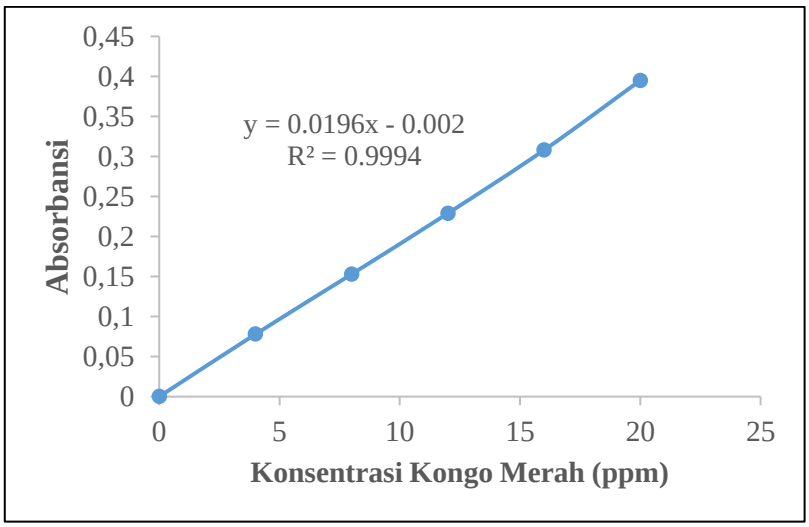
  M_1V_1 = M_2V_2

  8 ppm . V_1 = 4 ppm . 100 mL

  V_1 = 50 mL

III.6.3. Pembuatan kurva kalibrasi standar

Konsentrasi Kongo Merah (ppm)	Absorbansi
4	0,078
8	0,153
12	0,229
16	0,308
20	0,395



III.6.4. Perhitungan konsentrasi adsorpsi (Ct) untuk semua variasi pH CR

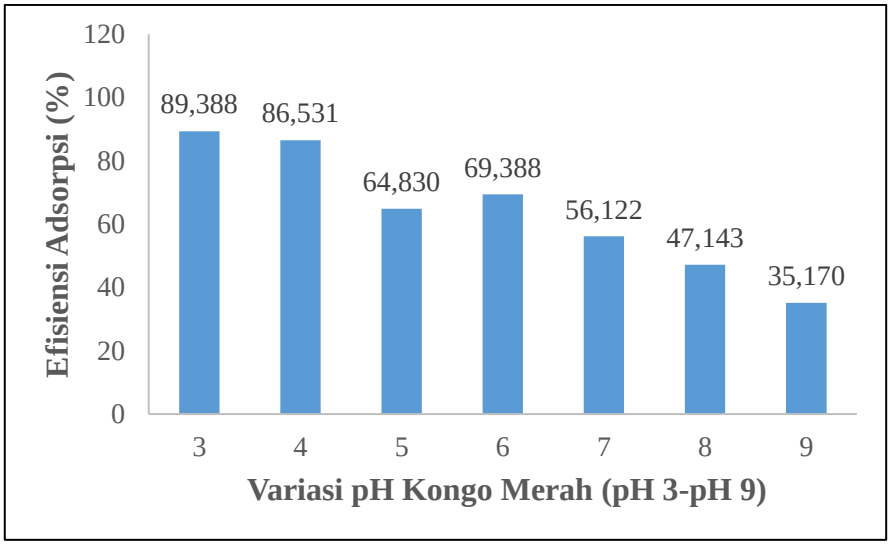
$y = 0{,}0196x - 0{,}002$

$x = \frac{y + 0{,}002}{0{,}0196}$

Massa adsorben = 0,02 g

Volume adsorben = 0,02 L

pH	C_0 (ppm)	Absorbansi/y	Ct/x (ppm)	%EA
3	25	0,050	2,653	89,388
4	25	0,064	3,367	86,351
5	25	0,170	8,793	64,830
6	25	0,148	7,653	69,388
7	25	0,213	10,969	56,122
8	25	0,257	13,214	47,143
9	25	0,316	16,207	35,170



III.6.5 Perhitungan konsentrasi adsorpsi (Ct) tiap variasi waktu (t) pada CR pH 3

