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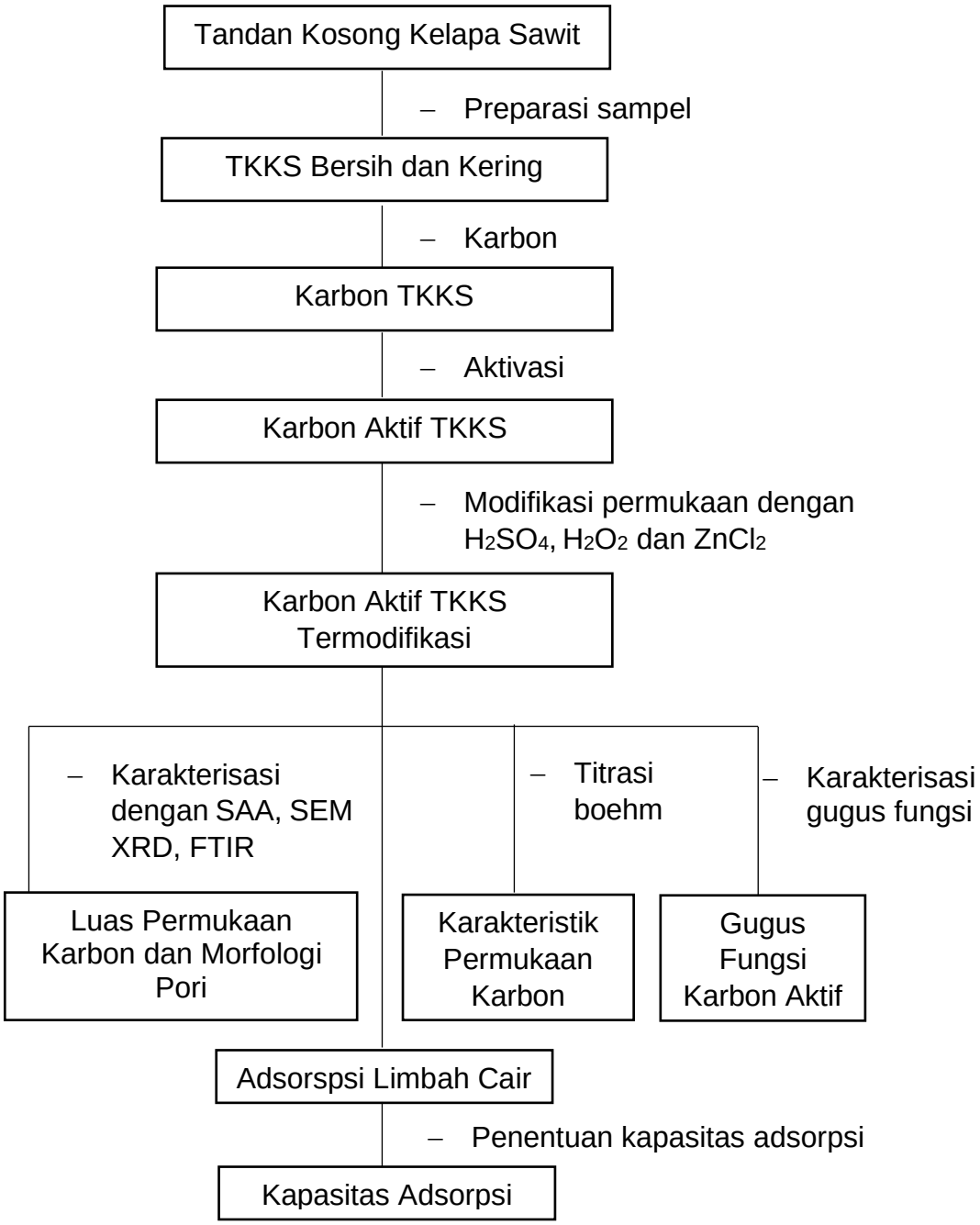
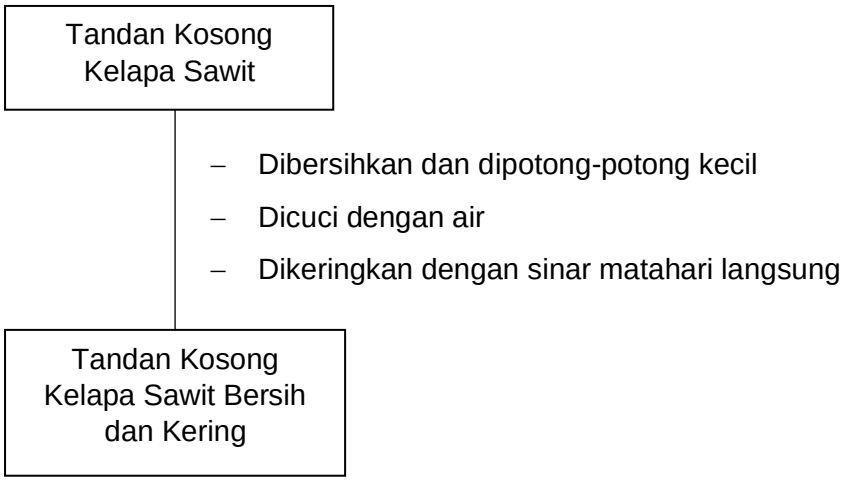
LAMPIRAN

Lampiran 1. Diagram Alir Penelitian

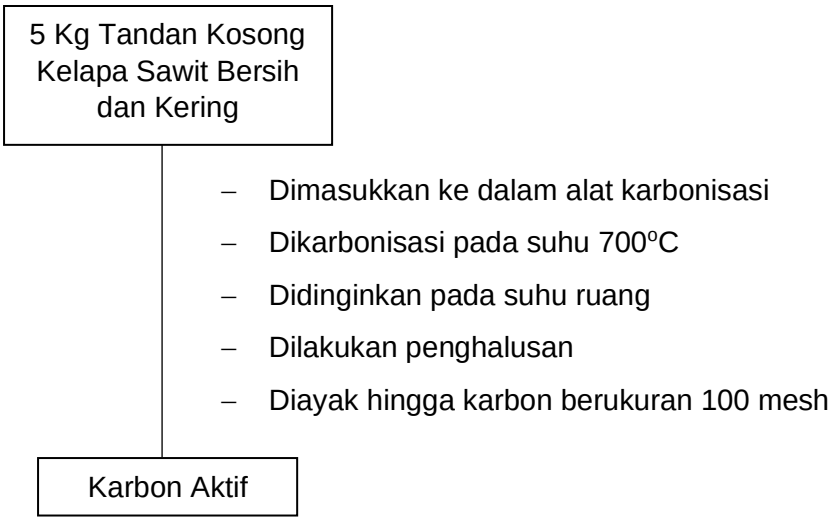


Lampiran 2. Skema Prosedur Kerja Penelitian

2.1. Preparasi Sampel



2.2. Karbonisasi



2.3. Aktivasi Karbon Tandan Kosong Kelapa Sawit

Karbon Aktif

- Dilakukan perendaman 100 g karbon aktif tandan kosong kelapa sawit dengan aktivator H_3PO_4 15% selama 24 jam dengan perbandingan 1:5.
- Diaduk menggunakan *magnetic stirrer* selama 2 jam
- Disaring
- Dinetralkan dengan menggunakan akuades
- Dikeringkan dengan oven pada suhu 105^oC selama 24 jam

Hasil

2.4. Modifikasi Karbon Aktif

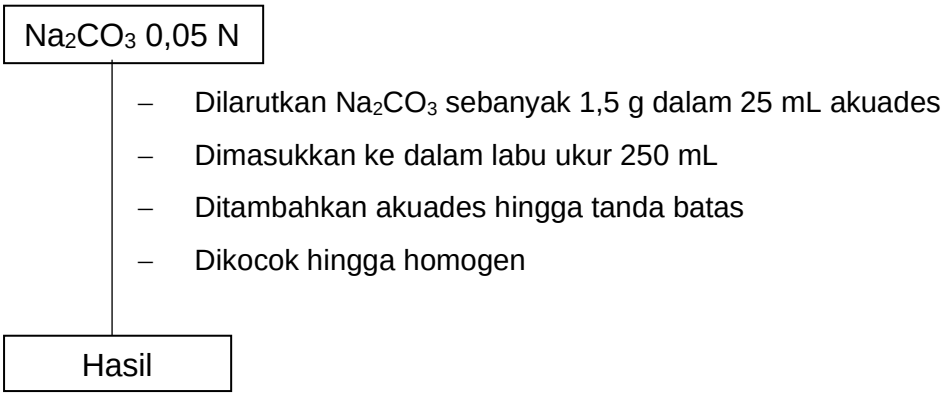
Karbon Aktif

- Ditambahkan ke dalam masing-masing larutan H_2SO_4, $ZnCl_2$ dan H_2O_2 dengan perbandingan 1:5
- Diaduk dengan kecepatan 130 rpm pada suhu 65 ^oC selama 15 menit
- Didiamkan selama 24 jam pada suhu kamar
- Disaring dan dinetralkan dengan akuades
- Dikeringkan dengan oven pada suhu 105^oC

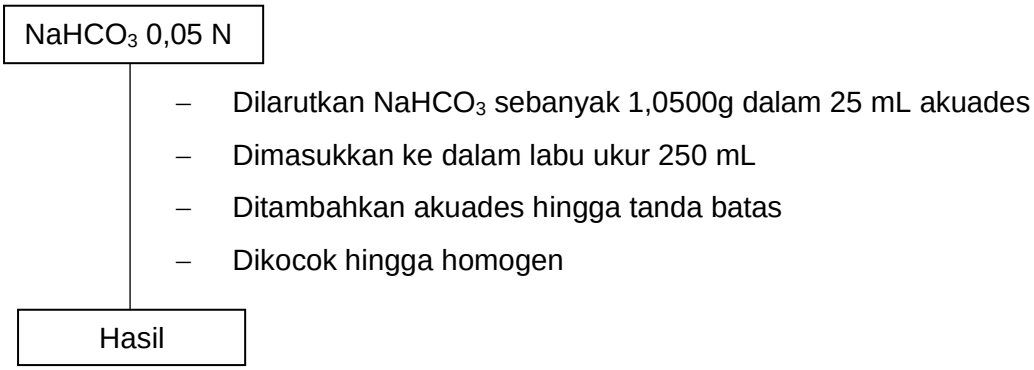
Hasil

2.5. Pembuatan Larutan Pereaksi

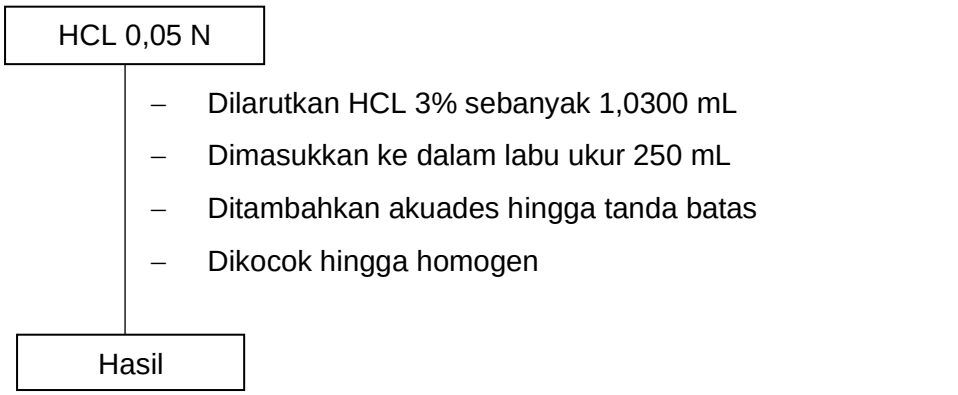
2.5.1. Pembuatan Larutan Na_2CO_3 0,05 N



2.5.2. Pembuatan Larutan $NaHCO_3$ 0,05 N



2.5.3. Pembuatan Larutan HCL 0,05 N



2.5.4. Pembuatan Larutan $Na_2B_4O_7$ 0,05 N

$Na_2B_4O_7$ 0,05 N

- Dilarutkan $Na_2B_4O_7.10H_2O$ sebanyak 0,9530 g dalam 25 mL akuades
- Dimasukkan ke dalam labu ukur 250 mL
- Ditambahkan akuades hingga tanda batas
- Dikocok hingga homogen

Hasil

2.5.5. Pembuatan Larutan NaOH 0,05 N

NaOH 0,05 N

- Dilarutkan NaOH sebanyak 0,500 g dalam 25 mL akuades
- Dimasukkan ke dalam labu ukur 250 mL
- Ditambahkan akuades hingga tanda batas
- Dikocok hingga homogen

Hasil

2.5.6. Pembuatan Larutan $H_2C_2O_4$ 0,05 N

$H_2C_2O_4$ 0,05 N

- Dilarutkan $H_2C_2O_4$ sebanyak 0,3150 g dalam 25 mL akuades
- Dimasukkan ke dalam labu ukur 250 mL
- Ditambahkan akuades hingga tanda batas
- Dikocok hingga homogen

Hasil

2.5.7. Standarisasi Larutan HCl dengan larutan $Na_2B_4O_7$ 0,05 N

10 mL $Na_2B_4O_7$ 0,05 N

- Dilarutkan $Na_2B_4O_7$ sebanyak 10 mL dimasukkan ke dalam erlenmeyer 250 mL
- Ditambahkan 2-3 tetes indicator metal merah
- Dititrasi dengan HCl hingga terjadi perubahan warna
- Diulangi sebanyak 3 kali
- Ditentukan konsentrasi HCl

Hasil

2.5.8. Standarisasi Larutan NaOH dengan larutan $H_2C_2O_4$ 0,05 N

10 mL $H_2C_2O_4$ 0,05 N

- Dilarutkan dan dimasukkan ke dalam erlenmeyer 250 mL
- Ditambahkan 2-3 tetes indicator metal merah
- Dititrasi dengan NaOH hingga terjadi perubahan warna
- Diulangi sebanyak 3 kali
- Ditentukan konsentrasi NaOH

Hasil

2.6. Penentuan Kadar Air

Karbon Aktif

- Ditimbang karbon aktif sebanyak 0,5 g
- Ditimbang dan dipanaskan cawan porselin dalam oven pada suhu 105^{o}C selama 1 jam
- Dimasukkan karbon aktif ke dalam cawan porselin
- Dipanaskan dalam oven pada suhu 105^{o}C selama 1 jam
- Didinginkan dalam desikator selama 15 menit
- Ditimbang hingga diperoleh bobot konstan
- Dihitung kadar air

