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Lampiran 1. Bagan Kerja

1. Sintesis Silika Mesopori MCM-48

14,30 g larutan ludox HS40

- Ditambahkan 45,25 g larutan NaOH 1 M.
- Dipanaskan sambil diaduk selama 2 jam pada suhu 80 °C.

Larutan

- Didinginkan.

6,12 g CTAB

- Ditambahkan 1,34 g Triton X-100.
- Dicampur dengan 83,47 g akuades.
- Dipanaskan sampai larut.

Larutan Surfaktan

- Didinginkan.

- Dicampur dalam botol propilen.
- Botol ditutup dan dikocok.

Campuran Gel

- Dipanaskan selama 24 jam pada suhu 100 °C.
- Dikocok sekali-kali.
- Didinginkan pada suhu kamar.
- Ditambahkan CH_3COOH 30% sampai pH 10.

Campuran Gel pH 10

- Dipanaskan selama 24 jam pada suhu 100 °C.
- Didinginkan pada suhu kamar.
- Disaring.
- Residu dicuci dengan akuades.

MCM-48 dengan Surfaktan | Filtrat

2. Penghilangan Surfaktan dari Silika Mesopori MCM-48 TC dengan Pencucian HCl-etanol

MCM-48 dengan Surfaktan

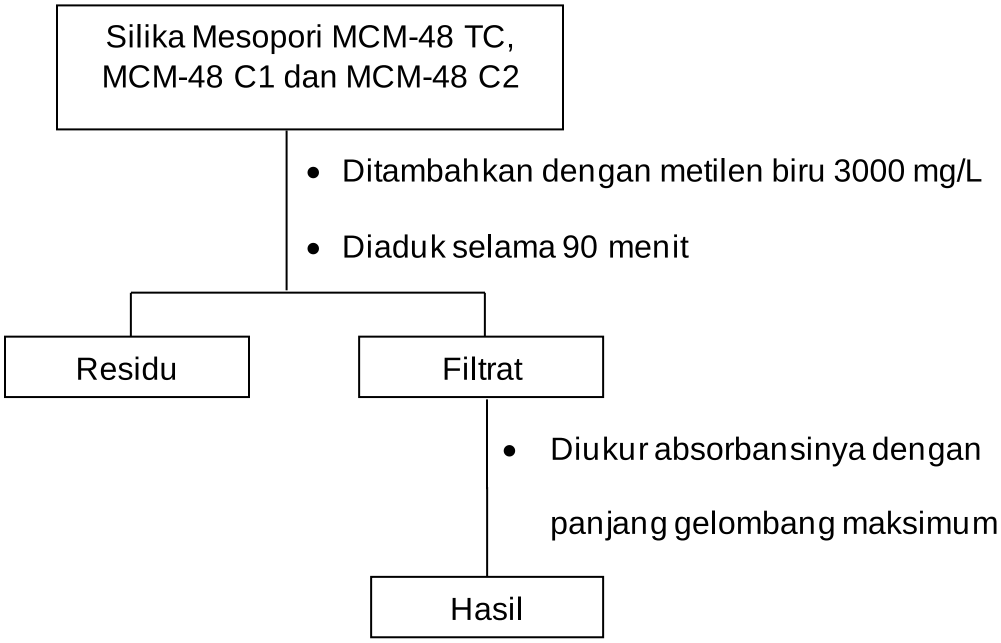
- Dikeringkan dalam oven pada suhu 120 °C.
- Dicuci dengan campuran HCl-etanol sambil diaduk selama 30 menit pada suhu kamar.
- Disaring.
- Dicuci dengan akuades sampai netral.
- Dikeringkan pada suhu 100 °C.

MCM-48 dengan sebagian Surfaktan

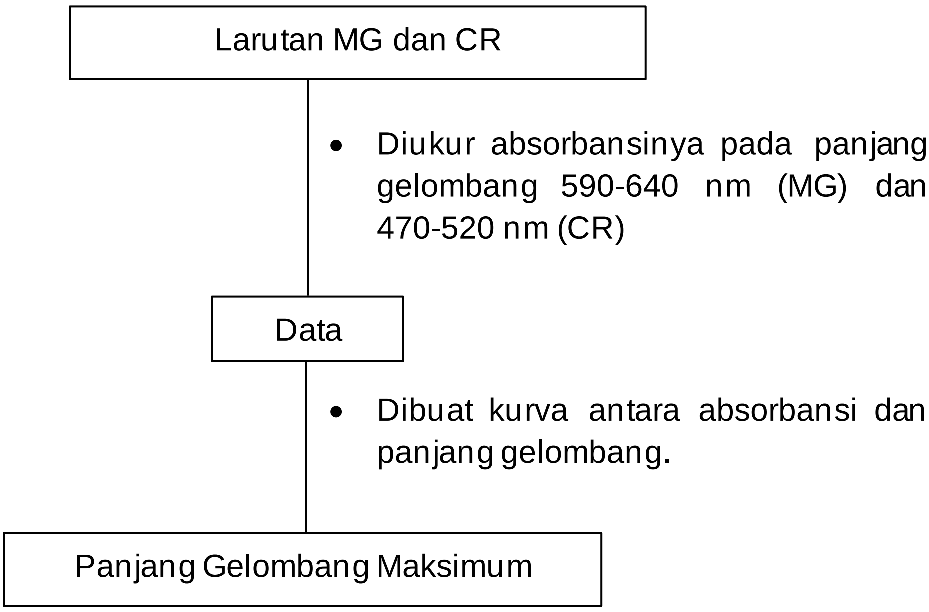
- Dianalisis menggunakan FTIR, XRD, BJH, SEM dan Metilen Biru

Data

3. Skema Kerja Luas Permukaan dengan Metilen Biru



4. Penentuan Panjang Gelombang Maksimum



5. Penentuan Waktu Optimum Adsorpsi MG dan CR oleh Silika Mesopori MCM-48 TC, MCM-48 C1, MCM-48 C2

Silika Mesopori MCM-48 TC, MCM-48 C1 dan MCM-48 C2

- Ditimbang sebanyak 100 mg.
- Dimasukkan ke dalam erlemeyer sebesar 50 mL zat warna MG dan CR masing-masing 50 mg/L dan 300 mg/L.
- Diaduk dengan pengaduk magnetik dengan variasi waktu 5, 10, 15, 30, 45, 60, 75,90, 105, 120 dan 150 menit untuk zat warna MG dan 3, 5, 7, 10, 15, 20, 25, 30, 35, dan 40 menit untuk zat warna CR
- Disaring.