$y = 0{,}0196x - 0{,}002$

$x = \frac{y + 0{,}002}{0{,}0196}$

Massa adsorben = 0,02 g

Volume adsorben = 0,02 L

Waktu (menit)	C_0 (ppm)	Absorbansi/y	Ct/x (ppm)	%EA
15	25	0,122	3,759	84,966
30	25	0,109	2,389	90,408
45	25	0,108	2,415	90,340
60	25	0,103	1,956	92,177
75	25	0,100	1,888	92,449

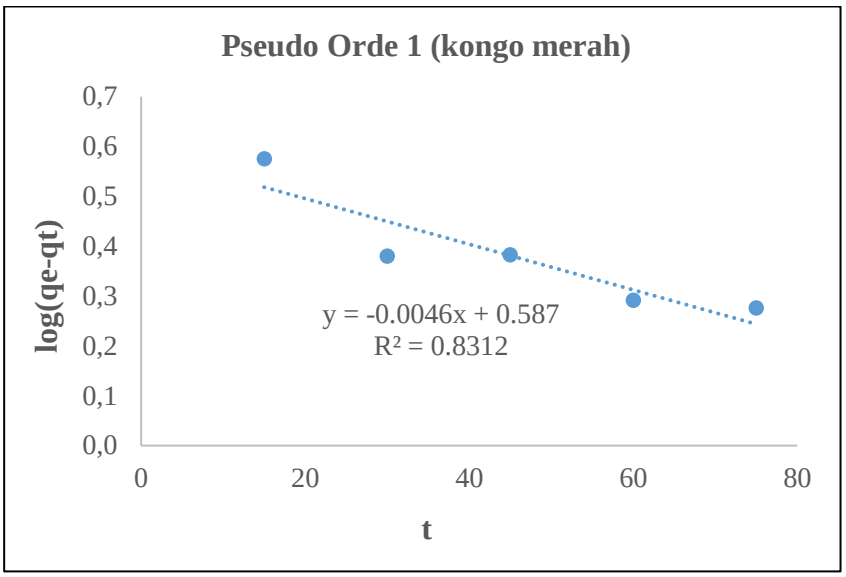
III.6.6 Perhitungan kinetika adsorpsi SAM pada CR pH 3

- Tabel data kinetika adsorpsi

T (menit)	C_0 (ppm)	Ct (ppm)	Qe ($mg.g^{-1}$)	Qt ($mg.g^{-1}$)	Qe-Qt ($mg.g^{-1}$)	log(Qe-Qt)	t/Qt ($menit.g.mg^{-1}$)
15	25	3,759	25	21,241	3,759	0,575	0,706
30	25	2,398	25	22,602	2,398	0,380	1,327
45	25	2,415	25	22,585	2,415	0,383	1,992
60	25	1,956	25	23,044	1,956	0,291	2,604
75	25	1,888	25	23,112	1,888	0,276	3,245