Hasil

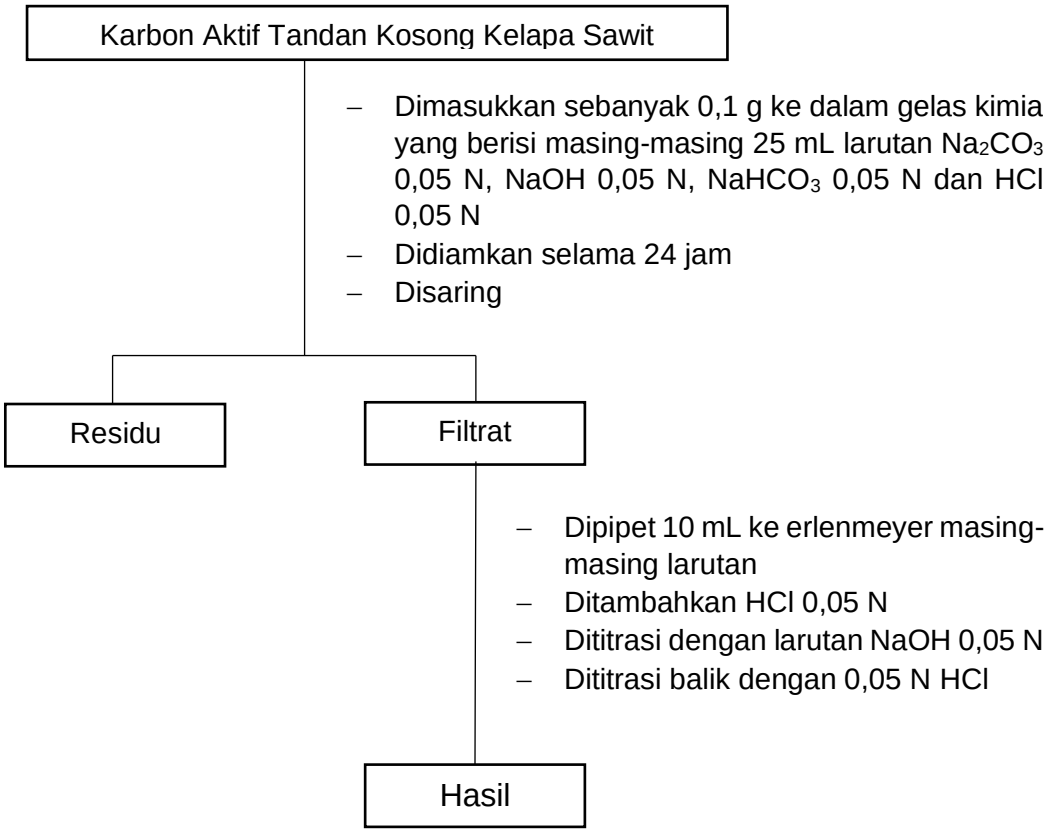
2.7. Penentuan Kadar Abu

Karbon Aktif

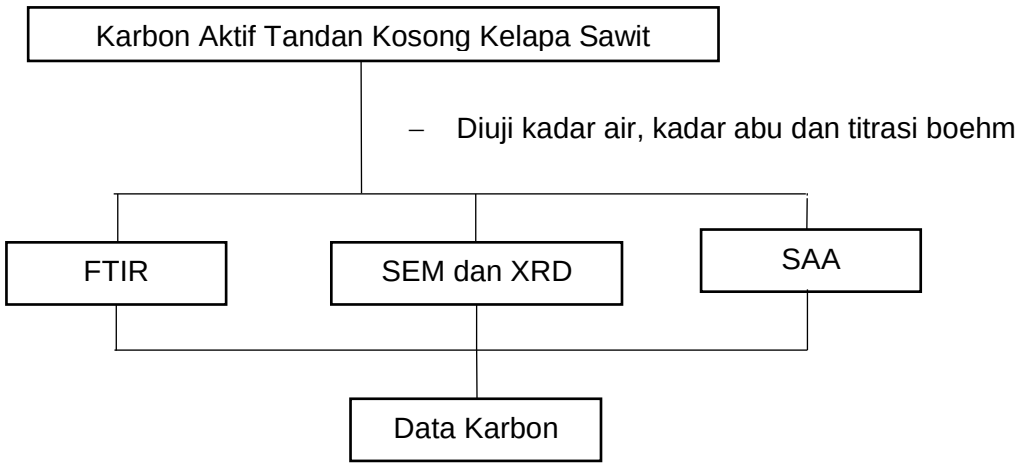
- Ditimbang karbon aktif sebanyak 1 g
- Ditimbang cawan porselin
- Dimasukkan ke dalam cawan porselin
- Dimasukkan ke dalam tanur dengan suhu 600^{o}C selama 3 jam
- Didinginkan pada suhu ruang
- Ditimbang
- Dihitung kadar abu

Hasil

2.8. Skema Kerja Karakterisasi Permukaan Karbon melalui Titrasi Boehm



2.9. Karakterisasi Karbon Aktif



2.10. Persiapan Limbah Cair

Limbah Cair

- Diambil dengan menggunakan gayung dan disaring
- Dimasukkan ke dalam jerigen
- Disimpan selama 48 jam
- Dibersihkan dari kotoran yang mengapung
- Dilakukan analisa pendahuluan terhadap beberapa parameter meliputi parameter KOK
- Dilakukan analisis dengan menggunakan spektrofotometer
- Dilakukan 10 kali pengenceran untuk mengatur konsentrasi awal sampel dengan cara mengambil 25 mL cairan limbah hasil penyaringan
- Ditambahkan akuades sehingga akan menghasilkan 250 mL cairan limbah
- Disaring menggunakan kertas saring

Hasil

2.11. Penentuan Nilai KOK Limbah Cair dengan Refluks Tertutup Secara Spektrofotometri (SNI 6989.2: 2019)

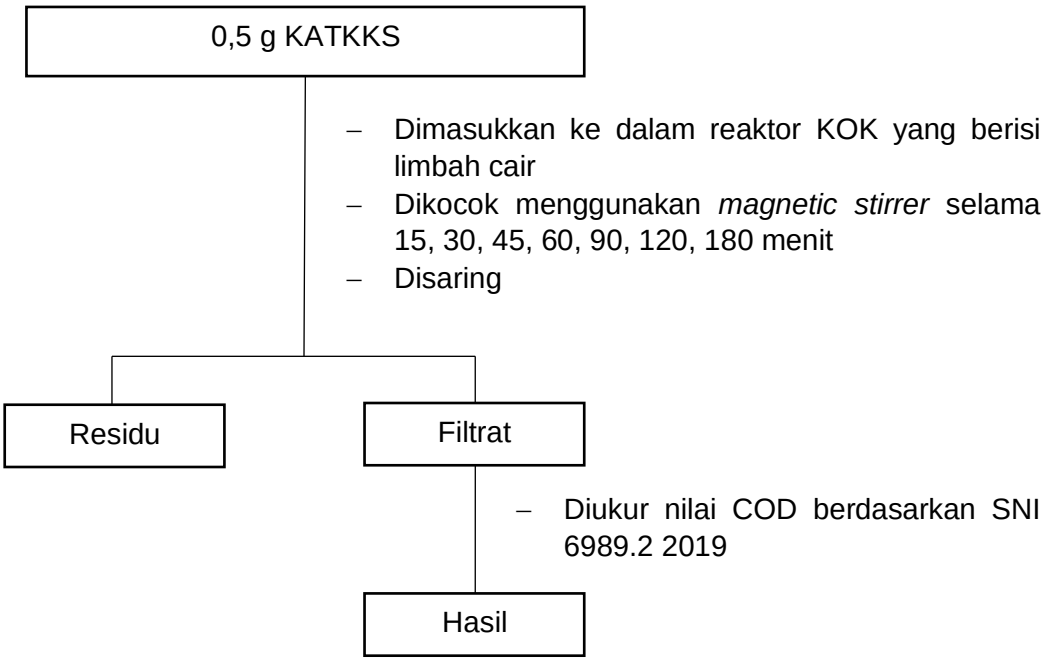
2.11.1 Pembuatan deret standar penetapan KOK

425 mg KHP

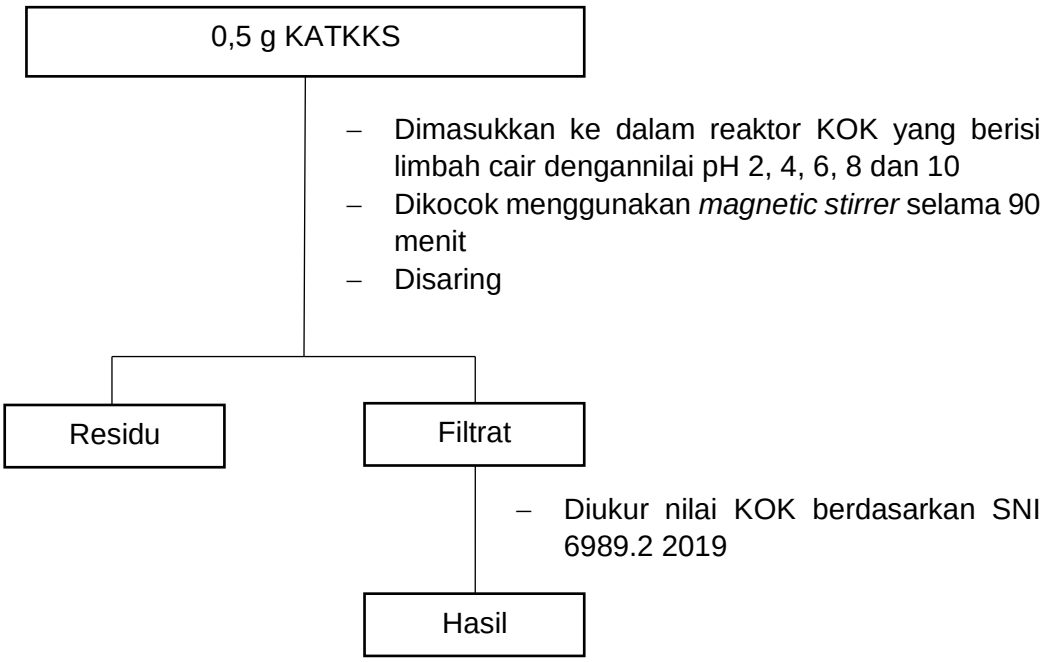
- Dimasukkan ke dalam labu ukur 1000 mL dan dihimpitkan hingga tanda batas
- Dibuat larutan standar dengan deret 10, 20, 30, 40, 50, 60, 70, 80 dan 90
- Diambil 2,5 mL masing-masing larutan deret standar
- Ditambahkan 1,5 mL *digestion solution* dan 3,5 mL larutan pereaksi asam sulfat ke dalam tabung
- Ditambahkan masing-masing 2,5 mL larutan sampel dan larutan kerja pada tabung tersebut
- Dihomogenkan
- Diletakkan pada *heating block* yang telah dipanaskan pada suhu 150^{o}C
- Direfluks selama 2 jam

Hasil

2.11.2 Penentuan Waktu Optimum



2.11.3. Penentuan pH Optimum



Lampiran 3. Perhitungan Pembuatan Larutan Pereaksi

3.1. Pembuatan Larutan H_3PO_4 15%

$V_1 \times M_1 = V_2 \times M_2$

$V_1 \times 85\% = 250\ mL \times 15\%$

$V_1 = 44{,}11\ mL$

3.2. Pembuatan Larutan $ZnCl_2$ 30%

$$\%\ V = \frac{\text{massa zat terlarut}}{\text{Volume Larutan}} \text{ x } 100\%$$

$$m = \frac{30\% \text{ x } 250\ mL}{100\%}$$

$m = 75$ gram

3.3. Pembuatan Larutan Na_2CO_3 0,05 N

gram = L × N × BE

gram = 0,25 L × 0,05 N × 106 g/eq

gram = 1,3250 gram

3.4. Pembuatan Larutan $NaHCO_3$ 0,05 N

gram = L × N × BE

gram = 0,25 L × 0,05 N × 84 g/eq

gram = 1,0500 gram

3.5. Pembuatan Larutan NaOH 0,05 N

gram = L × N × BE

gram = 0,25 L × 0,05 N × 40 g/eq

gram = 0,5000 gram

3.6. Pembuatan Larutan HCl 0,05 N

$$N = \frac{\% \times bj \times 10}{BE}$$

$$N = \frac{37 \times 1{,}19 \text{ g/mL} \times 10}{36{,}5 \text{ g/eq}}$$

$$N = 12{,}06 \text{ N}$$

$V_1 \times N_1 = V_2 \times N_2$

$V_1 \times 12{,}06 \text{ N} = 250 \text{ mL} \times 0{,}05 \text{ N}$

$V_1 = 1{,}03 \text{ mL}$

3.7. Pembuatan Larutan $Na_2B_4O_7$ 0,05 N

gram = L × N × BE

gram = 0,1 L × 0,05 N × 190,6 g/eq

gram = 0,9530 gram

3.8. Pembuatan Larutan $H_2C_2O_4$ 0,05 N

gram = L × N × BE

gram = 0,1 L × 0,05 N × 63 g/eq

gram = 0,3150 gram

Lampiran 4. Perhitungan Kadar Air

4.1. KATKKS

No	Berat Cawan Kosong	Berat Cawan dan Sampel	Berat Penimbangan Akhir	Bobot Akhir	Bobot Sampel	Kadar Air
1	46,6611	47,1614	47,145	0,0164	0,5003	3,27803318
2	43,49	43,9904	43,9748	0,0156	0,5004	3,117505995
3	45,2478	45,748	45,731	0,017	0,5002	3,398640544
Rata-Rata						**3,264726573**

$$\text{Kadar air (\%)} = \frac{\text{bobot akhir}}{\text{berat sampel}} \times 100\ \% = \frac{0{,}0164\ \text{gram}}{0{,}5003\ \text{gram}} \times 100\ \% = 3{,}278\ \%$$

4.2. KAM H_2SO_4

No	Berat Cawan Kosong	Berat Cawan dan Sampel	Berat Penimbangan Akhir	Bobot Akhir	Bobot Sampel	Kadar Air
1	45,7597	46,2601	46,248	0,0121	0,5004	2,418065548
2	43,5892	44,0894	44,0781	0,0113	0,5002	2,259096361
3	44,3402	44,8408	44,828	0,0128	0,5006	2,556931682
Rata-Rata						**2,41136453**

$$\text{Kadar air (\%)} = \frac{\text{bobot akhir}}{\text{berat sampel}} \times 100\ \% = \frac{0{,}0121\ \text{gram}}{0{,}5004\ \text{gram}} \times 100\ \% = 2{,}418\ \%$$

4.3. KAM H_2O_2

No	Berat Cawan Kosong	Berat Cawan dan Sampel	Berat Penimbangan Akhir	Bobot Akhir	Bobot Sampel	Kadar Air
1	22,3088	22,8092	22,798	0,0112	0,5004	2,238209432
2	22,861	23,3618	23,349	0,0128	0,5008	2,555910543
3	22,3086	22,8093	22,798	0,0113	0,5007	2,256840423
Rata-Rata						**2,350320133**

$$\text{Kadar air (\%)} = \frac{\text{bobot akhir}}{\text{berat sampel}} \times 100\ \% = \frac{0{,}0112\ \text{gram}}{0{,}5004\ \text{gram}} \times 100\ \% = 2{,}238\ \%$$

4.4. KAM $ZnCl_2$

No	Berat Cawan Kosong	Berat Cawan dan Sampel	Berat Penimbangan Akhir	Bobot Akhir	Bobot Sampel	Kadar Air
1	21,221	21,7214	21,707	0,0144	0,5004	2,877697842
2	21,135	21,6352	21,621	0,0142	0,5002	2,838864454
3	22,45	22,9506	22,936	0,0146	0,5006	2,9165002
Rata-Rata						**2,877687499**

$$\text{Kadar air (\%)} = \frac{\text{bobot akhir}}{\text{berat sampel}} \times 100\ \% = \frac{0{,}0144\ \text{gram}}{0{,}5004\ \text{gram}} \times 100\ \% = 2{,}877\ \%$$

Lampiran 5. Perhitungan Kadar Abu

5.1. KATKKS

No	Berat Cawan Kosong	Berat Cawan dan Sampel	Berat Penimbangan Akhir	Bobot Abu	Bobot Sampel	Kadar Abu
1	21,0624	21,5628	21,524	0,0388	0,5004	7,753796962
2	22,3088	22,8092	22,77	0,0392	0,5004	7,833733014
3	22,3064	22,807	22,767	0,04	0,5006	7,990411506
Rata-Rata						**7,859313827**

$$\text{Kadar abu (\%)} = \frac{\text{bobot abu}}{\text{bobot sampel}} \times 100\ \% = \frac{0{,}0388\ \text{gram}}{0{,}5004\ \text{gram}} \times 100\ \% = 7{,}753\ \%$$