Penentuan Waktu Optimum

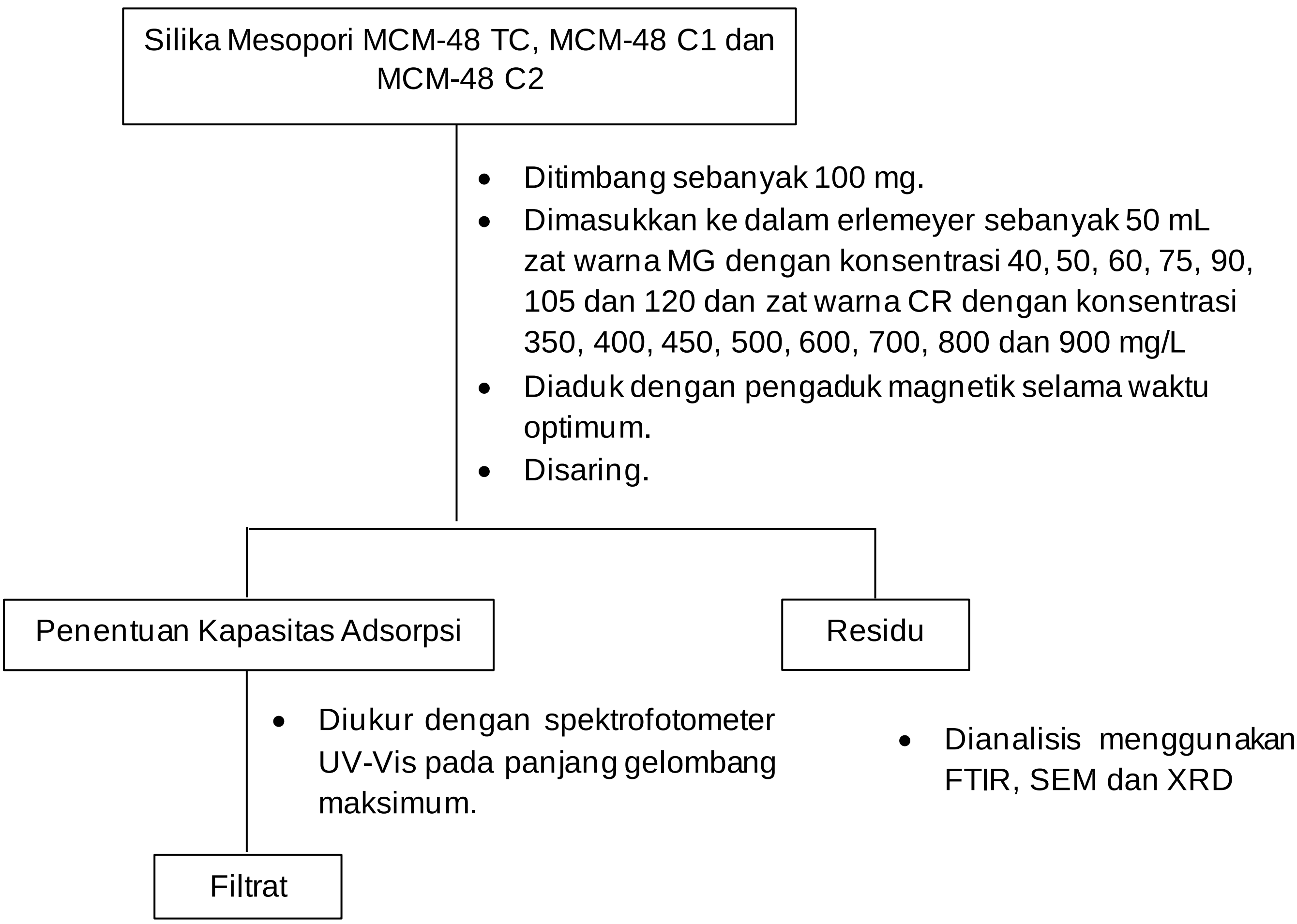
- Diukur dengan spektrofotometer UV-Vis pada panjang gelombang maksimum.