- Model pseudo orde 1

T (menit)	log(Qe-Qt)
15	0,575
30	0,380
45	0,383
60	0,291
75	0,276



$$\frac{dQt}{dt} = k\,(Qe - Qt)$$

$$\log\,(Qe - Qt) = \log Qe - kt/2{,}303$$

$$\text{Slope} = \frac{-k}{2{,}303}$$

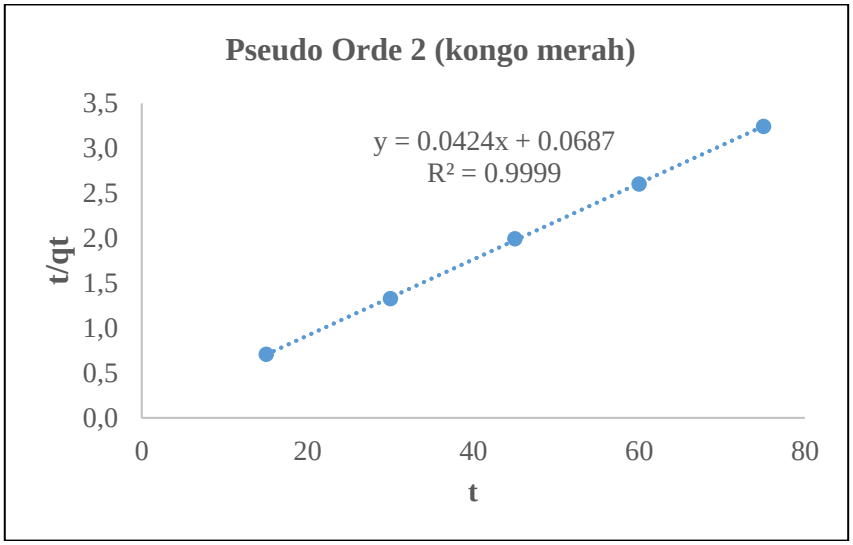
$$-0{,}0046 = \frac{-k}{2{,}303}$$

$$k = 2{,}303 \times 0{,}0046$$

k =0,0105938 g.mg^{-1}.menit^{-1}

- Model pseudo orde 2

T	t/qt
15	0,706
30	1,327
45	1,992
60	2,604
75	3,245



$$\frac{dqt}{dt} = k(Qe - Qt)^2$$

$$\frac{t}{Qt} = \frac{1}{k.\,Qe^2} + \frac{t}{Qe}$$

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

$$0{,}0424 = \frac{1}{Qe}$$

$$Qe = \frac{1}{0{,}0424}$$

$$Qe = 23{,}586$$

$$\text{Intersep} = \frac{1}{k.\,Qe^2}$$

$$0{,}0687 = \frac{1}{k \times (23{,}585)^2}$$

$$k = \frac{1}{0{,}0687 \times 556{,}248}$$

$k = 0{,}0262$ g.mg^{-1}.menit^{-1}

III.7. Uji keasaman

$$\text{Total keasaman } \left(\frac{\text{mmol}}{\text{g}}\right) = \frac{W_3 - W_2}{W_2 - W_1 \times M\text{r}\text{NH}_3} \times 1000$$