5.2. KAM H_2SO_4

No	Berat Cawan Kosong	Berat Cawan dan Sampel	Berat Penimbangan Akhir	Bobot Abu	Bobot Sampel	Kadar Abu
1	25,781	26,2818	26,2515	0,0303	0,5008	6,050319489
2	25,808	26,3086	26,278	0,0306	0,5006	6,112664802
3	25,55	26,0505	26,018	0,0325	0,5005	6,493506494
Rata-Rata						**6,218830262**

$$\text{Kadar abu (\%)} = \frac{\text{bobot abu}}{\text{bobot sampel}} \times 100\ \% = \frac{0{,}0303\ \text{gram}}{0{,}5008\ \text{gram}} \times 100\ \% = 6{,}05\ \%$$

5.3. KAM H_2O_2

No	Berat Cawan Kosong	Berat Cawan dan Sampel	Berat Penimbangan Akhir	Bobot Abu	Bobot Sampel	Kadar Abu
1	22,861	23,3614	23,331	0,0304	0,5004	6,075139888
2	21,505	22,0056	21,975	0,0306	0,5006	6,112664802
3	21,621	22,1213	22,091	0,0303	0,5003	6,05636618
Rata-Rata						**6,08139029**

$$\text{Kadar abu (\%)} = \frac{\text{bobot abu}}{\text{bobot sampel}} \times 100\ \% = \frac{0{,}0304\ \text{gram}}{0{,}5004\ \text{gram}} \times 100\ \% = 6{,}075\ \%$$

5.4. KAM $ZnCl_2$

No	Berat Cawan Kosong	Berat Cawan dan Sampel	Berat Penimbangan Akhir	Bobot Abu	Bobot Sampel	Kadar Abu
1	26,6737	27,1743	27,14	0,0343	0,5006	6,851777867
2	24,6183	25,1187	25,084	0,0347	0,5004	6,934452438
3	25,0539	25,5546	25,524	0,0306	0,5007	6,111443978
Rata-Rata						**6,632558094**

$$\text{Kadar abu (\%)} = \frac{\text{bobot abu}}{\text{bobot sampel}} \times 100\ \% = \frac{0{,}0007\ \text{gram}}{0{,}1021\ \text{gram}} \times 100\ \% = 0{,}6856\ \%$$

Lampiran 6. Perhitungan Titrasi Boehm

6.1. KATKKS

6.1.1. Penentuan Kadar Gugus Karboksilat

No	V. Sampel (mL)	V. Titran NaHCO3 (mL)	N. NaHCO3	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Carboxyl (meq/g)
1	25	5	0,05	0,0475	7	0,0544	2,2	0,1015	1,831527094
2	25	5	0,05	0,0475	7	0,0544	2,2	0,1024	1,815429688
3	25	5	0,05	0,0475	7	0,0544	2,1	0,1009	1,5728444
Rata - rata									**1,739933727**

Contoh perhitungan:

$$n_{karboksil} = \frac{\left[V_{NaHCO_3} N_{NaHCO_3} - (N_{HCl} V_{HCl} - N_{NaOH} V_{NaOH})\right] \frac{V_p}{V_s}}{w}$$

$$n_{karboksil} = \frac{\left[5\ mL \times 0{,}05\ N - (0{,}0475\ N \times 7\ mL - 0{,}0544\ N \times 2{,}2\ mL)\right] \frac{25\ mL}{5\ mL}}{0{,}1015\ gram}$$

$$n_{karboksil} = \frac{\left[0{,}25\ meq - (0{,}3325\ meq - 0{,}1196\ meq)\right] \frac{25\ mL}{5\ mL}}{0{,}1015\ gram}$$

$$n_{karboksil} = \frac{\left[0{,}25\ meq - 0{,}2128\ meq\right] \frac{25\ mL}{5\ mL}}{0{,}1015\ gram} = 1{,}8315\ \frac{meq}{gram}$$

6.1.2. Penentuan Kadar Gugus Lakton

No	V. Sampel (mL)	V. Titran Na2CO3 (mL)	N. Na2CO3	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Lakton (meq/g)
1	25	5	0,05	0,0475	7	0,0544	2,4	0,1018	0,528983712
2	25	5	0,05	0,0475	7	0,0544	2,4	0,1024	0,53125
3	25	5	0,05	0,0475	7	0,0544	2,4	0,1033	0,753389869
Rata - rata									**0,604541194**

Contoh perhitungan:

$$n_{lakton} = \frac{\left[V_{Na_2CO_3} N_{Na_2CO_3} - (N_{HCl} V_{HCl} - N_{NaOH} V_{NaOH})\right] \frac{V_p}{V_s}}{w} - n_{karboksil}$$

$$n_{lakton} = \frac{[5\ mL \times 0{,}05\ N - (0{,}0475\ N \times 7\ mL - 0{,}0544\ N \times 2{,}4\ mL)] \frac{25\ mL}{5\ mL}}{0{,}1018\ gram} - 1{,}8315\ \frac{meq}{gram}$$

$$n_{lakton} = \frac{[0{,}25\ meq - (0{,}3325\ meq - 0{,}13056\ meq)] \frac{25\ mL}{5\ mL}}{0{,}1018\ gram} - 1{,}8315\ \frac{meq}{gram}$$

$$n_{lakton} = 2{,}3605\ \frac{meq}{gram} - 1{,}8315\ \frac{meq}{gram}$$

$$n_{lakton} = 0{,}529\ \frac{meq}{gram}$$

6.1.3. Penentuan Kadar Gugus Fenol

No	V. Sampel (mL)	V. Titran NaOH (mL)	N. NaOH	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Fenol (meq/g)
1	25	5	0,0544	0,0475	7	0,0544	2,5	0,1014	1,362368879
2	25	5	0,0544	0,0475	7	0,0544	2,5	0,1006	1,405805402
3	25	5	0,0544	0,0475	7	0,0544	2,4	0,1008	1,148964144
Rata - rata									**1,305712808**

Contoh perhitungan:

$$n_{fenol} = \frac{[V_{NaOH}N_{NaOH} - (N_{HCl}V_{HCl} - N_{NaOH}V_{NaOH})]\frac{V_p}{V_s}}{w} - n_{karboksil} - n_{lakton}$$

$$n_{fenol} = \frac{[5\ mL \times 0,0544\ N - (0,0475\ N \times 7\ mL - 0,0544\ N \times 2,5\ mL)]\frac{25\ mL}{5\ mL}}{0,1014\ gram} - 1,8315\ \frac{meq}{gram} - 0,529\ \frac{meq}{gram})$$

$$n_{fenol} = \frac{[0,25\ meq - (0,5280\ meq - 0,363636\ meq)]\frac{25\ mL}{5\ mL}}{0,1014\ gram} - 1,5635\ \frac{meq}{gram} - 0,529\ \frac{meq}{gram})$$

$$n_{fenol} = 3,722\ \frac{meq}{gram} - 1,5635\frac{meq}{gram} - 0,529\ \frac{meq}{gram})$$

$$n_{fenol} = 1,362\frac{meq}{gram}$$

6.1.4. Penentuan Kadar Gugus Total Basa

No	V. Sampel (mL)	V. Titran HCl (mL)	N. HCl	N. NaOH	V. NaOH (mL)	N. HCl	V. HCl (mL)	Massa Karbon (g)	n total base (meq/g)
1	25	5	0,0475	0,0544	7	0,0475	3,1	0,1005	0,196517413
2	25	5	0,0475	0,0544	7	0,0475	3,1	0,1014	0,194773176
3	25	5	0,0475	0,0544	7	0,0475	3	0,1012	-0,039525692
Rata - rata									**0,117254966**

Contoh perhitungan:

$$n_{total\ basa} = \frac{[\ V_{HCl}N_{HCl} - (N_{NaOH}V_{NaOH} - N_{HCl}V_{HCl})\ ]\ \frac{V_p}{V_s}}{w}$$

$$n_{total\ basa} = \frac{[5\ mL \times 0{,}0475\ N - (0{,}0544\ N \times 7\ mL - 0{,}0475\ N \times 3{,}1\ mL)\ ]\ \frac{25\ mL}{5\ mL}}{0{,}1005\ gram}$$

$$n_{total\ basa} = \frac{[0{,}2375\ meq - (0{,}3808\ meq - 0{,}14725\ meq)\ ]\ \frac{25\ mL}{5\ mL}}{0{,}1005\ gram}$$

$$n_{total\ basa} = \frac{[0{,}2375\ meq - 0{,}2335\ meq\ ]\ \frac{25\ mL}{5\ mL}}{0{,}1005\ gram}$$

$$n_{total\ basa} = 0{,}1965\ \frac{meq}{gram}$$

6.2. KAM H_2SO_4

6.2.1. Penentuan Kadar Gugus Karboksil

No	V. Sampel (mL)	V. Titran $NaHCO_3$ (mL)	N. $NaHCO_3$	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Karboksil (meq/g)
1	25	5	0,05	0,0475	7	0,0544	2,4	0,1005	2,391044776
2	25	5	0,05	0,0475	7	0,0544	2,4	0,1003	2,395812562
3	25	5	0,05	0,0475	7	0,0544	2,3	0,1012	2,105731225
Rata - rata									**2,297529521**

6.2.2. Penentuan Kadar Gugus Lakton

No	V. Sampel (mL)	V. Titran Na_2CO_3 (mL)	N. Na_2CO_3	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Lakton (meq/g)
1	25	5	0,05	0,0475	7	0,0544	2,7	0,1026	0,746382124
2	25	5	0,05	0,0475	7	0,0544	2,8	0,1012	1,053792181
3	25	5	0,05	0,0475	7	0,0544	2,8	0,1013	1,340468182
Rata - rata									**1,046880829**

6.2.3. Penentuan Kadar Gugus Fenol

No	V. Sampel (mL)	V. Titran NaOH (mL)	N. NaOH	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Fenol (meq/g)
1	25	5	0,0544	0,0475	7	0,0544	3	0,1027	1,862573099
2	25	5	0,0544	0,0475	7	0,0544	3,1	0,1009	1,909166317
3	25	5	0,0544	0,0475	7	0,0544	3	0,1005	1,663253329
Rata - rata									**1,811664248**

6.2.4. Penentuan Kadar Gugus Basa Total

No	V. Sampel (mL)	V. Titran HCl (mL)	N. HCl	N. NaOH	V. NaOH (mL)	N. HCl	V. HCl (mL)	Massa Karbon (g)	n Total Basa (meq/g)
1	25	5	0,0475	0,0544	7	0,0475	3,1	0,1055	0,187203791
2	25	5	0,0475	0,0544	7	0,0475	2,9	0,1045	-0,265550239
3	25	5	0,0475	0,0544	7	0,0475	3,1	0,1049	0,188274547
Rata - rata									**0,0366427**

6.3. KAM H_2O_2

6.3.1. Penentuan Kadar Gugus Karboksil

No	V. Sampel (mL)	V. Titran $NaHCO_3$ (mL)	N. $NaHCO_3$	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Karboksil (meq/g)
1	25	5	0,05	0,0475	7	0,0544	2,8	0,1006	3,470179
2	25	5	0,05	0,0475	7	0,0544	2,8	0,1004	3,477092
3	25	5	0,05	0,0475	7	0,0544	2,7	0,1008	3,193452
Rata - rata									**3,380241**

6.3.2. Penentuan Kadar Gugus Lakton

No	V. Sampel (mL)	V. Titran Na_2CO_3 (mL)	N. Na_2CO_3	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Lakton (meq/g)
1	25	5	0,05	0,0475	7	0,0544	3,2	0,1005	1,086040
2	25	5	0,05	0,0475	7	0,0544	3,3	0,1002	1,364226
3	25	5	0,05	0,0475	7	0,0544	3,3	0,1007	1,623827
Rata - rata									**1,358031**

6.3.3. Penentuan Kadar Gugus Fenol

No	V. Sampel (mL)	V. Titran NaOH (mL)	N. NaOH	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Fenol (meq/g)
1	25	5	0,0544	0,0475	7	0,0544	3,8	0,101	2,682395
2	25	5	0,0544	0,0475	7	0,0544	3,8	0,1004	2,440555
3	25	5	0,0544	0,0475	7	0,0544	3,9	0,1005	2,727995
Rata - rata									**2,616982**

6.3.4. Penentuan Kadar Gugus Basa Total

No	V. Sampel (mL)	V. Titran $NaHCO_3$ (mL)	N. HCl	N. NaOH	V. NaOH (mL)	N. HCl	V. HCl (mL)	Massa Karbon (g)	n total basa (meq/g)
1	25	5	0,0475	0,0544	7	0,0475	3	0,101	-0,039604
2	25	5	0,0475	0,0544	7	0,0475	3	0,1012	-0,039526
3	25	5	0,0475	0,0544	7	0,0475	3,1	0,1012	0,195158
Rata - rata									**0,038676**

6.4. KAM $ZnCl_2$

6.4.1. Penentuan Kadar Gugus Karboksil

No	V. Sampel (mL)	V. Titran $NaHCO_3$ (mL)	N. $NaHCO_3$	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Carboxyl (meq/g)
1	25	5	0,05	0,0475	7	0,0544	2,3	0,1004	2,12250996
2	25	5	0,05	0,0475	7	0,0544	2,2	0,1003	1,853439681
3	25	5	0,05	0,0475	7	0,0544	2,2	0,1004	1,851593625
Rata - rata									**1,942514422**

6.4.2. Penentuan Kadar Gugus Lakton

No	V. Sampel (mL)	V. Titran Na_2CO_3 (mL)	N. Na_2CO_3	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Lactone (meq/g)
1	25	5	0,05	0,0475	7	0,0544	2,7	0,1006	1,077291233
2	25	5	0,05	0,0475	7	0,0544	2,6	0,1008	1,07017143
3	25	5	0,05	0,0475	7	0,0544	2,6	0,1003	1,086591818
Rata - rata									**1,07801816**

6.4.3. Penentuan Kadar Gugus Fenol

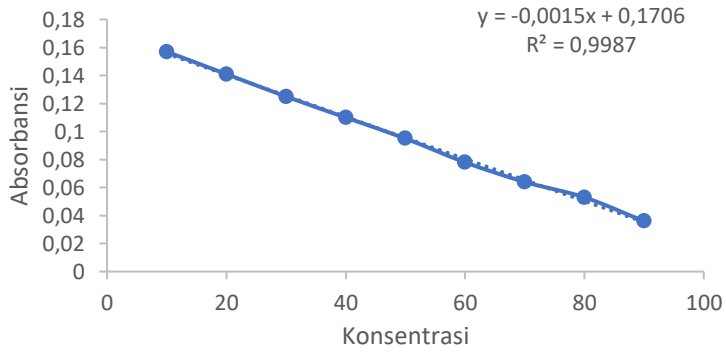
No	V. Sampel (Vs) (mL)	V. Titran NaOH (Vp) (mL)	N. NaOH	N. HCl	V. HCl (mL)	N. NaOH	V. NaOH (mL)	Massa Karbon (g)	n Phenolic (meq/g)
1	25	5	0,0544	0,0475	7	0,0544	2,8	0,1007	1,359285202
2	25	5	0,0544	0,0475	7	0,0544	2,8	0,1008	1,630952381
3	25	5	0,0544	0,0475	7	0,0544	2,9	0,1006	1,89581058
Rata - rata									**1,628682721**