Filtrat

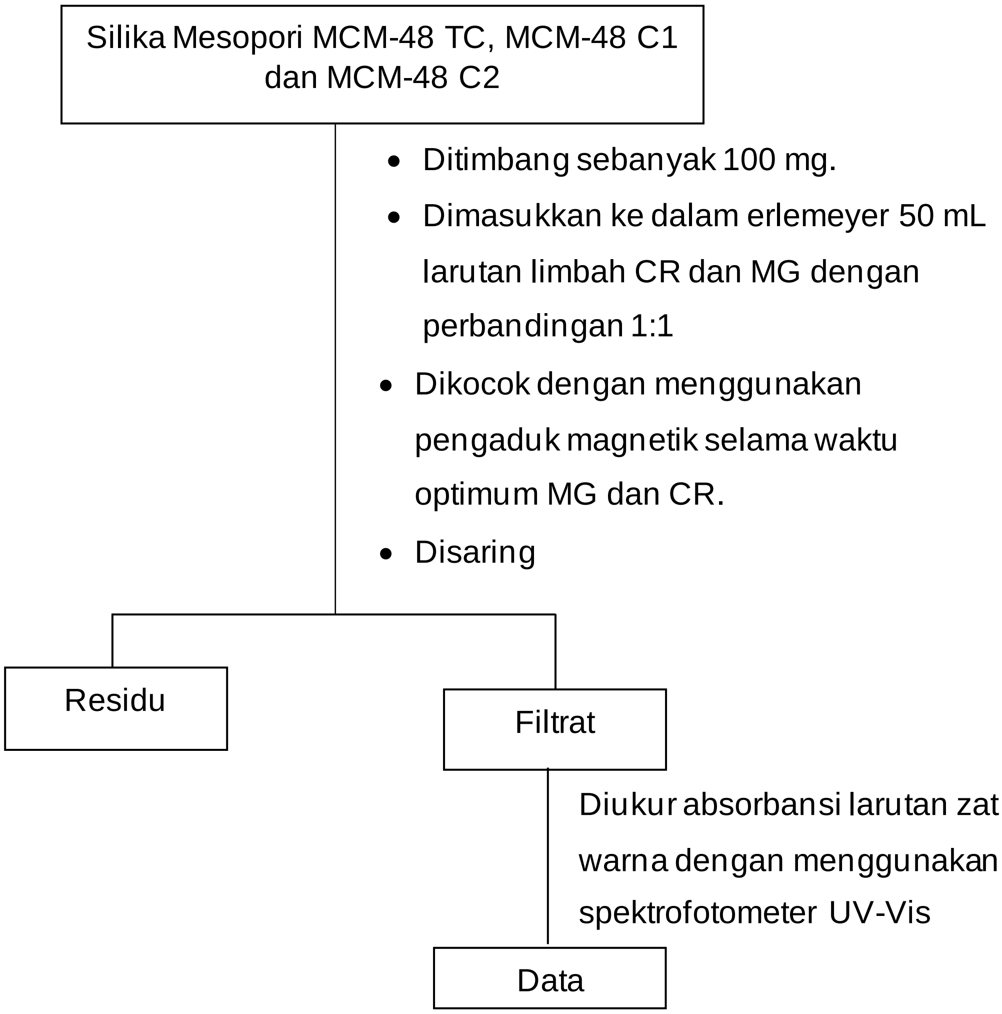
Residu

- Dibuang

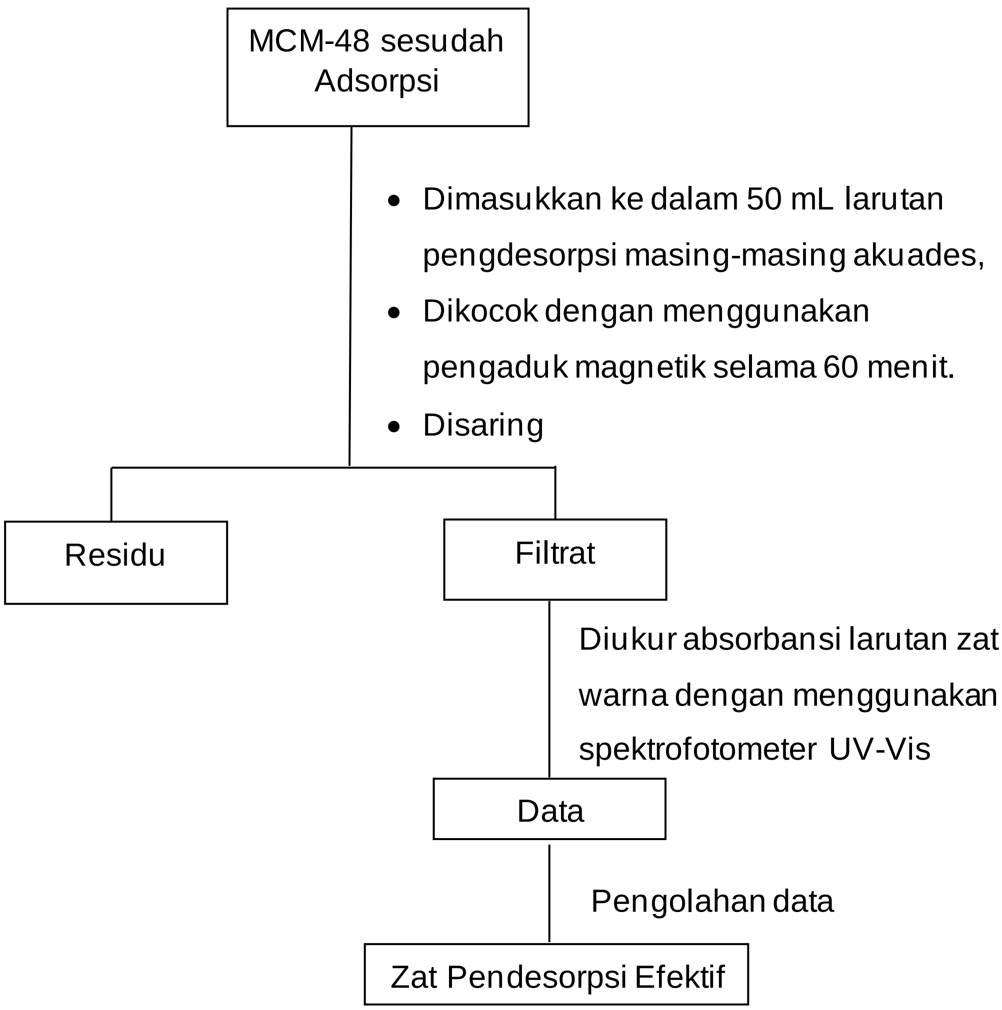
6. Penentuan Konsentrasi Optimum adsorpsi MG dan CR oleh Silika Mesopori MCM-48 TC, MCM-48 C1, MCM-48 C2