Data hasil percobaan :

W_1 = 32,7777 g

W_2 = 42,8277 g

W_3 = 42,8296 g

$$\text{Total keasaman } \left(\frac{\text{mmol}}{\text{g}}\right) = \frac{(42{,}8296 - 42{,}8277)}{(42{,}8277 - 32{,}7777) \times 17} \times 1000$$

$$\text{Total keasaman } \left(\frac{\text{mmol}}{\text{g}}\right) = 2{,}19607 \text{ mmol.g}^{-1}$$

Keterangan :

M : Massa atom

ρ : Massa jenis (gram.mL)

W : Massa (gram)

kadar : Konsentrasi HCl awal (%)

V : Volume (mL)

M_1 : Konsentrasi awal (M)

M_2 : Konsentrasi akhir (M)

V_1 : Volume awal (mL)

V_2 : Volume akhir (mL)

n : Jumlah mol

C_0 : Konsentrasi awal (ppm)

Ct : Konsentrasi pada waktu t (ppm)

Qe : Kapasitas adsorpsi pada kesetimbangan ($mg.g^{-1}$)

Qt : Kapasitas adsorpsi pada waktu t ($mg.g^{-1}$)

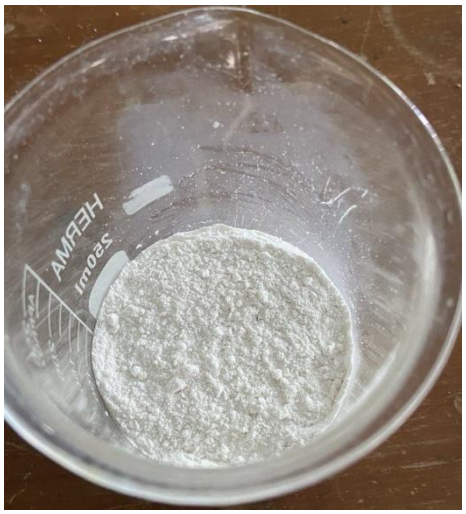
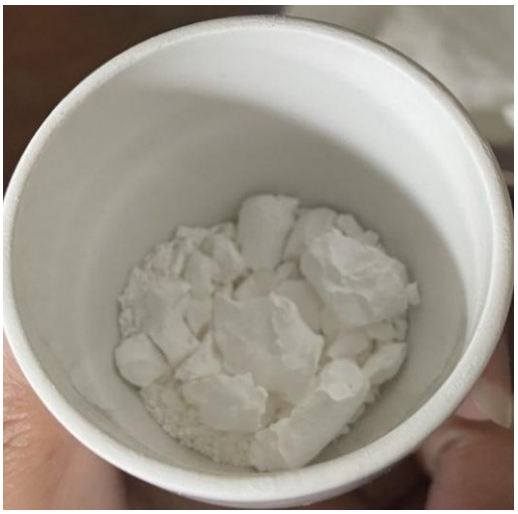
k : Konstanta laju reaksi