6.4.4. Penentuan Kadar Gugus Basa Total

No	V. Sampel (Vs) (mL)	V. Titran HCl (Vp) (mL)	N. HCl	N. NaOH	V. NaOH (mL)	N. HCl	V. HCl (mL)	Massa Karbon (g)	n total base (meq/g)
1	25	5	0,0475	0,0544	7	0,0475	3	0,1014	-0,039447732
2	25	5	0,0475	0,0544	7	0,0475	3,1	0,1013	0,194965449
3	25	5	0,0475	0,0544	7	0,0475	3,1	0,101	0,195544554
Rata - rata									**0,117020757**

Lampiran 7. Data Absorbansi Untuk Penentuan Waktu dan pH Optimum Dalam Menurunkan Kadar COD

Konsentrasi	Absorbansi
10	0.157
20	0.141
30	0.125
40	0.11
50	0.095
60	0.078
70	0.064
80	0.053
90	0.036



Lampiran 8. Data Hasil Penentuan Waktu Optimum Adsorpsi oleh Karbon Aktif Dalam Penurunan Kadar KOK

Waktu	C_o (mg/L)	C_e (mg/L)	V (L)	W (g)	q_e (mg/g)
15	88,40	69,07	0,0250	0,5001	0,9665
30	88,40	61,73	0,0250	0,5003	1,3325
45	88,40	57,73	0,0250	0,5004	1,5321
60	88,40	49,73	0,0250	0,5003	1,9322
90	88,40	35,07	0,0250	0,5005	2,6640
120	88,40	37,73	0,0250	0,5005	2,5308
150	88,40	39,07	0,0250	0,5004	2,4647
180	88,40	39,73	0,0250	0,5006	2,4304

Contoh Perhitungan hasil adsorpsi:

$$q_e = \frac{(C_o - C_e)V}{W}$$

$$q_e = \frac{\left(88{,}40\,\frac{mg}{L} - \frac{69{,}07 mg}{L}\right) 0{,}0250\ L}{0{,}5001\ g}$$

$$q_e = 0{,}9665\ mg/g$$

Lampiran 9. Data Hasil Penentuan Waktu Optimum Adsorpsi oleh Karbon Aktif Modifikasi dengan H_2O_2 Dalam Penurunan Kadar KOK

Waktu	C_o (mg/L)	C_e (mg/L)	V (L)	W (g)	q_e (mg/g)
15	88,40	47,07	0,0250	0,5004	2,0650
30	88,40	37,07	0,0250	0,5004	2,5646
45	88,40	31,73	0,0250	0,5004	2,8311
60	88,40	27,73	0,0250	0,5003	3,0315
90	88,40	21,73	0,0250	0,5003	3,3313
120	88,40	28,40	0,0250	0,5003	2,9982
150	88,40	33,73	0,0250	0,5003	2,7317
180	88,40	33,73	0,0250	0,5004	2,7311

Contoh Perhitungan hasil adsorpsi:

$$q_e = \frac{(C_o - C_e)V}{W}$$

$$q_e = \frac{\left(88{,}40\,\frac{mg}{L} - \frac{47{,}07 mg}{L}\right) 0{,}0250\ L}{0{,}5004\ g}$$

$$q_e = 2{,}0650\ mg/g$$

Lampiran 10. Data Hasil Penentuan Waktu Optimum Adsorpsi oleh Karbon Aktif Modifikasi dengan $ZnCl_2$ Dalam Penurunan Kadar KOK

Waktu	C_o (mg/L)	C_e (mg/L)	V (L)	W (g)	q_e (mg/g)
15	88,40	49,07	0,0250	0,5004	1,9651
30	88,40	47,07	0,0250	0,5003	2,0654
45	88,40	40,40	0,0250	0,5003	2,3986
60	88,40	35,07	0,0250	0,5004	2,6645
90	88,40	28,40	0,0250	0,5004	2,9976
120	88,40	33,73	0,0250	0,5001	2,7328
150	88,40	37,73	0,0250	0,5004	2,5313
180	88,40	37,73	0,0250	0,5004	2,5313

Contoh Perhitungan hasil adsorpsi:

$$q_e = \frac{(C_o - C_e)V}{W}$$

$$q_e = \frac{\left(88{,}40\,\frac{mg}{L} - \frac{49{,}07 mg}{L}\right) 0{,}0250\ L}{0{,}5004\ g}$$

$$q_e = 1{,}9651\ mg/g$$

Lampiran 11. Data Hasil Penentuan Waktu Optimum Adsorpsi oleh Karbon Aktif Modifikasi dengan H_2SO_4 Dalam Penurunan Kadar KOK

Waktu	C_o (mg/L)	C_e (mg/L)	V (L)	W (g)	q_e (mg/g)
15	88,40	57,07	0,0250	0,5003	1,5657
30	88,40	47,07	0,0250	0,5003	2,0654
45	88,40	41,73	0,0250	0,5003	2,3319
60	88,40	37,07	0,0250	0,5003	2,5651
90	88,40	24,40	0,0250	0,5002	3,1987
120	88,40	31,07	0,0250	0,5002	2,8655
150	88,40	33,73	0,0250	0,5003	2,7317
180	88,40	34,40	0,0250	0,5004	2,6978

Contoh Perhitungan hasil adsorpsi:

$$q_e = \frac{(C_o - C_e)V}{W}$$

$$q_e = \frac{\left(88{,}40\,\frac{mg}{L} - \frac{57{,}0667\ mg}{L}\right)0{,}0250\ L}{0{,}5003\ g}$$

$$q_e = 1{,}5657\ mg/g$$

Lampiran 12. Data Hasil Penentuan pH Optimum Adsorpsi Oleh Karbon Aktif

pH	C_o (mg/L)	C_e (mg/L)	V (L)	W (g)	q_e (mg/g)
2	88,40	32,40	0,0250	0,5002	2,7989
4	88,40	33,07	0,0250	0,5006	2,7634
6	88,40	35,07	0,0250	0,5001	2,6661
8	88,40	35,73	0,0250	0,5002	2,6323
10	88,40	35,73	0,0250	0,5003	2,6318

Contoh Perhitungan hasil adsorpsi:

$$q_e = \frac{(C_o - C_e)V}{W}$$

$$q_e = \frac{\left(88{,}40\,\frac{mg}{L} - \frac{32{,}40\ mg}{L}\right)0{,}0250\ L}{0{,}5002\ g}$$

$$q_e = 2{,}7989\ mg/g$$

Lampiran 13. Data Hasil Penentuan pH Optimum Adsorpsi Oleh Karbon Aktif Modifikasi H_2SO_4

pH	C_o (mg/L)	C_e (mg/L)	V (L)	W (g)	q_e (mg/g)
2	88,40	21,73	0,0250	0,5005	3,3300
4	88,40	22,40	0,0250	0,5005	3,2967
6	88,40	24,40	0,0250	0,5003	3,1981
8	88,40	25,73	0,0250	0,5004	3,1308
10	88,40	25,73	0,0250	0,5004	3,1308

Contoh Perhitungan hasil adsorpsi:

$$q_e = \frac{(C_o - C_e)V}{W}$$

$$q_e = \frac{\left(88{,}40\,\frac{mg}{L} - \frac{21{,}73\ mg}{L}\right)0{,}0250\ L}{0{,}5005\ g}$$

$$q_e = 3{,}3300\,\frac{mg}{g}$$

Lampiran 14. Data Hasil Penentuan pH Optimum Adsorpsi Oleh Karbon Aktif Modifikasi $ZnCl_2$

pH	C_o (mg/L)	C_e (mg/L)	V (L)	W (g)	q_e (mg/g)
2	88,40	27,07	0,0250	0,5004	3,0642
4	88,40	27,07	0,0250	0,5004	3,0642
6	88,40	28,40	0,0250	0,5001	2,9994
8	88,40	29,73	0,0250	0,5002	2,9322
10	88,40	30,40	0,0250	0,5003	2,8983

Contoh Perhitungan hasil adsorpsi:

$$q_e = \frac{(C_o - C_e)V}{w}$$

$$q_e = \frac{\left(88{,}40\,\frac{mg}{L} - \frac{27{,}07\ mg}{L}\right)0{,}0250\ L}{0{,}5004\ g}$$

$$q_e = 3{,}0642\,\frac{mg}{g}$$

Lampiran 15. Data Hasil Penentuan pH Optimum Adsorpsi Oleh KAM H_2O_2

pH	C_o (mg/L)	C_e (mg/L)	V (L)	W (g)	q_e (mg/g)
2	88,40	19,07	0,0250	0,5002	3,4653
4	88,40	19,07	0,0250	0,5003	3,4646
6	88,40	21,73	0,0250	0,5005	3,3300
8	88,40	25,07	0,0250	0,5004	3,1641
10	88,40	25,73	0,0250	0,5004	3,1308

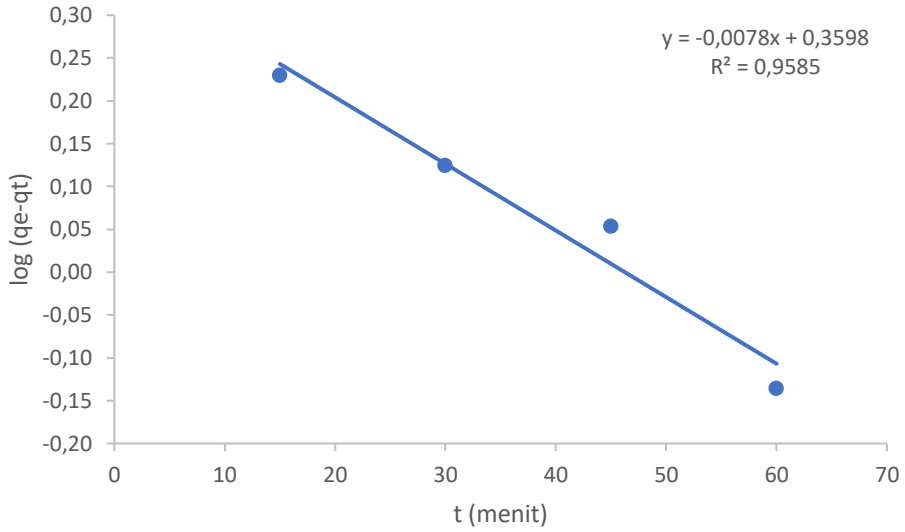
Contoh Perhitungan hasil adsorpsi:

$$q_e = \frac{(C_o - C_e)V}{W}$$

$$q_e = \frac{\left(88{,}40\,\frac{\text{mg}}{\text{L}} - \frac{19{,}07\ \text{mg}}{\text{L}}\right)0{,}0250\ \text{L}}{0{,}5002\ \text{g}}$$

$$q_e = 3{,}4653\ \text{mg/g}$$

Lampiran 16. Contoh Perhitungan Nilai Parameter Kinetika Orde Satu Semu



Data grafik kinetika orde satu semu diperoleh persamaan garis:

Y = -0,0078x + 0,3598

Dari persamaan garis diperoleh nilai R^2 = 0,9586, nilai slope (a) = -0,0078 dan nilai intersep (b) = 0,3598

Nilai k_1 dapat diperoleh dengan persamaan sebagai berikut:

Slope $= -\frac{k_1}{2{,}303}$

K_1 = -slope . 2,303

= -(-0,0078) . 2,303

= 0,01796 $menit^{-1}$

Nilai adsorpsi dapat dihitung dengan persamaan sebagai berikut:

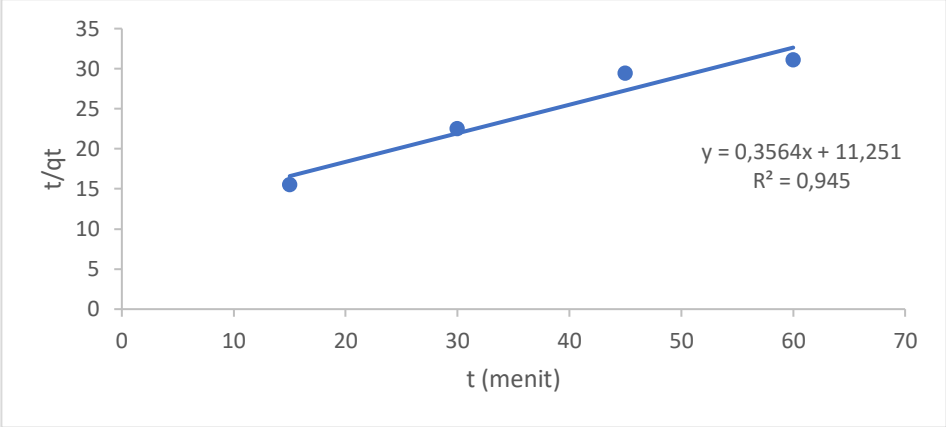
Intersep = Log q_e

q_e = Antilog Intersep

= Antilog 0,3598

= 2,2898 $mg.g^{-1}$

Lampiran 17. Contoh Perhitungan Nilai Parameter Kinetika Orde Dua Semu



Data grafik kinetika orde dua semu diperoleh persamaan garis sebagai berikut:

Y = 0,3564x + 11,251

Dari persamaan garis diperoleh nilai R^2 = 0,945, nilai slope (a) = 0,3564 dan nilai intersep (b) = 11,251.