7. Efektifitas Limbah Zat Warna MG dan CR oleh MCM-48



8. Desorpsi Zat Warna MG dan CR oleh MCM-48



Lampiran 2. Dokumentasi Penelitian

Pembuatan Natrium Tetrasilikat

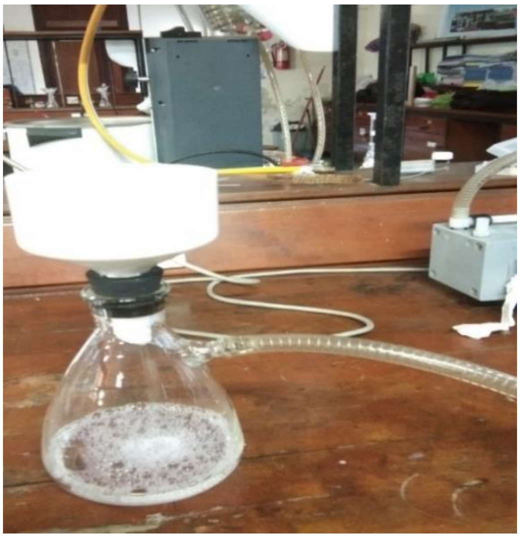
Pembuatan Larutan Surfaktan

Larutan Natrium Tetrasilikat

Pembuatan Larutan Surfaktan

Campuran Gel

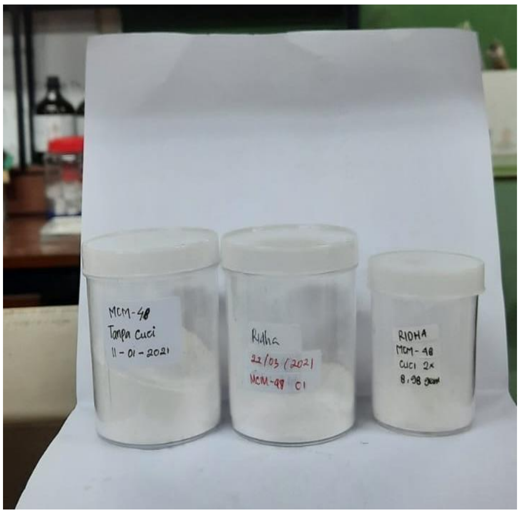
Pemanasan Campuran Gel



Proses Penyaringan Sampel

Hasil Penyaringan Sampel

Pengeringan Sampel



Sampel MCM-48

Pencucian dengan HCl-etanol

Proses Penyaringan HCl-etanol

Larutan Induk CR

Larutan Induk MG

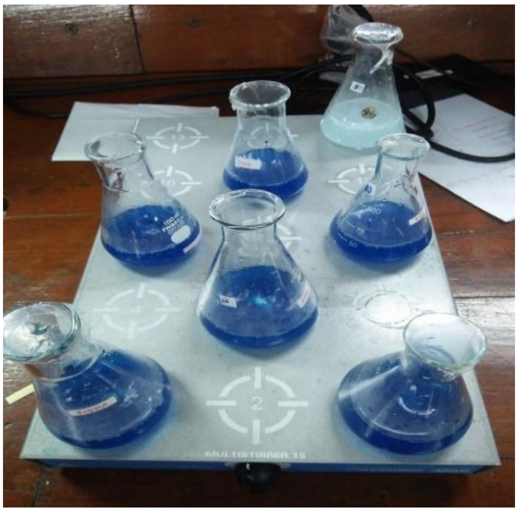
Larutan Deret Standar MG

Larutan Deret Standar CR

Pengadukan waktu optimum MG

Pengadukan waktu optimum CR

Variasi Konsentrasi Larutan MG



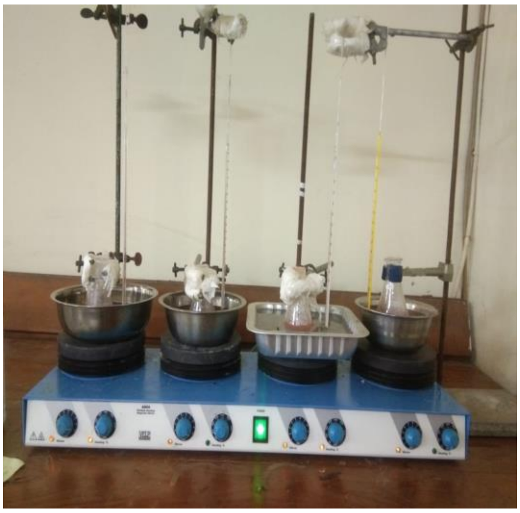
Pengadukan variasi konsentrasi MG

Pengadukan variasi konsentrasi CR

Sampel Setelah Adsorpsi

Larutan MG dan CR 100 mg/L

Proses pengadukan Limbah


Proses desorpsi CR


Proses desorpsi MG

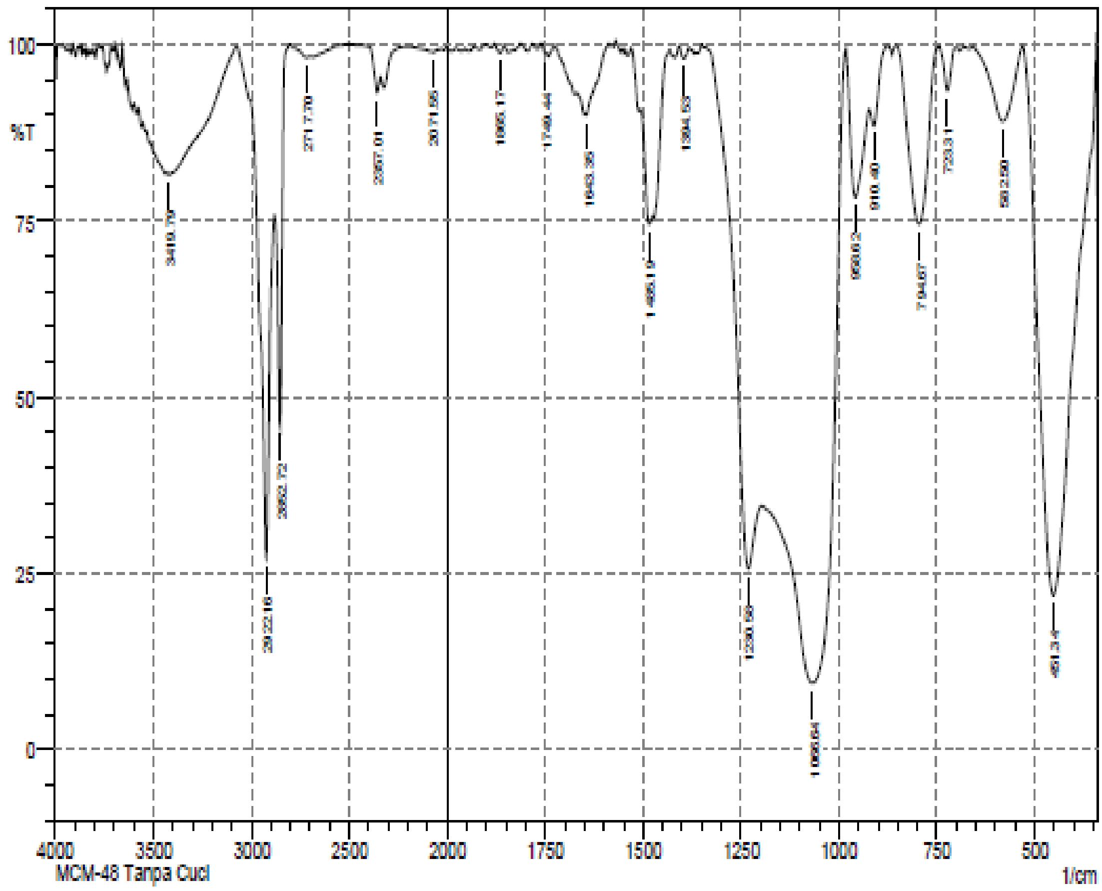

Larutan Induk MB

Larutan deret standar MB

Proses pengadukkan larutan MB

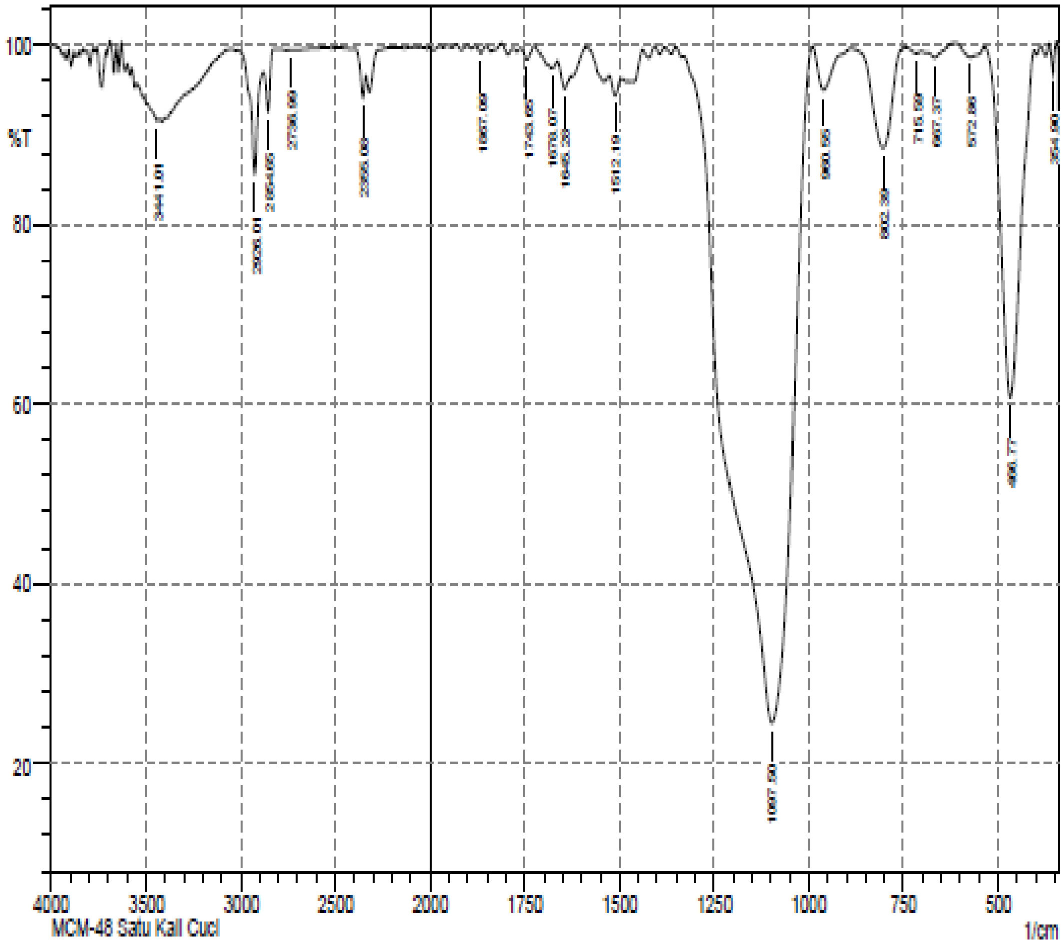

Larutan MB setelah adsorpsi

Lampiran 3. Data Karakterisasi FTIR



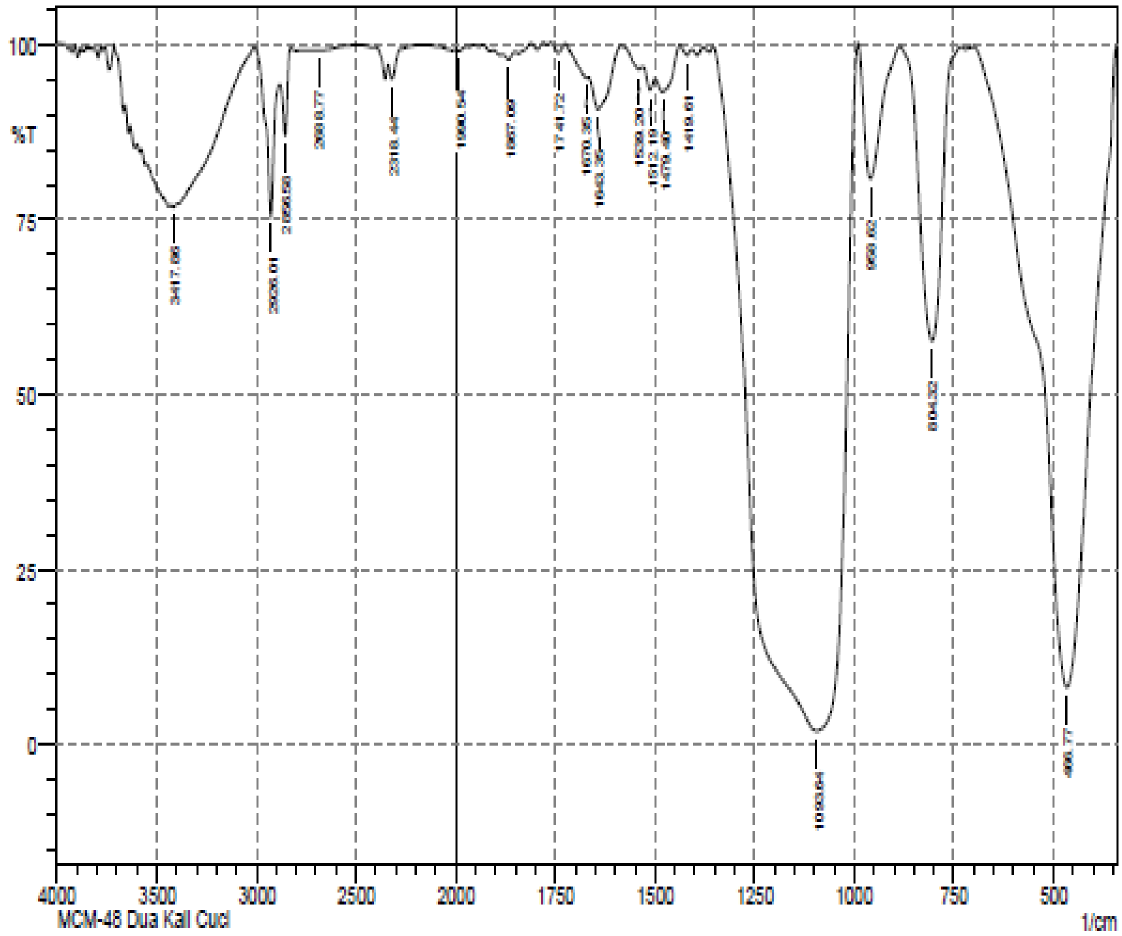
No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	451.34	21.849	77.506	528.5	343.33	52.792	52.218
2	582.5	89.154	10.666	655.8	530.42	3.117	3.017
3	723.31	93.53	6.138	744.52	704.02	0.571	0.514
4	794.67	74.574	25.269	852.54	744.52	6.711	6.639
5	910.4	88.469	4.735	921.97	877.61	1.186	0.344
6	958.62	78.34	17.654	981.77	923.9	4.139	2.821
7	1066.64	9.44	64.5	1195.87	983.7	128.829	79.941