W_3 : Berat Cawan + SAM sesudah adsorpsi NH_3

W_2 : Berat Cawan + SAM sebelum adsorpsi NH_3

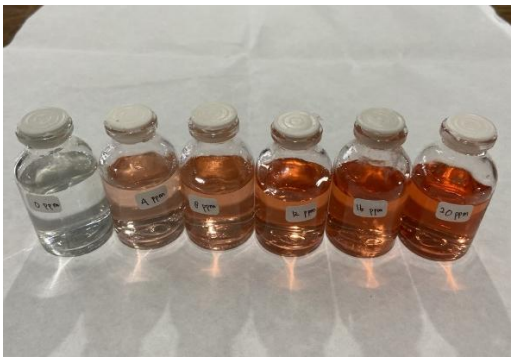
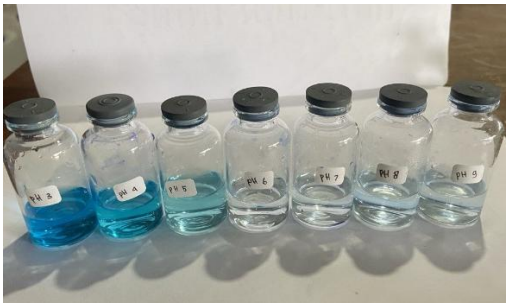
W_1 : Berat Cawan

Lampiran 4. Dokumentasi Penelitian

	
Penghalusan lumpur kering	Proses ekstraksi lumpur Lapindo
	
Hasil silika setelah dikeringkan	Hasil alumina

 Larutan natrium aluminat dan silika aluminat hasil ekstraksi	 Penetesan silika dan alumina pada *template* CTAB dan gelatin
 Pengadukan 24 jam	 Proses solvotermal

 Pengeringan SAM dengan suhu 100^0C selama 18 jam	 Kalsinasi pada suhu 500^0C
 Hasil sintesis silika alumina	 Adsorpsi Amonia/Uji Keasaman Total

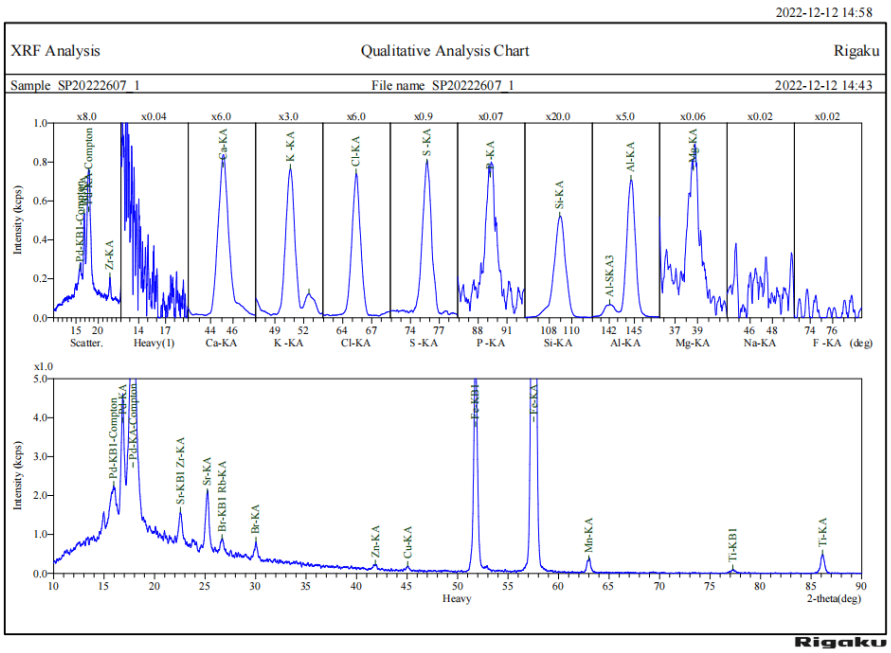
 Larutan deret standar metilen biru	 Larutan deret standar kongo merah
 Proses adsorpsi variasi pH	 Proses adsorpsi variasi waktu
 Hasil adsorpsi variasi pH MB	 Hasil adsorpsi variasi pH CR