Nilai k_2 dapat dihitung dengan persamaan sebagai berikut:

Intersep $= \frac{1}{k_2 . q_e^2}$

$K_2 = \frac{1}{q_e^2 , \text{intersep}}$

$= \frac{1}{2{,}80^2 , 11{,}251}$

$= 0{,}0112$ g,$mg^{-1}$$menit^{-1}$

Nilai adsorpsi dapat dihitung dengan persamaan sebagai berikut:

Slope $= \frac{1}{q_e}$

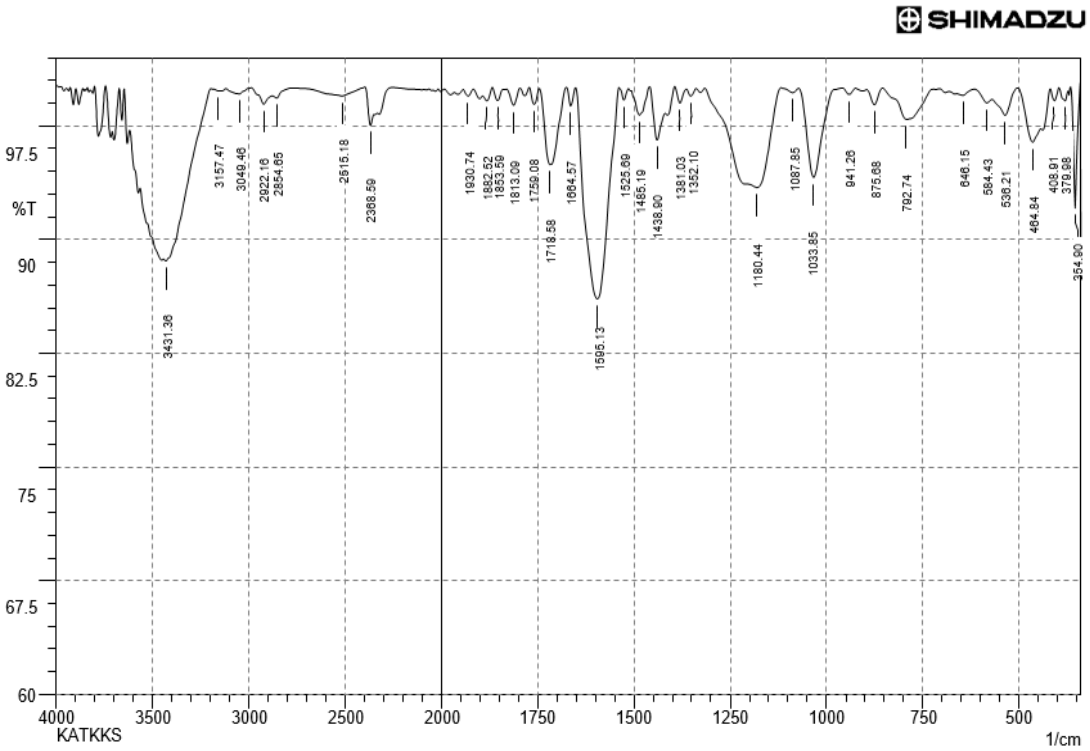
$q_e = \frac{1}{\text{slope}}$

$= \frac{1}{0{,}3564}$

$= 2{,}8058$ $mg.g^{-1}$

Lampiran 18. Hasil Analisis FTIR

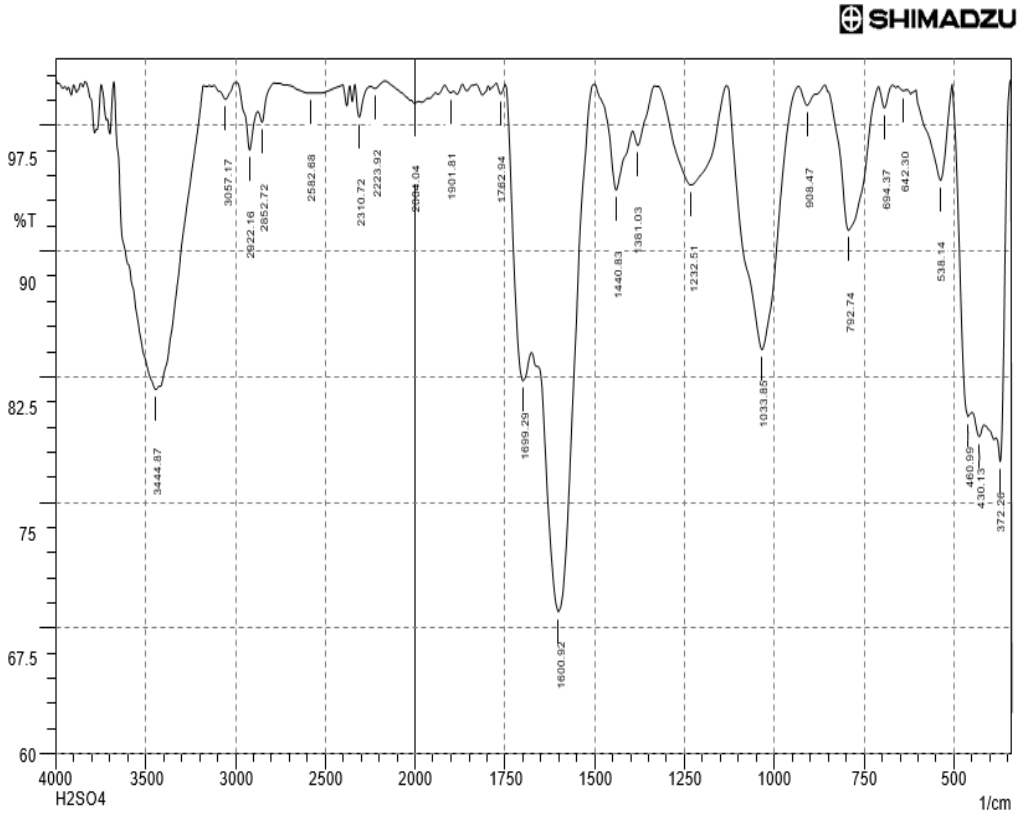
a. KATKKS



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	354.9	92.083	8.122	366.48	341.4	0.358	0.382
2	379.98	99.167	0.689	397.34	374.19	0.052	0.044
3	408.91	99.174	0.815	418.55	397.34	0.045	0.044
4	464.84	96.433	1.814	505.35	443.63	0.591	0.229
5	536.21	98.208	1.445	570.93	505.35	0.291	0.185
6	584.43	99.03	0.416	617.22	570.93	0.115	0.032
7	646.15	99.527	0.213	661.58	617.22	0.059	0.017
8	792.74	97.939	2.03	854.47	723.31	0.605	0.587
9	875.68	98.905	1.044	894.97	854.47	0.096	0.088
10	941.26	99.585	0.411	960.55	923.9	0.03	0.03
11	1033.85	94.107	5.86	1072.42	977.91	1.106	1.089
12	1087.85	99.701	0.287	1111	1072.42	0.027	0.025
13	1180.44	93.443	2.07	1205.51	1118.71	1.684	0.495
14	1352.1	99.473	0.49	1363.67	1338.6	0.033	0.029
15	1381.03	99.017	1.026	1394.53	1363.67	0.061	0.066
16	1438.9	96.586	2.585	1460.11	1419.61	0.368	0.228
17	1485.19	98.214	1.744	1508.33	1460.11	0.208	0.2
18	1525.69	99.24	0.764	1539.2	1514.12	0.036	0.037
19	1595.13	86.104	13.936	1651.07	1539.2	4.213	4.233
20	1664.57	98.821	1.226	1674.21	1651.07	0.057	0.062
21	1718.58	94.96	0.349	1745.58	1716.65	0.356	0.031
22	1759.08	98.937	1.085	1772.58	1745.58	0.066	0.069
23	1813.09	98.873	1.097	1830.45	1795.73	0.087	0.082
24	1853.59	99.191	0.792	1867.09	1840.09	0.053	0.051
25	1882.52	99.172	0.521	1892.17	1867.09	0.058	0.032
26	1930.74	99.477	0.439	1942.32	1917.24	0.036	0.027
27	2368.59	97.549	1.444	2397.52	2349.3	0.307	0.133
28	2515.18	99.481	0.508	2721.56	2414.88	0.357	0.339
29	2854.65	99.351	0.258	2877.79	2789.07	0.124	0.022
30	2922.16	98.944	0.757	2985.81	2877.79	0.266	0.149
31	3049.46	99.621	0.352	3116.97	3003.17	0.115	0.1
32	3157.47	99.816	0.041	3182.55	3147.83	0.021	0.003
33	3431.36	88.607	0.65	3442.94	3197.98	6.963	0.677

Date/Time; 2/22/2022 10:02:24 AM
No. of Scans;

b. KAM-H_2SO_4

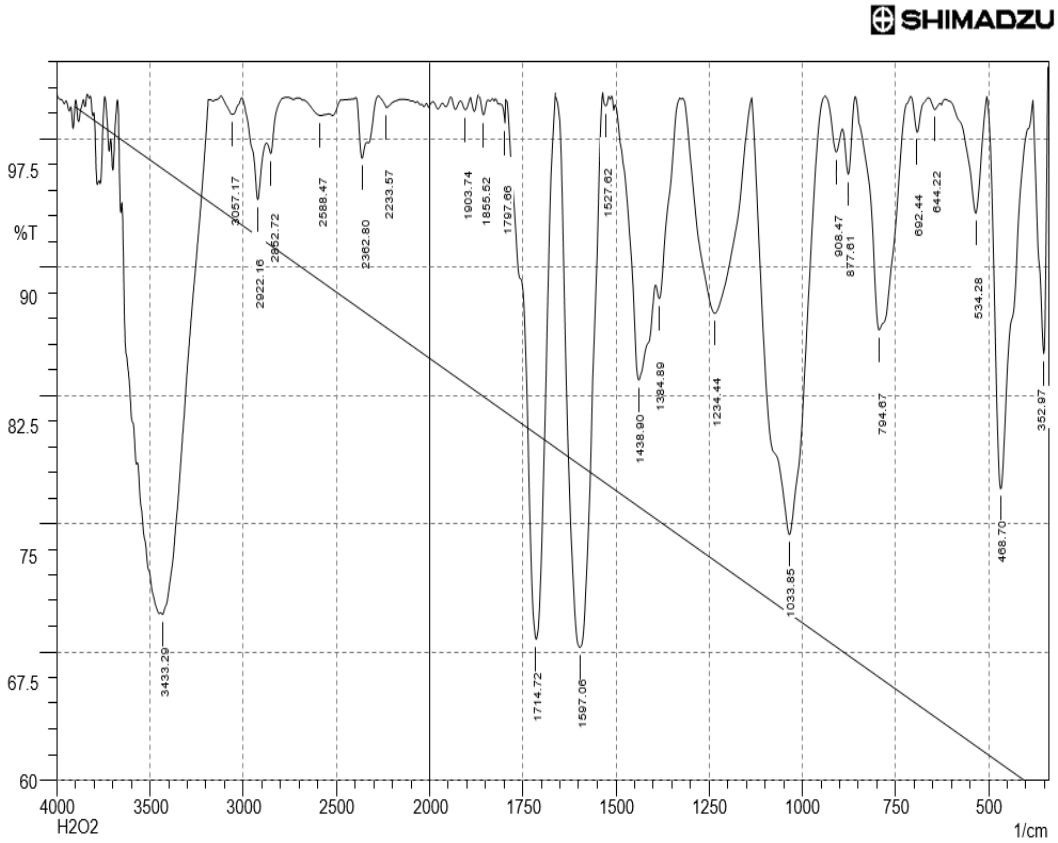


No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	372.26	77.453	6.735	381.91	343.33	2.385	0.601
2	430.13	78.944	0.958	449.41	418.55	3.076	0.081
3	460.99	80.136	3.732	505.35	451.34	3.308	0.67
4	538.14	94.268	5.461	605.65	507.28	1.41	1.286
5	642.3	99.594	0.165	655.8	630.72	0.035	0.01
6	694.37	98.582	1.302	709.8	671.23	0.123	0.105
7	792.74	91.275	8.369	848.68	711.73	2.917	2.722
8	908.47	98.735	1.152	933.55	860.25	0.207	0.175
9	1033.85	84.133	15.752	1132.21	933.55	7.66	7.56
10	1232.51	93.97	5.919	1321.24	1134.14	3.114	3.025
11	1381.03	96.336	1.471	1394.53	1334.74	0.586	0.204
12	1440.83	93.676	4.718	1498.69	1396.46	1.538	0.887
13	1600.92	68.484	22.474	1674.21	1506.41	15.679	9.376
14	1699.29	82.282	6.868	1747.51	1676.14	4.282	1.497
15	1762.94	99.419	0.61	1774.51	1749.44	0.033	0.036
16	1901.81	99.493	0.2	1917.24	1894.1	0.036	0.011
17	2004.04	98.857	0.201	2167.99	1990.54	0.382	0.051
18	2223.92	99.73	0.216	2247.07	2167.99	0.027	0.032
19	2310.72	98.024	1.924	2335.8	2247.07	0.332	0.3
20	2582.68	99.455	0.062	2719.63	2565.33	0.228	0.032
21	2852.72	97.706	1.113	2877.79	2785.21	0.425	0.106
22	2922.16	96.056	2.983	2989.66	2877.79	1.001	0.61
23	3057.17	99.096	0.911	3118.9	3003.17	0.231	0.232
24	3444.87	81.766	1.705	3676.32	3423.65	15.312	4.352

Comment;
H2SO4

Date/Time; 1/14/2022 11:58:53 AM
No. of Scans;
Resolution;
Apodization;

c. KAM-H_2O_2

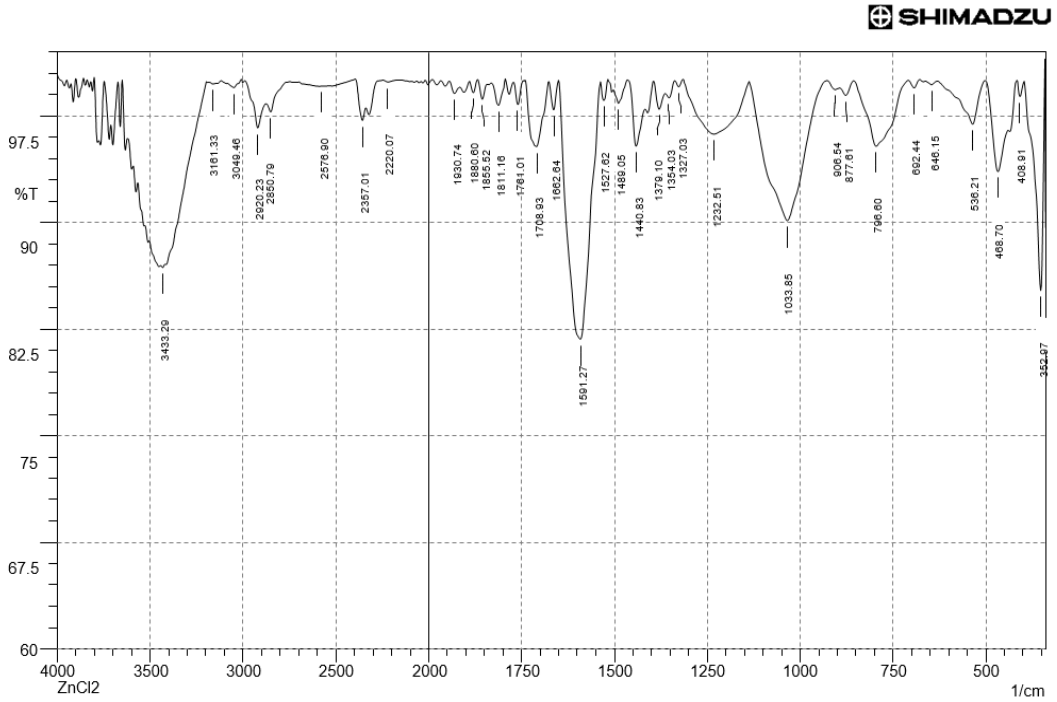


No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	352.97	84.939	13.712	381.91	343.33	1.571	1.4
2	468.7	77.047	22.774	505.35	383.83	5.89	5.735
3	534.28	93.152	6.61	615.29	507.28	1.277	1.174
4	644.22	99.23	0.501	661.58	630.72	0.065	0.032
5	692.44	97.908	2.063	709.8	661.58	0.174	0.166
6	794.67	86.344	13.602	856.39	709.8	4.4	4.371
7	877.61	95.435	3.5	893.04	858.32	0.41	0.263
8	908.47	96.741	1.997	939.33	893.04	0.365	0.174
9	1033.85	74.377	25.591	1136.07	941.26	14.071	14.043
10	1234.44	87.308	12.533	1319.31	1138	6.433	6.305
11	1384.89	88.173	2.076	1392.61	1328.95	1.8	0.258
12	1438.9	83.398	9.945	1500.62	1394.53	5.14	2.269
13	1527.62	99.431	0.687	1535.34	1519.91	0.023	0.03
14	1597.06	67.758	32.16	1660.71	1537.27	11.497	11.453
15	1714.72	68.244	31.836	1793.8	1662.64	9.676	9.705
16	1714.72	98.434	1.355	1807.3	1793.8	0.043	0.026
17	1855.52	98.902	1.013	1869.02	1843.95	0.059	0.051
18	1903.74	99.216	0.62	1917.24	1890.24	0.057	0.038
19	2233.57	99.356	0.586	2276	2156.42	0.172	0.127
20	2362.8	96.37	2.12	2395.59	2335.8	0.622	0.258
21	2588.47	98.889	0.357	2679.13	2542.18	0.482	0.11
22	2852.72	96.65	1.17	2875.86	2765.92	0.652	-0.026
23	2922.16	93.958	4.204	3007.02	2877.79	1.757	0.937
24	3057.17	98.948	1.011	3118.9	3008.95	0.284	0.268
25	3433.29	69.697	1.244	3442.94	3188.33	22.206	2.374