8	1230.58	25.622	23.878	1340.53	1197.79	36.521	7.656
9	1394.53	98.061	1.662	1408.04	1382.96	0.131	0.103
10	1485.19	74.576	4.912	1506.41	1477.47	2.773	0.351
11	1643.35	90.008	0.854	1647.21	1589.34	1.269	0.05
12	1749.44	98.484	0.715	1759.08	1745.58	0.048	0.019
13	1865.17	98.892	1.188	1880.6	1855.52	0.065	0.076
14	2071.55	98.965	0.148	2077.33	2050.33	0.108	0.012
15	2357.01	93.163	2.85	2439.95	2341.58	0.996	0.245
16	2717.7	98.196	0.439	2775.57	2700.34	0.415	0.072
17	2852.72	45.966	38.019	2879.72	2800.64	8.565	4.678
18	2922.16	27.144	53.761	3070.68	2881.65	28.962	17.608
19	3419.79	81.534	0.386	3431.36	3404.36	2.371	0.032

SHIMADZU

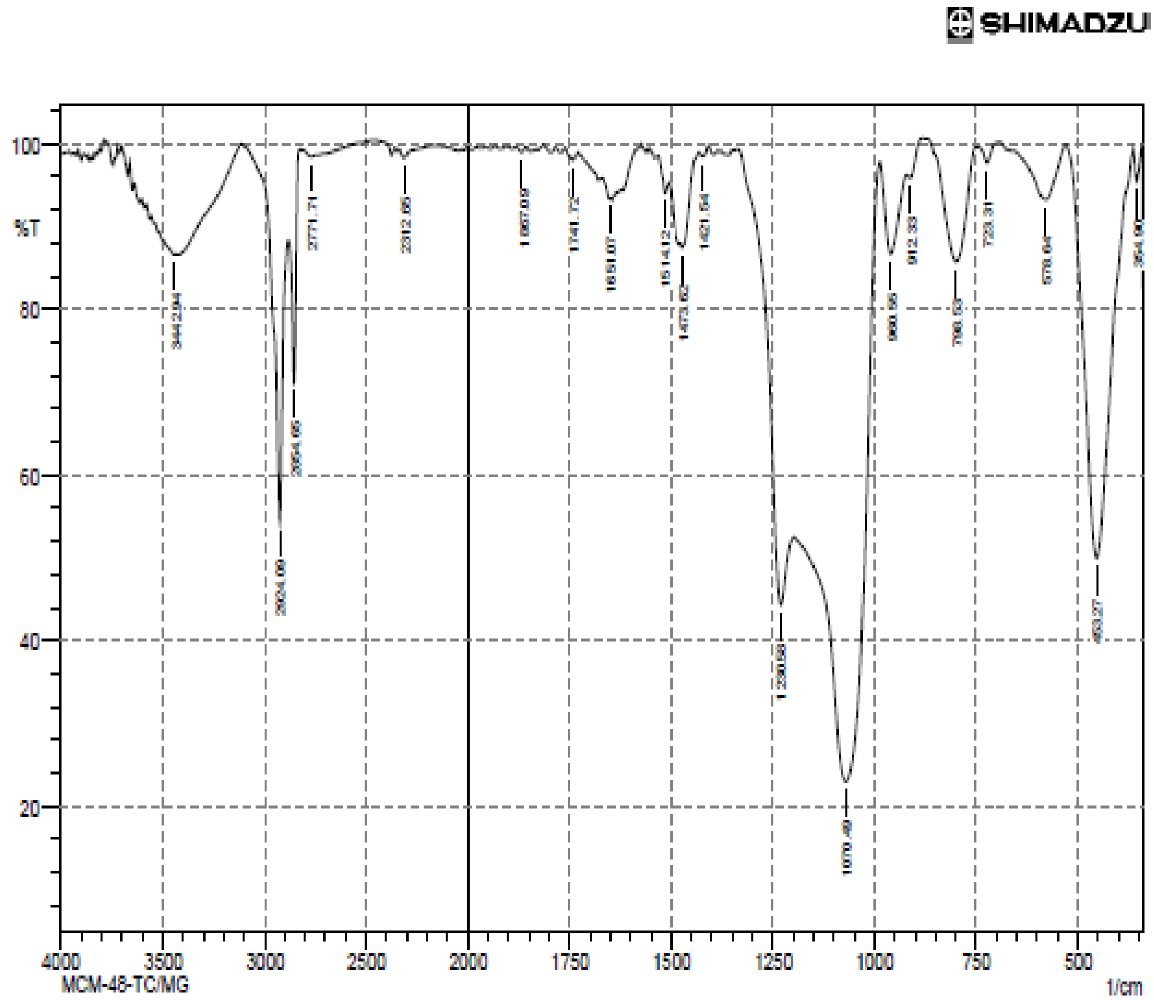


No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	354.9	96.844	3.418	364.55	347.19	0.093	0.112
2	466.77	60.727	38.854	534.28	405.05	11.872	11.64
3	572.86	98.661	1.361	611.43	534.28	0.257	0.265
4	667.37	98.596	0.851	686.66	611.43	0.194	0.099
5	715.59	99.116	0.349	744.52	702.09	0.113	0.032
6	802.39	88.548	11.193	883.4	744.52	3.018	2.855
7	960.55	95.01	4.799	989.48	891.11	1.016	0.913
8	1097.5	24.538	74.983	1328.95	991.41	90.588	89.585
9	1512.19	94.388	2.008	1527.62	1492.9	0.703	0.147
10	1645.28	95.132	2.186	1664.57	1627.92	0.597	0.171
11	1678.07	97.416	1.209	1724.36	1664.57	0.429	0.193
12	1743.65	98.392	1.433	1761.01	1724.36	0.143	0.116
13	1867.09	99.105	0.823	1880.6	1853.59	0.051	0.043
14	2355.08	94.149	3.219	2397.52	2339.65	0.752	0.266
15	2736.99	99.444	0.016	2744.71	2569.18	0.315	-0.002
16	2854.65	92.587	5.274	2879.72	2808.36	0.971	0.49
17	2926.01	85.646	12.089	3016.67	2881.65	3.178	2.09
18	3441.01	91.57	0.446	3491.16	3431.36	2.058	0.053