	
Hasil adsorpsi dengan variasi waktu kontak MB pH 9	Hasil adsorpsi dengan variasi waktu kontak CR pH 3

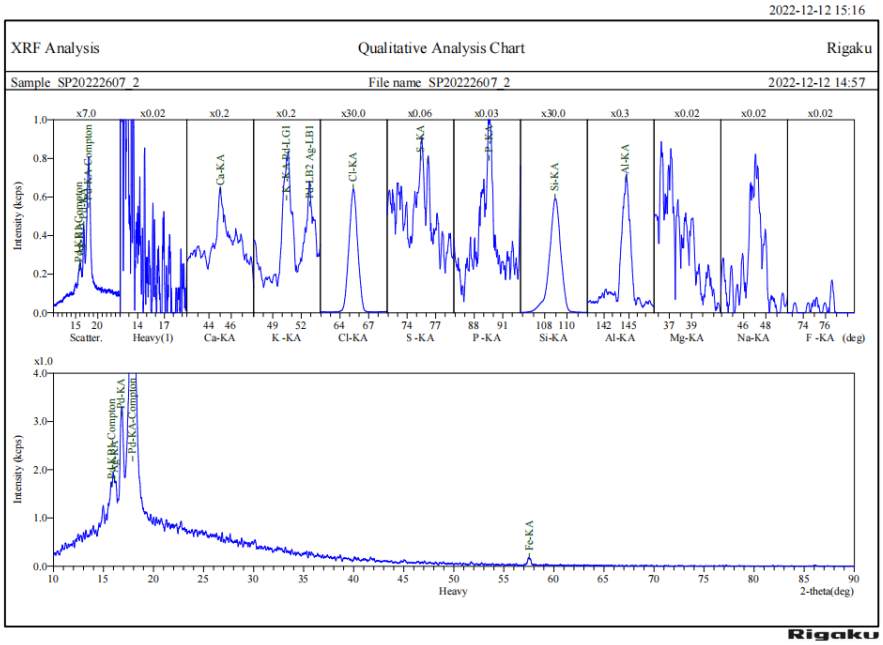
Lampiran 5. Hasil Uji

V.1 XRF

V.1.1 XRF Lumpur Lapindo

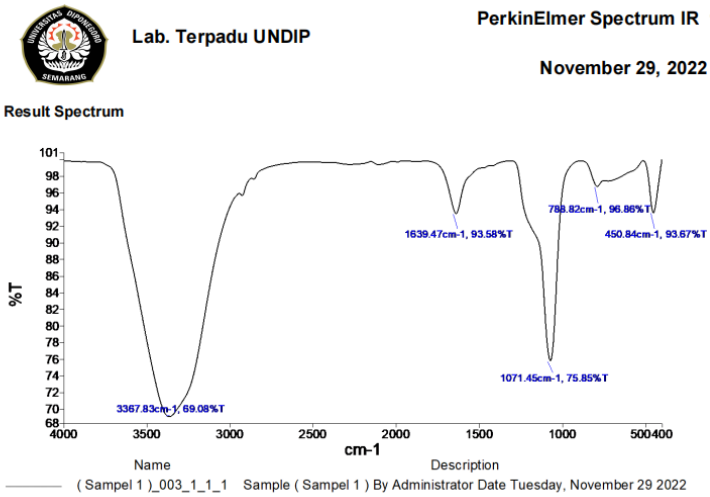


V.1.2 XRF Silika Hasil Ekstraksi



V.2 FT-IR

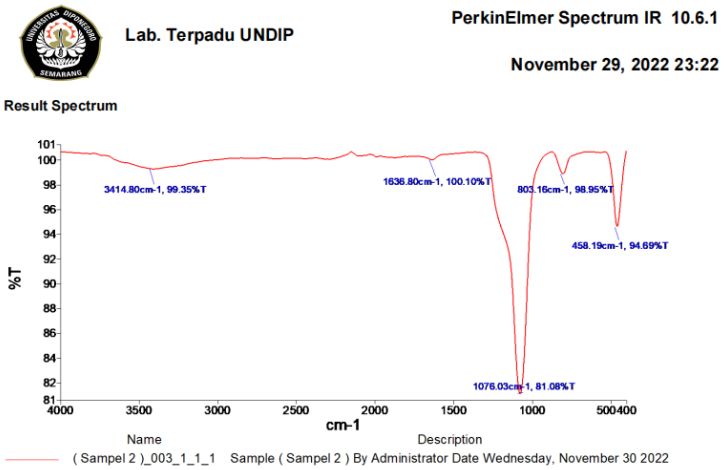
V.2.1 Sebelum Kalsinasi



Peak Table

Peak Number	X (cm-1)	Y (%T)
1	3367.83	69.08
2	1639.47	93.58
3	1071.45	75.85
4	788.82	96.86
5	450.84	93.67

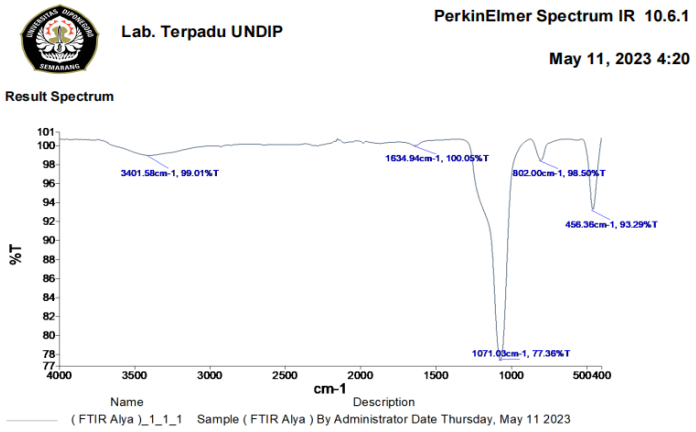
V.2.2 Setelah Kalsinasi



Peak Table

Peak Number	X (cm-1)	Y (%T)
1	3414.80	99.35
2	1636.80	100.10
3	1076.03	81.08
4	803.16	98.95
5	458.19	94.69