Comment;
H2O2

Date/Time; 2/22/2022 10:07:02 AM
No. of Scans;
Resolution;

d. KAM-$ZnCl_2$



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	352.97	85.217	13.225	397.34	343.33	1.673	1.436
2	408.91	98.883	1.115	416.62	397.34	0.049	0.048
3	468.7	93.609	4.461	501.49	441.7	1.051	0.572
4	536.21	96.927	3.071	630.72	503.42	0.723	0.716
5	646.15	99.706	0.256	661.58	630.72	0.021	0.016
6	692.44	99.493	0.558	709.8	677.01	0.03	0.037
7	796.6	95.374	4.618	854.47	709.8	1.535	1.533
8	877.61	98.962	0.743	894.97	856.39	0.105	0.06
9	906.54	99.369	0.29	927.76	894.97	0.059	0.021
10	1033.85	90.144	9.821	1138	927.76	4.903	4.872
11	1232.51	96.231	3.723	1313.52	1139.93	1.935	1.893
12	1327.03	99.56	0.481	1338.6	1315.45	0.02	0.024
13	1354.03	98.783	0.654	1363.67	1338.6	0.09	0.04
14	1379.1	97.994	1.533	1394.53	1363.67	0.174	0.11
15	1440.83	95.393	3.592	1465.9	1417.68	0.535	0.329
16	1489.05	98.387	1.216	1502.55	1465.9	0.151	0.103
17	1527.62	98.607	1.401	1537.27	1517.98	0.069	0.07
18	1591.27	81.803	18.062	1649.14	1539.2	5.676	5.611
19	1662.64	97.96	2.02	1676.14	1651.07	0.122	0.119
20	1708.93	95.36	4.616	1741.72	1676.14	0.811	0.804
21	1761.01	98.313	1.621	1772.58	1745.58	0.094	0.088
22	1811.16	98.274	1.723	1832.38	1793.8	0.154	0.151
23	1855.52	98.68	1.228	1869.02	1842.02	0.076	0.065
24	1880.6	99.149	0.865	1890.24	1869.02	0.041	0.043
25	1930.74	99.088	0.667	1944.25	1915.31	0.073	0.041
26	2220.07	99.902	0.122	2247.07	2160.27	0.009	0.019
27	2357.01	97.187	1.525	2395.59	2339.65	0.414	0.192
28	2576.9	99.602	0.003	2580.76	2563.4	0.03	0
29	2850.79	97.79	0.881	2875.86	2748.56	0.527	0.049
30	2920.23	96.674	2.313	2991.59	2875.86	0.878	0.46
31	3049.46	99.507	0.421	3084.18	3008.95	0.093	0.073
32	3161.33	99.757	0.077	3182.55	3145.9	0.032	0.006
33	3433.29	86.84	0.179	3442.94	3419.79	1.406	0.01

Lampiran 19. Hasil Analisis BET-BJH

a. KATKKS

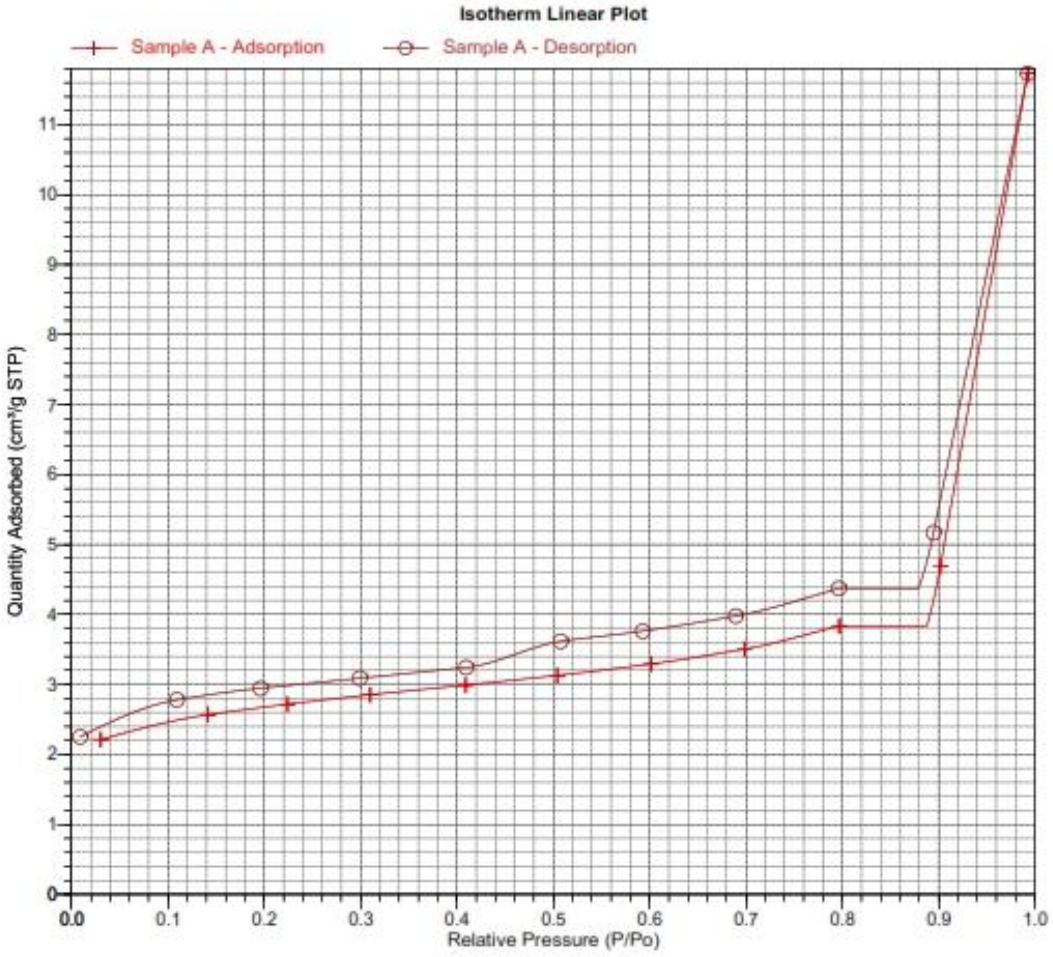
micromeritics

TriStar II 3020 2.00 TriStar II 3020 Version 2.00 Unit 1 Port 3 Serial #: 1108 Page 4

Sample: Sample A
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\A.SMP

Started: 5/9/2022 7:23:14 AM
Completed: 5/9/2022 11:53:36 AM
Report Time: 5/10/2022 9:31:18 AM
Sample Mass: 0.2688 g
Cold Free Space: 31.0247 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 10.9894 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³



micromeritics®

Sample: Sample A
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\A.SMP

Started: 5/9/2022 7:23:14 AM
Completed: 5/9/2022 11:53:36 AM
Report Time: 5/10/2022 9:31:18 AM
Sample Mass: 0.2688 g
Cold Free Space: 31.0247 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 10.9894 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³

BJH Adsorption Pore Distribution Report

Faas Correction
Harkins and Jura
$t = [\ 13.99 / (\ 0.034 - \log(P/Po)\ )\ ]\ ^{\wedge}\ 0.5$

Diameter Range: 1.7000 nm to 300.0000 nm
Adsorbate Property Factor: 0.95300 nm
Density Conversion Factor: 0.0015468
Fraction of Pores Open at Both Ends: 0.00

Pore Diameter Range (nm)	Average Diameter (nm)	Incremental Pore Volume (cm³/g)	Cumulative Pore Volume (cm³/g)	Incremental Pore Area (m²/g)	Cumulative Pore Area (m²/g)
258.2 - 21.1	22.3	0.014050	0.014050	2.515	2.515
21.1 - 10.4	12.3	0.000902	0.014952	0.293	2.808
10.4 - 7.0	8.0	0.000137	0.015089	0.068	2.877
7.0 - 5.2	5.8	0.000030	0.015119	0.021	2.897
5.2 - 4.1	4.5	0.000019	0.015137	0.017	2.914
4.1 - 3.3	3.6	0.000021	0.015159	0.024	2.938
3.3 - 2.6	2.9	0.000062	0.015221	0.086	3.023
2.6 - 2.2	2.4	0.000143	0.015363	0.242	3.265
2.2 - 1.8	1.9	0.000190	0.015554	0.396	3.661

micromeritics

Sample: Sample A
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mel\Sample ID 3...\A.SMP

Started: 5/9/2022 7:23:14 AM
Completed: 5/9/2022 11:53:36 AM
Report Time: 5/10/2022 9:31:18 AM
Sample Mass: 0.2688 g
Cold Free Space: 31.0247 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 10.9894 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³

BJH Desorption Pore Distribution Report

Faas Correction
Harkins and Jura
$t = [13.99 / (0.034 - \log(P/Po))] ^ 0.5$

Diameter Range: 1.7000 nm to 300.0000 nm
Adsorbate Property Factor: 0.95300 nm
Density Conversion Factor: 0.0015468
Fraction of Pores Open at Both Ends: 0.00

Pore Diameter Range (nm)	Average Diameter (nm)	Incremental Pore Volume (cm³/g)	Cumulative Pore Volume (cm³/g)	Incremental Pore Area (m²/g)	Cumulative Pore Area (m²/g)
258.2 - 19.7	20.8	0.013246	0.013246	2.542	2.542
19.7 - 10.4	12.2	0.000869	0.014115	0.284	2.826
10.4 - 6.8	7.8	0.000238	0.014353	0.122	2.948
6.8 - 5.1	5.7	0.000048	0.014400	0.034	2.981
5.1 - 4.1	4.5	0.000016	0.014417	0.015	2.996
4.1 - 3.3	3.6	0.000779	0.015196	0.871	3.867
3.3 - 1.6	1.8	0.000142	0.015338	0.321	4.188

b. KAM-H_2SO_4

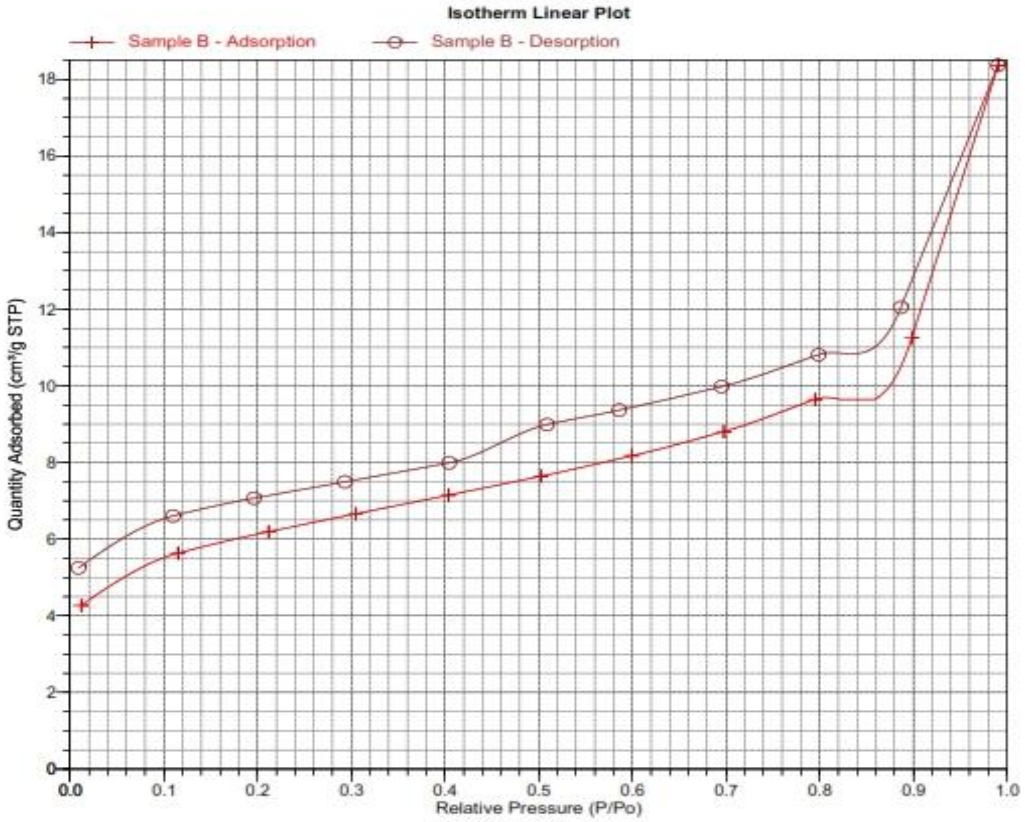
micromeritics

TriStar II 3020 2.00 TriStar II 3020 Version 2.00 Unit 1 Port 3 Serial #: 1108 Page 4

Sample: Sample B
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\B.SMP

Started: 5/9/2022 12:57:48 PM
Completed: 5/9/2022 4:39:40 PM
Report Time: 5/10/2022 9:31:53 AM
Sample Mass: 0.4003 g
Cold Free Space: 31.0309 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 10.8333 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³



micromeritics

Sample: Sample B
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\B.SMP

Started: 5/9/2022 12:57:48 PM
Completed: 5/9/2022 4:39:40 PM
Report Time: 5/10/2022 9:31:53 AM
Sample Mass: 0.4003 g
Cold Free Space: 31.0309 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 10.8333 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³

BJH Adsorption Pore Distribution Report

Faas Correction
Harkins and Jura
t = [13.99 / (0.034 - log(P/Po))] ^ 0.5

Diameter Range: 1.7000 nm to 300.0000 nm
Adsorbate Property Factor: 0.95300 nm
Density Conversion Factor: 0.0015468
Fraction of Pores Open at Both Ends: 0.00

Pore Diameter Range (nm)	Average Diameter (nm)	Incremental Pore Volume (cm³/g)	Cumulative Pore Volume (cm³/g)	Incremental Pore Area (m²/g)	Cumulative Pore Area (m²/g)
203.8 - 20.4	21.9	0.014199	0.014199	2.591	2.591
20.4 - 10.3	12.2	0.002607	0.016806	0.856	3.446
10.3 - 7.0	8.0	0.001278	0.018083	0.640	4.087
7.0 - 5.2	5.8	0.000986	0.019069	0.679	4.766
5.2 - 4.1	4.5	0.000869	0.019938	0.777	5.543
4.1 - 3.2	3.5	0.000855	0.020794	0.965	6.507
3.2 - 2.6	2.8	0.000901	0.021695	1.266	7.774
2.6 - 2.1	2.3	0.000873	0.022568	1.517	9.291
2.1 - 1.6	1.8	0.001076	0.023644	2.386	11.677

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Sample: Sample B
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\B.SMP

Started: 5/9/2022 12:57:48 PM
Completed: 5/9/2022 4:39:40 PM
Report Time: 5/10/2022 9:31:53 AM
Sample Mass: 0.4003 g
Cold Free Space: 31.0309 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 10.8333 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³

BJH Desorption Pore Distribution Report

Faas Correction
Harkins and Jura
t = [13.99 / (0.034 - log(P/Po))] ^ 0.5

Diameter Range: 1.7000 nm to 300.0000 nm
Adsorbate Property Factor: 0.95300 nm
Density Conversion Factor: 0.0015468
Fraction of Pores Open at Both Ends: 0.00