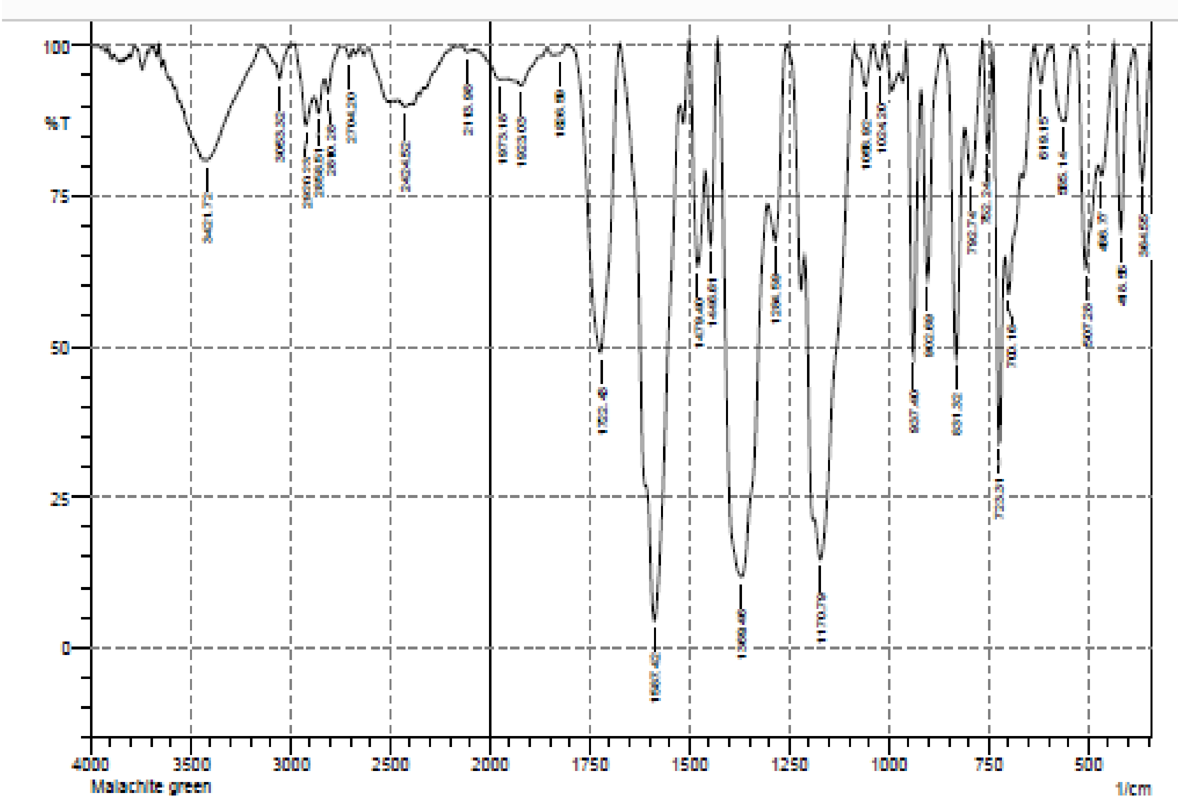
SHIMADZU



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	466.77	8.161	91.563	700.16	343.33	108.93	108.492
2	804.32	57.628	42.077	885.33	732.95	13.703	13.507
3	958.62	80.792	19.271	989.48	887.26	4.321	4.298
4	1093.64	1.943	98.103	1352.1	991.41	285.704	285.596
5	1419.61	98.511	1.082	1436.97	1406.11	0.124	0.074
6	1479.4	93.235	3.474	1498.69	1438.9	1.272	0.641
7	1512.19	93.511	2.386	1529.55	1498.69	0.709	0.161
8	1539.2	96.45	0.671	1585.49	1533.41	0.421	0.035
9	1643.35	90.736	5.818	1664.57	1587.42	2.021	1.206
10	1670.35	95.242	0.537	1724.36	1664.57	0.715	0.106
11	1741.72	98.831	1.37	1761.01	1724.36	0.074	0.107
12	1867.09	97.804	0.972	1882.52	1851.66	0.222	0.057
13	1990.54	99.094	0.417	2002.11	1971.25	0.081	0.023
14	2318.44	95.112	2.728	2339.65	2268.29	0.855	0.326
15	2688.77	99.212	0.059	2702.27	2495.89	0.376	0.005
16	2856.58	87.101	9.685	2881.65	2829.57	1.707	1.007
17	2926.01	75.493	20.519	3010.88	2883.58	5.81	4.036
18	3417.86	76.758	0.921	3429.43	3012.81	26.39	2.809