V.3 FT-IR Sisa Uji Keasaman

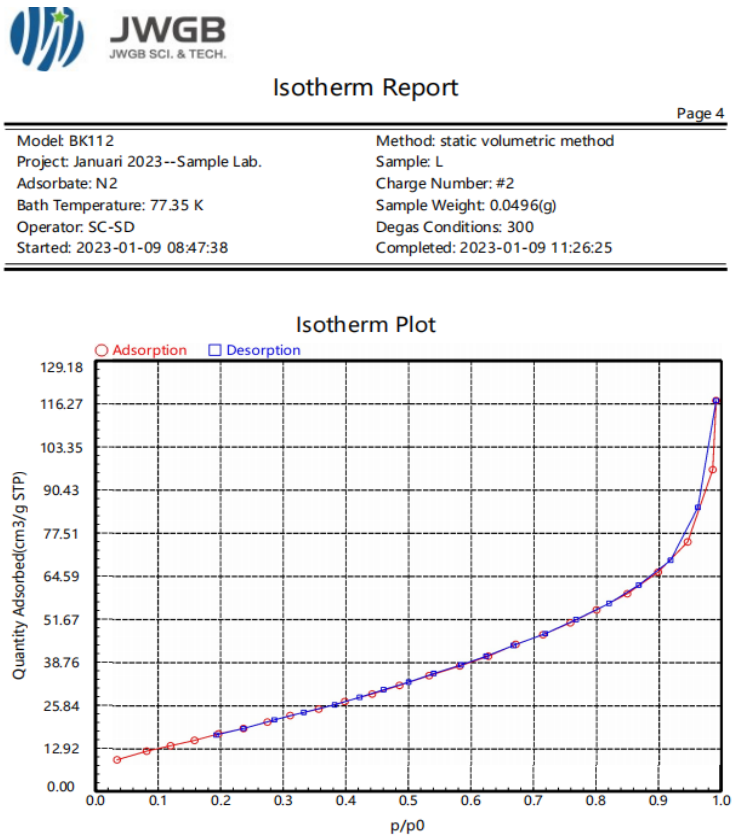


Peak Table

Peak Number	X (cm-1)	Y (%T)
1	3401.58	99.01
2	1634.94	100.05
3	1071.03	77.36
4	802.00	98.50
5	456.36	93.29

V.4 GSA

V.4.1 Plot Isoterm



V.4.2 Plot Distribusi Ukuran Pori Adsorpsi BJH

JWGB
JWGB SCI. & TECH.

BJH Adsorption Pore Distribution Report

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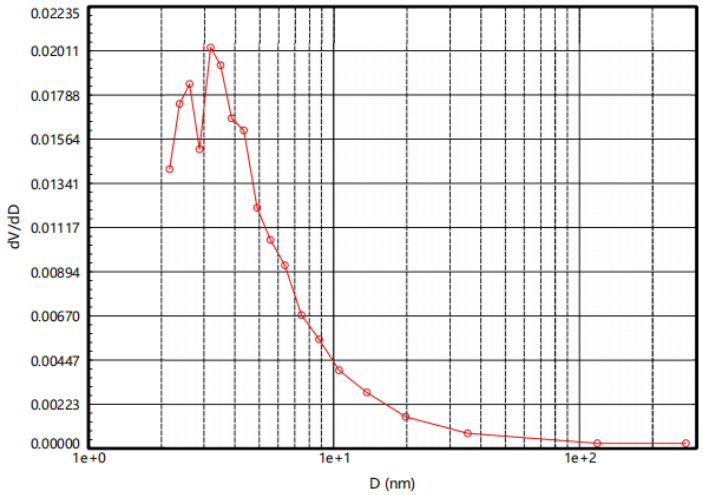
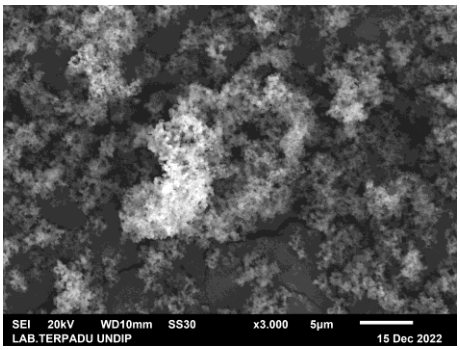
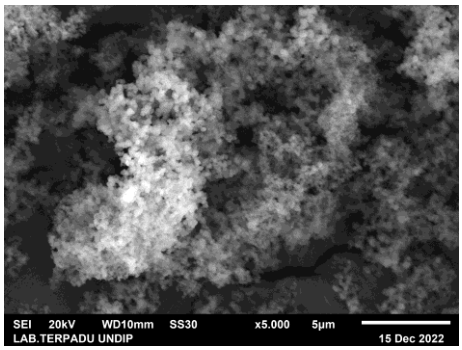
Model: BK112	Method: static volumetric method
Project: Januari 2023--Sample Lab.	Sample: L
Adsorbate: N2	Charge Number: #2
Bath Temperature: 77.35 K	Sample Weight: 0.0496(g)
Operator: SC-SD	Degas Conditions: 300
Started: 2023-01-09 08:47:38	Completed: 2023-01-09 11:26:25

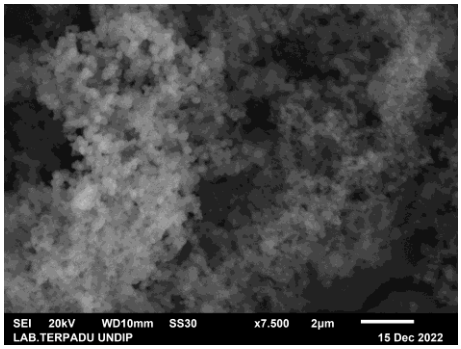
BJH Adsorption Pore Size Distribution Plot (dV/dD)