Pore Diameter Range (nm)	Average Diameter (nm)	Incremental Pore Volume (cm³/g)	Cumulative Pore Volume (cm³/g)	Incremental Pore Area (m²/g)	Cumulative Pore Area (m²/g)
203.8 - 18.4	19.6	0.012902	0.012902	2.634	2.634
18.4 - 10.5	12.3	0.001948	0.014850	0.633	3.267
10.5 - 7.0	8.0	0.001246	0.016096	0.626	3.893
7.0 - 5.0	5.6	0.000907	0.017003	0.644	4.537
5.0 - 4.1	4.5	0.000593	0.017596	0.530	5.067
4.1 - 3.2	3.6	0.002561	0.020157	2.871	7.938
3.2 - 2.5	2.8	0.000657	0.020813	0.939	8.877
2.5 - 2.0	2.2	0.000540	0.021353	0.970	9.847
2.0 - 1.6	1.8	0.000707	0.022060	1.603	11.450

c. KAM-H_2O_2

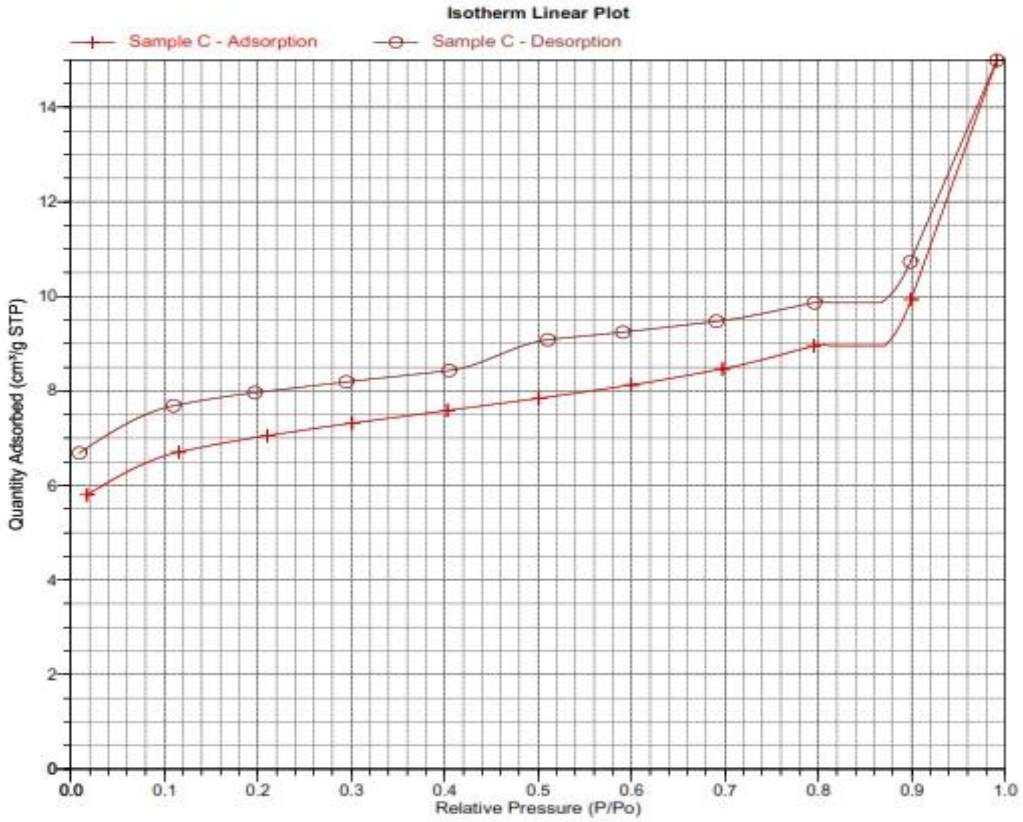
micromeritics

TriStar II 3020 2.00 TriStar II 3020 Version 2.00 Unit 1 Port 1 Serial #: 1108 Page 4

Sample: Sample C
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\C.SMP

Started: 5/9/2022 12:57:48 PM
Completed: 5/9/2022 4:39:40 PM
Report Time: 5/10/2022 9:32:31 AM
Sample Mass: 0.4321 g
Cold Free Space: 31.6119 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 10.9900 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³



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Sample: Sample C
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\C.SMP

Started: 5/9/2022 12:57:48 PM
Completed: 5/9/2022 4:39:40 PM
Report Time: 5/10/2022 9:32:31 AM
Sample Mass: 0.4321 g
Cold Free Space: 31.6119 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 10.9900 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³

BJH Adsorption Pore Distribution Report

Faas Correction
Harkins and Jura
t = [13.99 / (0.034 - log(P/Po))] ^ 0.5

Diameter Range: 1.7000 nm to 300.0000 nm
Adsorbate Property Factor: 0.95300 nm
Density Conversion Factor: 0.0015468
Fraction of Pores Open at Both Ends: 0.00

Pore Diameter Range (nm)	Average Diameter (nm)	Incremental Pore Volume (cm³/g)	Cumulative Pore Volume (cm³/g)	Incremental Pore Area (m²/g)	Cumulative Pore Area (m²/g)
217.4 - 20.6	22.1	0.010102	0.010102	1.831	1.831
20.6 - 10.4	12.2	0.001490	0.011592	0.488	2.318
10.4 - 7.0	8.0	0.000653	0.012245	0.327	2.645
7.0 - 5.2	5.8	0.000442	0.012687	0.304	2.950
5.2 - 4.1	4.5	0.000380	0.013067	0.340	3.290
4.1 - 3.2	3.5	0.000387	0.013454	0.437	3.727
3.2 - 2.6	2.8	0.000445	0.013899	0.629	4.356
2.6 - 2.1	2.3	0.000509	0.014408	0.889	5.245
2.1 - 1.6	1.8	0.000760	0.015168	1.686	6.930

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Sample: Sample C
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\C.SMP

Started: 5/9/2022 12:57:48 PM
Completed: 5/9/2022 4:39:40 PM
Report Time: 5/10/2022 9:32:31 AM
Sample Mass: 0.4321 g
Cold Free Space: 31.6119 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 10.9900 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³

BJH Desorption Pore Distribution Report

Faas Correction
Harkins and Jura
$t = [13.99 / (0.034 - \log(P/Po))] ^ {0.5}$

Diameter Range: 1.7000 nm to 300.0000 nm
Adsorbate Property Factor: 0.95300 nm
Density Conversion Factor: 0.0015468
Fraction of Pores Open at Both Ends: 0.00

Pore Diameter Range (nm)	Average Diameter (nm)	Incremental Pore Volume (cm³/g)	Cumulative Pore Volume (cm³/g)	Incremental Pore Area (m²/g)	Cumulative Pore Area (m²/g)
217.4 - 20.5	21.9	0.008529	0.008529	1.561	1.561
20.5 - 10.4	12.2	0.001337	0.009865	0.437	1.997
10.4 - 6.9	7.8	0.000479	0.010344	0.244	2.241
6.9 - 5.1	5.7	0.000207	0.010552	0.146	2.387
5.1 - 4.1	4.5	0.000175	0.010727	0.155	2.543
4.1 - 3.3	3.6	0.001773	0.012500	1.984	4.527
3.3 - 2.6	2.8	0.000220	0.012720	0.314	4.841
2.6 - 2.0	2.2	0.000263	0.012983	0.472	5.313
2.0 - 1.6	1.8	0.000497	0.013480	1.125	6.438

d. KAM-$ZnCl_2$

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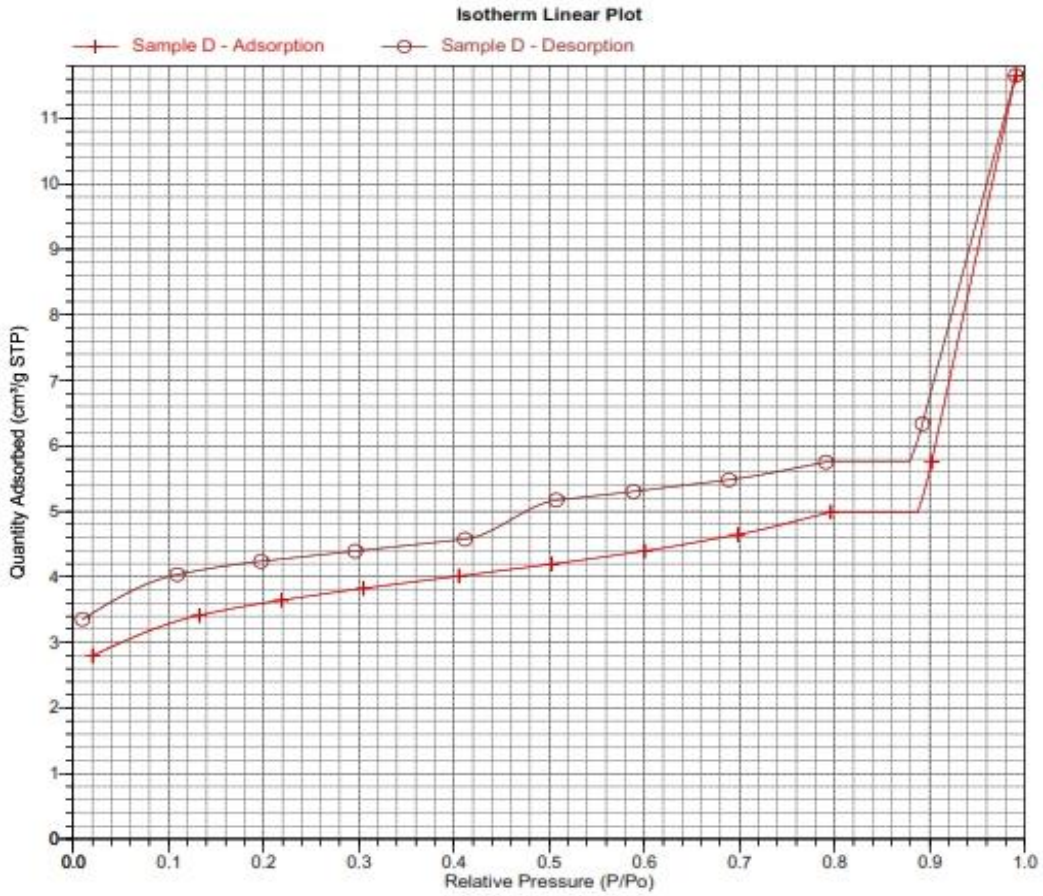
TriStar II 3020 2.00 TriStar II 3020 Version 2.00 Unit 1 Port 2 Serial #: 1108 Page 4

Sample: Sample D
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\D.SMP

Started: 5/9/2022 12:57:48 PM
Completed: 5/9/2022 4:39:40 PM
Report Time: 5/10/2022 9:33:06 AM
Sample Mass: 0.3445 g
Cold Free Space: 31.8137 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 11.0469 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³



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Sample: Sample D
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\D.SMP

Started: 5/9/2022 12:57:48 PM
Completed: 5/9/2022 4:39:40 PM
Report Time: 5/10/2022 9:33:06 AM
Sample Mass: 0.3445 g
Cold Free Space: 31.8137 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 11.0469 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³

BJH Adsorption Pore Distribution Report

Faas Correction
Harkins and Jura
t = [13.99 / (0.034 - log(P/Po))] ^ 0.5

Diameter Range: 1.7000 nm to 300.0000 nm
Adsorbate Property Factor: 0.95300 nm
Density Conversion Factor: 0.0015468
Fraction of Pores Open at Both Ends: 0.00

Pore Diameter Range (nm)	Average Diameter (nm)	Incremental Pore Volume (cm³/g)	Cumulative Pore Volume (cm³/g)	Incremental Pore Area (m²/g)	Cumulative Pore Area (m²/g)
200.4 - 21.1	22.7	0.011711	0.011711	2.060	2.060
21.1 - 10.4	12.3	0.000887	0.012598	0.289	2.349
10.4 - 7.0	8.0	0.000279	0.012877	0.140	2.489
7.0 - 5.2	5.8	0.000209	0.013086	0.144	2.632
5.2 - 4.1	4.5	0.000182	0.013268	0.162	2.795
4.1 - 3.3	3.6	0.000191	0.013459	0.215	3.009
3.3 - 2.6	2.9	0.000247	0.013706	0.346	3.355
2.6 - 2.1	2.3	0.000302	0.014008	0.519	3.874
2.1 - 1.7	1.9	0.000481	0.014489	1.023	4.898

micromeritics®

Sample: Sample D
Operator: Sarah
Submitter: 36851
File: C:\TriStar II 3020\data\SAMPEL\2022\Mei\Sample ID 3...\D.SMP

Started: 5/9/2022 12:57:48 PM
Completed: 5/9/2022 4:39:40 PM
Report Time: 5/10/2022 9:33:06 AM
Sample Mass: 0.3445 g
Cold Free Space: 31.8137 cm³
Low Pressure Dose: None
Automatic Degas: No

Analysis Adsorptive: N2
Analysis Bath Temp.: -195.850 °C
Thermal Correction: No
Warm Free Space: 11.0469 cm³ Measured
Equilibration Interval: 5 s
Sample Density: 1.000 g/cm³

BJH Desorption Pore Distribution Report

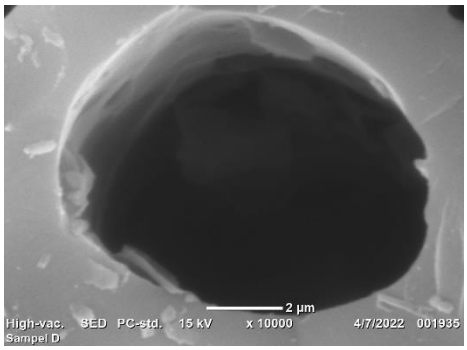
Faas Correction
Harkins and Jura
t = [13.99 / (0.034 - log(P/Po))] ^ 0.5

Diameter Range: 1.7000 nm to 300.0000 nm
Adsorbate Property Factor: 0.95300 nm
Density Conversion Factor: 0.0015468
Fraction of Pores Open at Both Ends: 0.00

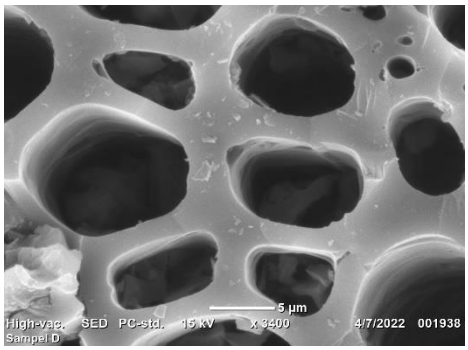
Pore Diameter Range (nm)	Average Diameter (nm)	Incremental Pore Volume (cm³/g)	Cumulative Pore Volume (cm³/g)	Incremental Pore Area (m²/g)	Cumulative Pore Area (m²/g)
200.4 - 19.3	20.7	0.010747	0.010747	2.079	2.079
19.3 - 10.2	11.9	0.000564	0.011311	0.189	2.268
10.2 - 6.8	7.8	0.000112	0.011423	0.058	2.326
6.8 - 5.1	5.6	0.000049	0.011472	0.035	2.361
5.1 - 4.1	4.5	0.000083	0.011555	0.074	2.435
4.1 - 3.3	3.6	0.001624	0.013179	1.802	4.237
3.3 - 2.6	2.8	0.000004	0.013183	0.006	4.243
2.6 - 2.0	2.2	0.000027	0.013210	0.048	4.291
2.0 - 1.6	1.8	0.000262	0.013472	0.593	4.884