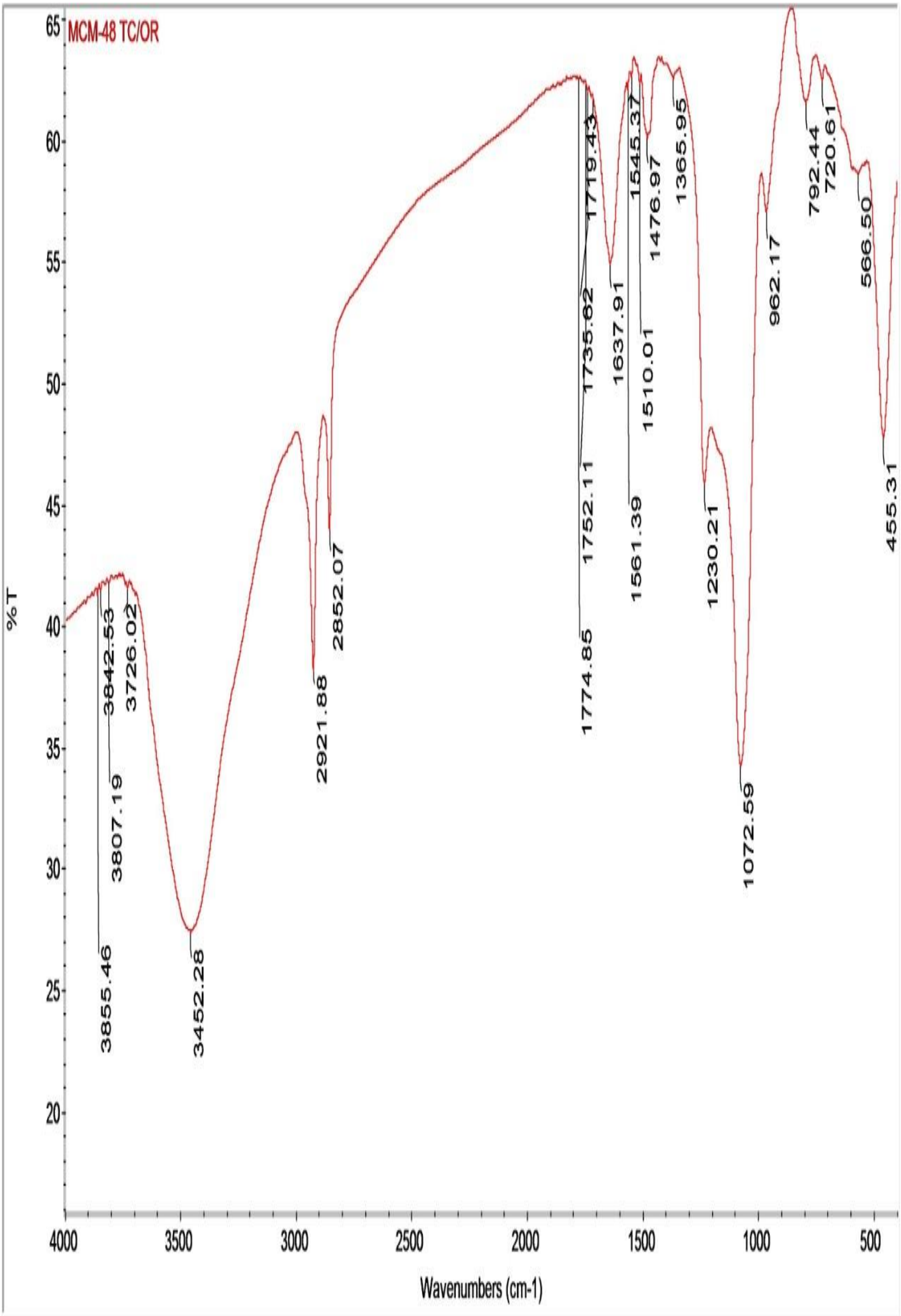


No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	354.9	95.531	4.183	364.55	341.4	0.242	0.217
2	453.27	49.974	49.755	528.5	364.55	20.258	20.05
3	578.64	93.293	6.337	655.8	530.42	2.023	1.78
4	723.31	97.723	2.132	744.52	692.44	0.19	0.17
5	798.53	85.776	14.262	871.82	750.31	3.737	3.809
6	912.33	95.89	1.509	921.97	883.4	0.355	0.097
7	960.55	86.687	10.52	985.62	921.97	2.538	1.703
8	1070.49	22.975	56.945	1197.79	987.55	76.514	46.323
9	1230.58	44.348	18.681	1336.67	1199.72	20.77	3.965
10	1421.54	98.479	0.853	1431.18	1408.04	0.114	0.053
11	1473.62	87.491	1.459	1477.47	1433.11	1.355	0.171
12	1514.12	94.057	2.415	1531.48	1504.48	0.512	0.145
13	1651.07	93.421	0.323	1666.5	1649.14	0.43	0.016
14	1741.72	98.052	0.586	1747.51	1730.15	0.124	0.027
15	1867.09	99.024	0.707	1882.52	1857.45	0.074	0.045
16	2312.65	98.311	1.082	2333.87	2171.85	0.524	0.222
17	2771.71	98.474	0.419	2823.79	2744.71	0.398	0.05
18	2854.65	71.205	22.231	2881.65	2823.79	3.876	2.32
19	2924.09	54.259	36.077	3115.04	2883.58	13.84	8.128
20	3442.94	86.551	0.392	3516.23	3435.22	4.658	0.147

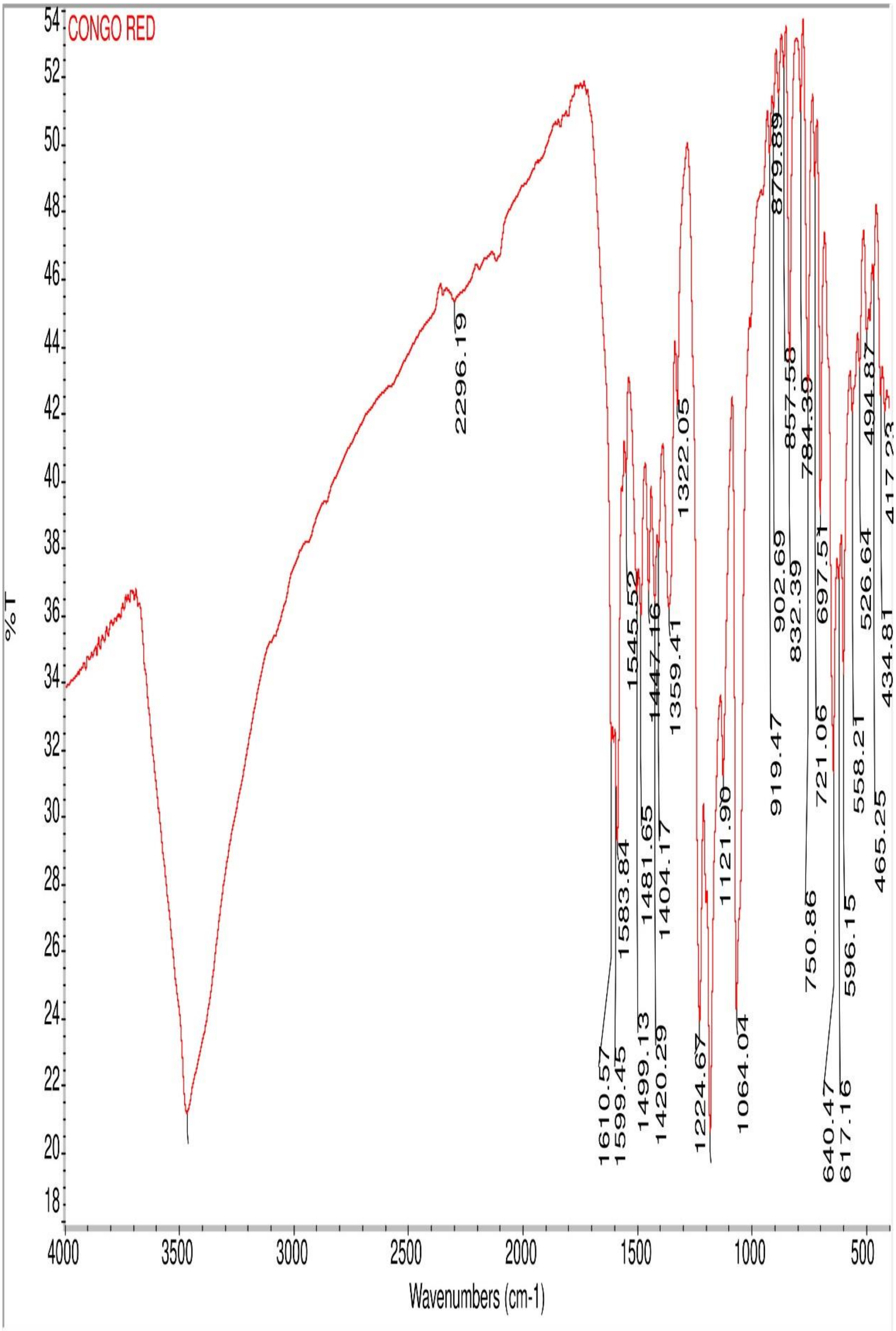


No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	364.55	77.578	22.171	385.76	343.33	2.208	2.164
2	418.55	69.322	29.992	433.98	387.69	3.083	2.944
3	466.77	78.341	5.712	474.49	435.91	2.489	0.726
4	507.28	63.023	28.449	528.5	476.42	6.576	3.889
5	565.14	87.602	0.962	590.22	563.21	0.987	0.207
6	619.15	93.704	6.234	634.58	599.86	0.471	0.459
7	700.16	58.8	8.744	707.88	669.3	6.659	1.092
8	723.31	34.004	46.602	738.74	709.8	7.708	4.714
9	752.24	82.838	17.17	763.81	740.67	1.099	1.096
10	792.74	77.791	13.74	808.17	765.74	2.847	1.619
11	831.32	48.208	43.566	864.11	810.1	6.848	5.092
12	902.69	61.069	33.743	918.12	866.04	4.161	3.337
13	937.4	48.336	47.473	954.76	920.05	5.409	4.726
14	1024.2	95.976	4.244	1039.63	1010.7	0.256	0.283
15	1058.92	93.169	5.568	1072.42	1039.63	0.571	0.419
16	1170.79	14.63	18.942	1186.22	1087.85	39.323	7.116
17	1284.59	67.59	16.325	1301.95	1257.59	4.733	1.935
18	1369.46	11.763	75.908	1427.32	1303.88	63.185	54.873
19	1446.61	67.087	20.522	1458.18	1429.25	3.018	1.673
20	1479.4	63.344	26.196	1500.62	1460.11	5.173	3.1
21	1587.42	4.452	89.87	1672.28	1523.76	60.443	57.026
22	1722.43	49.063	51.184	1803.44	1674.21	17.066	17.199
23	1826.59	98.519	0.312	1830.45	1803.44	0.094	0.023
24	1923.03	93.402	1.58	1934.6	1880.6	1.126	0.209
25	1973.18	94.338	0.515	2005.97	1967.39	0.775	0.06
26	2113.98	98.948	0.705	2142.91	2077.33	0.201	0.091
27	2424.52	89.82	0.819	2461.17	2391.73	3.094	0.133
28	2704.2	98.022	1.542	2735.06	2686.84	0.216	0.142
29	2810.28	92.111	3.533	2827.64	2752.42	1.296	0.361
30	2858.51	88.755	3.941	2879.72	2829.57	1.994	0.406
31	2920.23	86.735	8.199	2960.02	2881.65	3.521	1.647
32	3053.32	94.538	5.577	3128.54	2981.95	1.262	1.333
33	3421.72	80.954	0.798	3431.36	3149.76	13.093	0.562