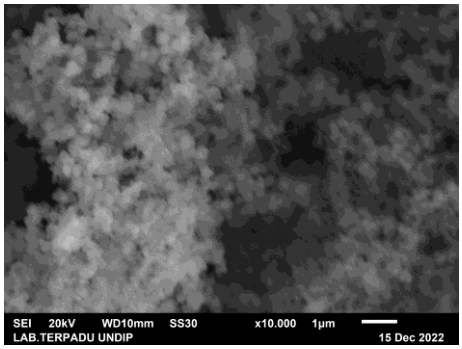


V.5 SEM

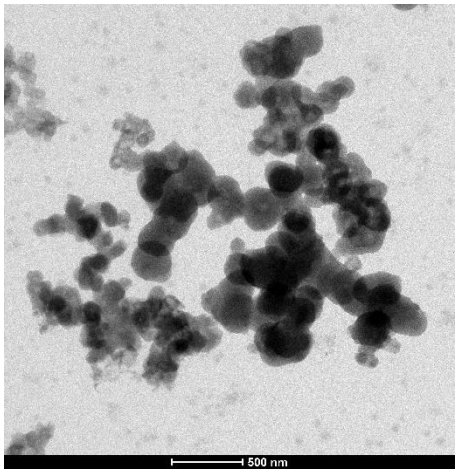


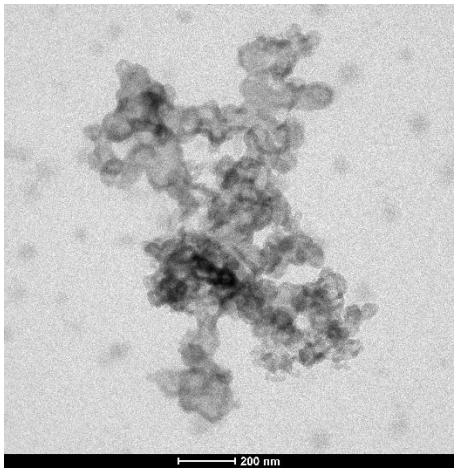


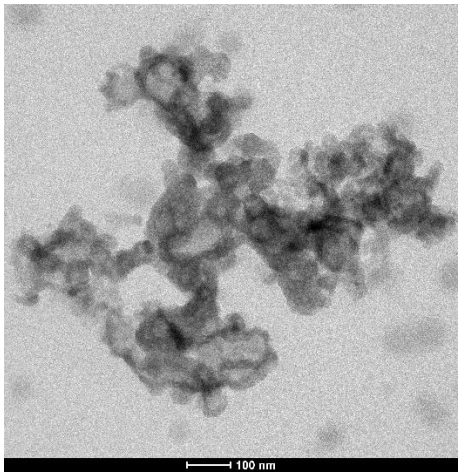

SEI 20kV WD10mm SS30 x7.500 2µm
LAB.TERPADU UNDIP 15 Dec 2022

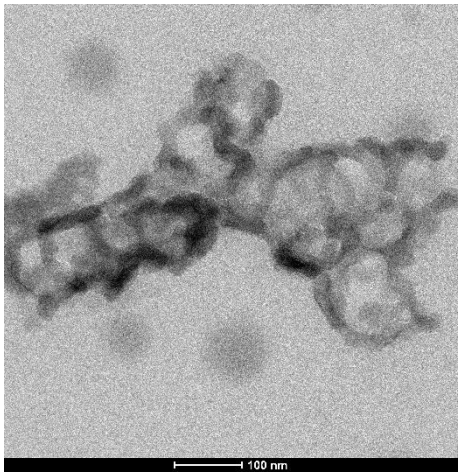

SEI 20kV WD10mm SS30 x10.000 1µm
LAB.TERPADU UNDIP 15 Dec 2022

V.6 TEM


500 nm


200 nm


100 nm


100 nm