Lampiran 20. Hasil Analisis SEM

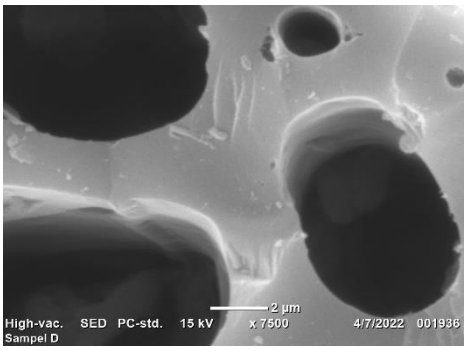
a. KATKKS



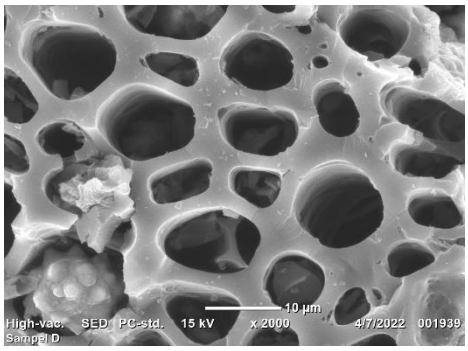
Perbesaran 10000



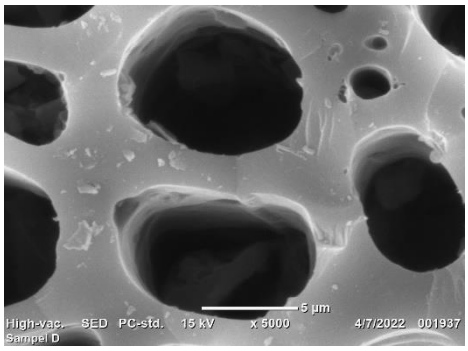
Perbesaran 3400



Perbesaran 7500

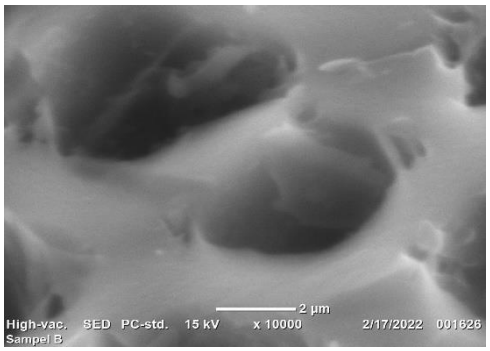


Perbesaran 2000

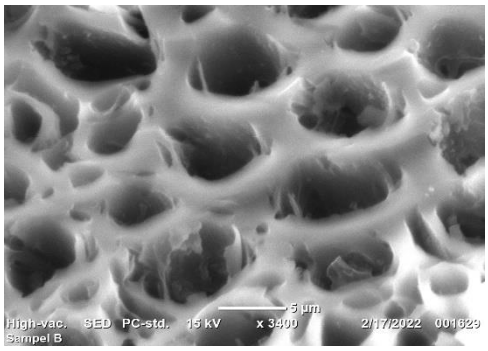


Perbesaran 5000

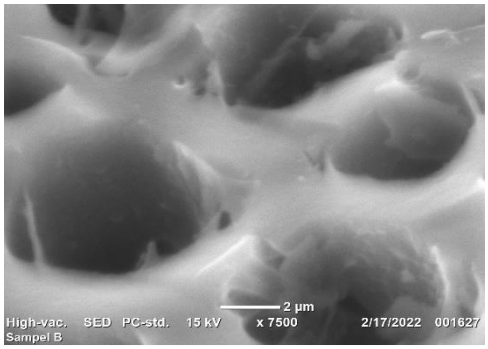
b. KAM-H_2SO_4



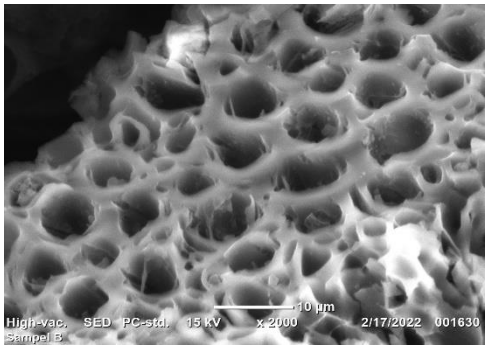
Perbesaran 10000



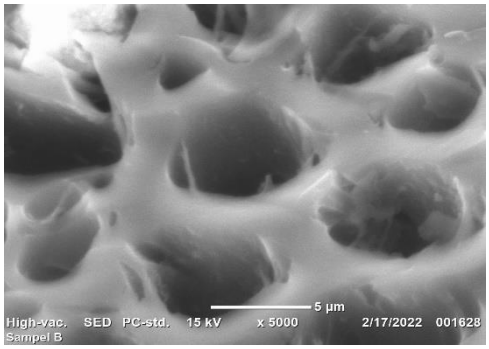
Perbesaran 3400



Perbesaran 7500

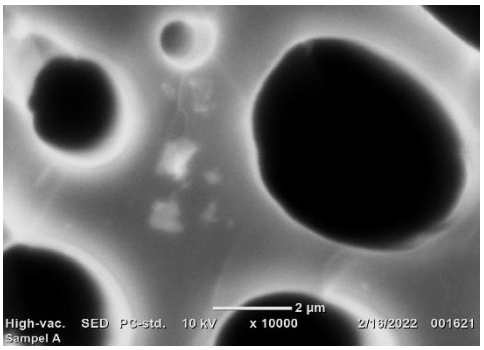


Perbesaran 2000

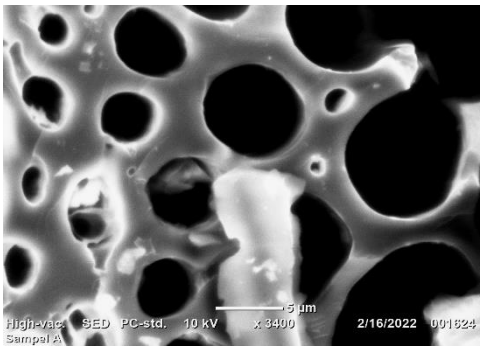


Perbesaran 5000

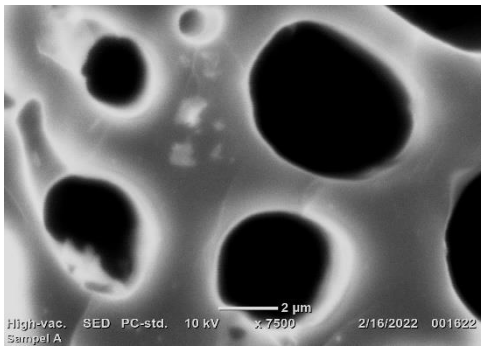
c. KAM-H_2O_2



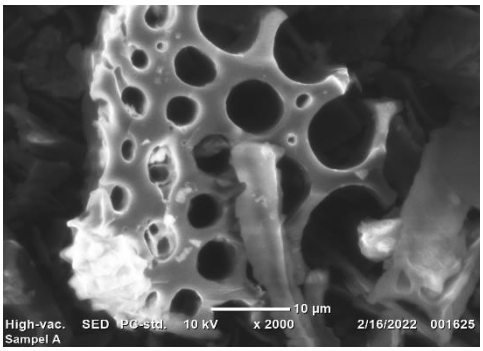
Perbesaran 10000



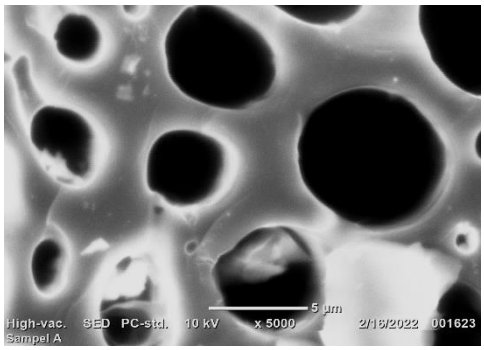
Perbesaran 3400



Perbesaran 7500

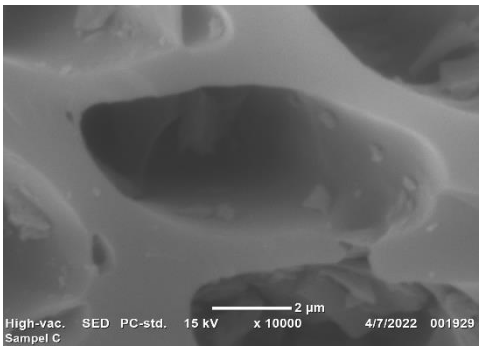


Perbesaran 2000

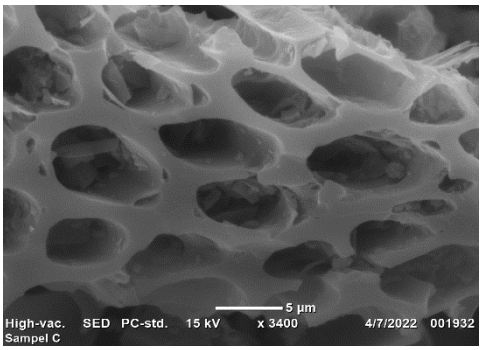


Perbesaran 5000

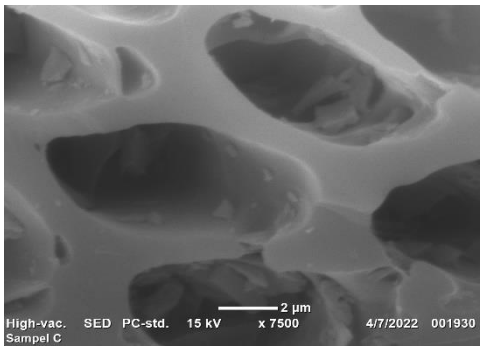
d. KAM-$ZnCl_2$



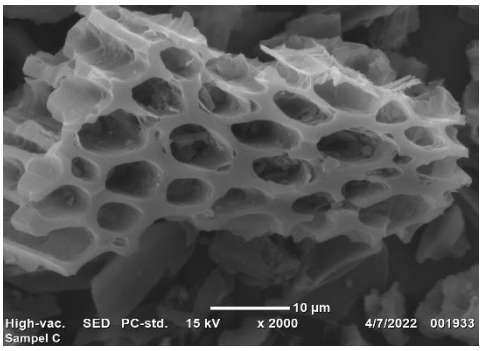
Perbesaran 10000



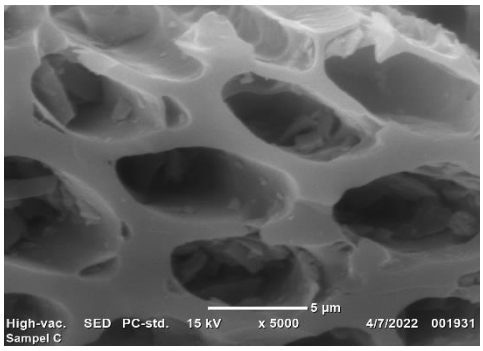
Perbesaran 3400



Perbesaran 7500



Perbesaran 2000



Perbesaran 5000

Lampiran 21. Hasil Analisis XRD

a. KATKKS

```
////////////////////////////////////////////////////////////////////////////////
/// Profile Data Ascii Dump (XRD)                                             ///
////////////////////////////////////////////////////////////////////////////////

  Group     : KENSA
  Data      : KA-D
  File Name : KA-D.RAW

# Profile Datafile
          comment             = 2-80
          date & time         = 02-24-22 10:18:03

# Measurement Condition
    X-ray tube
          target              = Cu
          voltage             = 40.0 (kV)
          current             = 30.0 (mA)
    Slits
          divergence slit     = 1.00000 (deg)
          scatter slit        = 1.00000 (deg)
          receiving slit      = 0.15000 (mm)
    Scanning
          drive axis          = Theta-2Theta
          scan range          =    2.000 -   80.000
          scan mode           = Continuous Scan
          scan speed          =   2.0000 (deg/min)
          sampling pitch      =   0.0200 (deg)
          preset time         =   0.60 (sec)
```

b. KAM-H_2SO_4

```
////////////////////////////////////////////////////////////
/// Profile Data Ascii Dump (XRD)
////////////////////////////////////////////////////////////

  Group     : KENSA
  Data      : KA-B
  File Name : KA-B.RAW

# Profile Datafile
          comment             = 2-80
          date & time         = 02-22-22 11:16:27

# Measurement Condition
    X-ray tube
          target              = Cu
          voltage             = 40.0 (kV)
          current             = 30.0 (mA)
    Slits
          divergence slit     = 1.00000 (deg)
          scatter slit        = 1.00000 (deg)
          receiving slit      = 0.15000 (mm)
    Scanning
          drive axis          = Theta-2Theta
          scan range          =    2.000 -   80.000
          scan mode           = Continuous Scan
          scan speed          =   2.0000 (deg/min)
          sampling pitch      =   0.0200 (deg)
          preset time         =   0.60 (sec)
```

c. KAM-H_2O_2

```
////////////////////////////////////////////////////////////////////////////
/// Profile Data Ascii Dump (XRD)                                        ///
////////////////////////////////////////////////////////////////////////////

  Group     : KENSA
  Data      : KA-A
  File Name : KA-A.RAW

# Profile Datafile
          comment             = 2-80
          date & time         = 02-22-22 10:07:37

# Measurement Condition
    X-ray tube
          target              = Cu
          voltage             = 40.0 (kV)
          current             = 30.0 (mA)
    Slits
          divergence slit     = 1.00000 (deg)
          scatter slit        = 1.00000 (deg)
          receiving slit      = 0.15000 (mm)
    Scanning
          drive axis          = Theta-2Theta
          scan range          =    2.000 -   80.000
          scan mode           = Continuous Scan
          scan speed          =   2.0000 (deg/min)
          sampling pitch      =   0.0200 (deg)
          preset time         =   0.60 (sec)
```

d. KAM-$ZnCl_2$

```
////////////////////////////////////////////////////////////////////////////
/// Profile Data Ascii Dump (XRD)                                        ///
////////////////////////////////////////////////////////////////////////////

  Group     : KENSA
  Data      : KA-C
  File Name : KA-C.RAW

# Profile Datafile
          comment             = 2-80
          date & time         = 02-24-22 09:19:59

# Measurement Condition
    X-ray tube
          target              = Cu
          voltage             = 40.0 (kV)
          current             = 30.0 (mA)
    Slits
          divergence slit     = 1.00000 (deg)
          scatter slit        = 1.00000 (deg)
          receiving slit      = 0.15000 (mm)
    Scanning
          drive axis          = Theta-2Theta
          scan range          =    2.000 -   80.000
          scan mode           = Continuous Scan
          scan speed          =   2.0000 (deg/min)
          sampling pitch      =   0.0200 (deg)
          preset time         =   0.60 (sec)
```

Lampiran 22. Foto Dokumentasi Penelitian

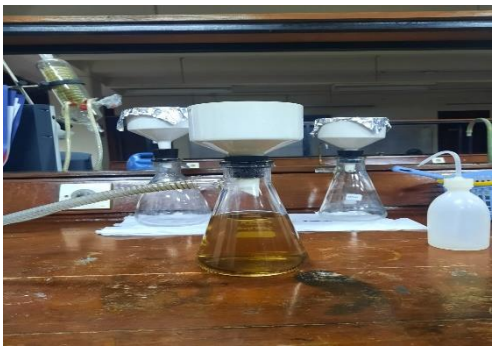
Tandan Kosong Kelapa Sawit

Hasil Karbonisasi

Grind Size 100 Mesh

Karbon

Proses Aktivasi



Penetralan

Modifikasi Karbon Aktif

Penimbangan

Proses Adsorpsi

Larutan Uji COD