Material MCM-48 TC/CR



Zat Warna CR



CONGO RED
%T
Wavenumbers (cm-1)
2296.19
1610.57
1599.45
1583.84
1545.52
1499.13
1481.65
1447.16
1420.29
1404.17
1359.41
1322.05
1224.67
1121.90
1064.04
919.47
902.69
879.89
857.58
832.39
784.39
750.86
721.06
697.51
640.47
617.16
596.15
558.21
526.64
494.87
465.25
434.81

Lampiran 4. Data Karakterisasi SEM

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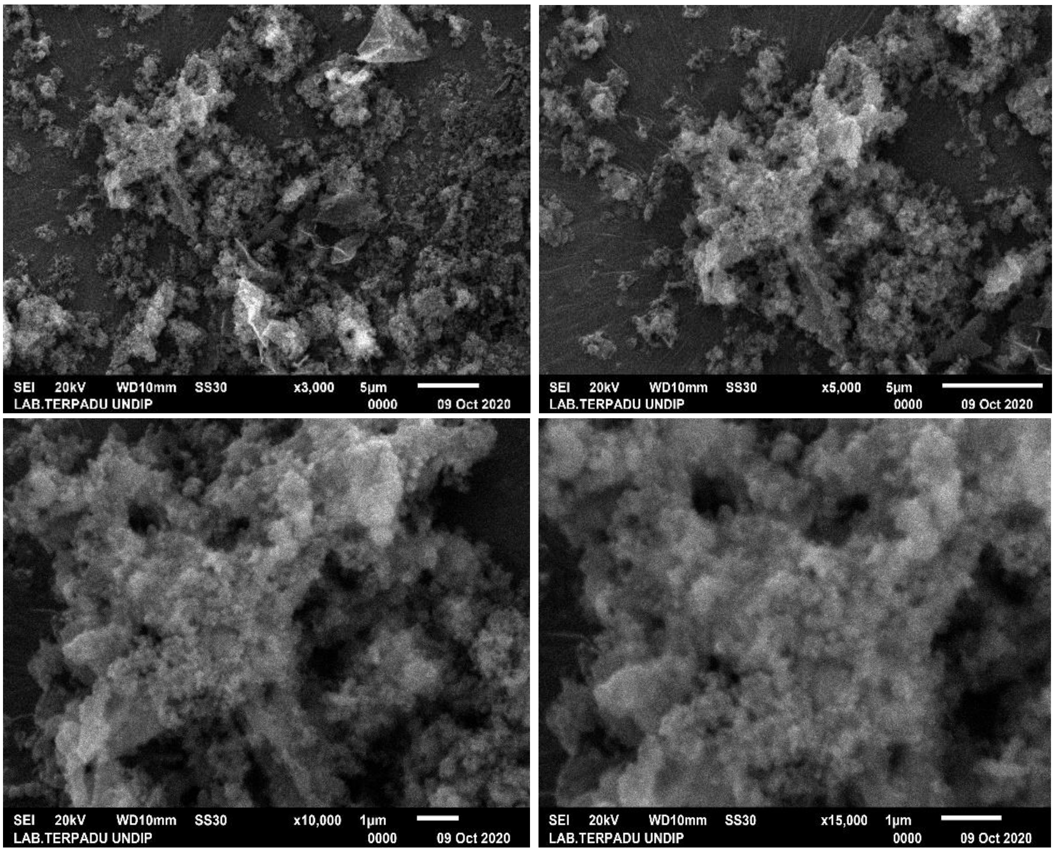
Telepon (024) 76918147- Faksimile (024) 76918148, Website :
http://labterpadu.undip.ac.id;
E-mail : labterpadu@live.undip.ac.id

Lampiran 5. Hasil SEM EDX

1. MCM-48 TC



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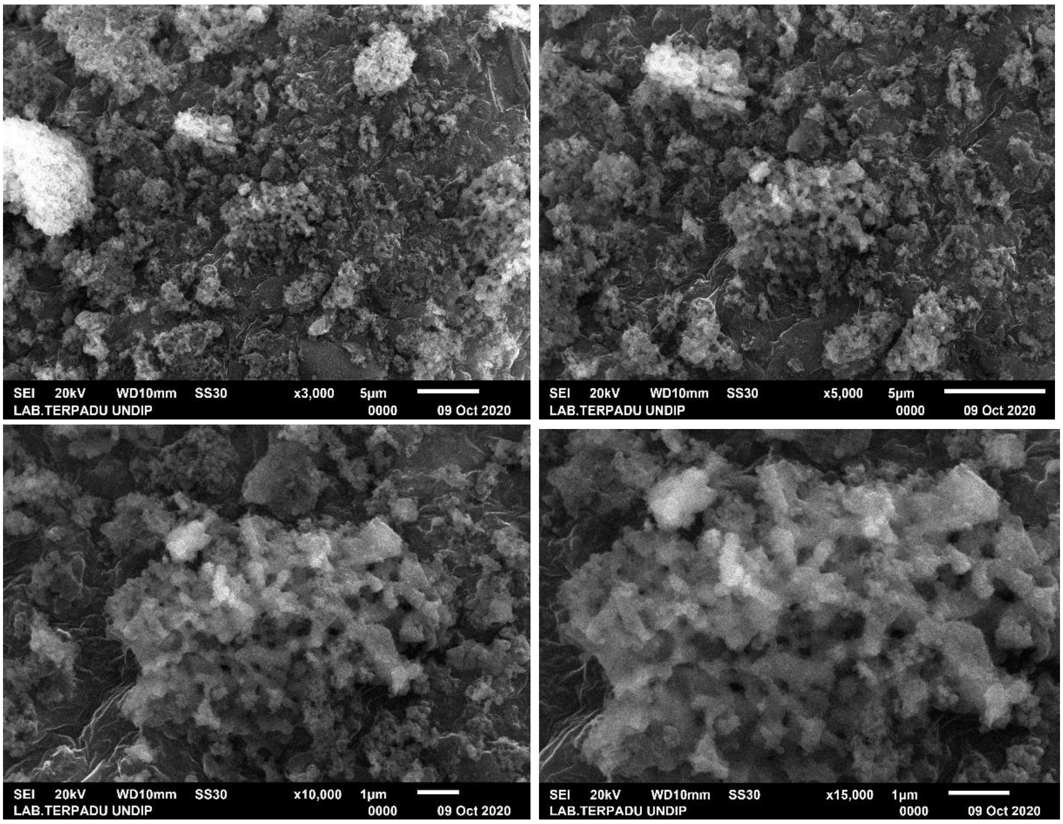
2. MCM-48 C1



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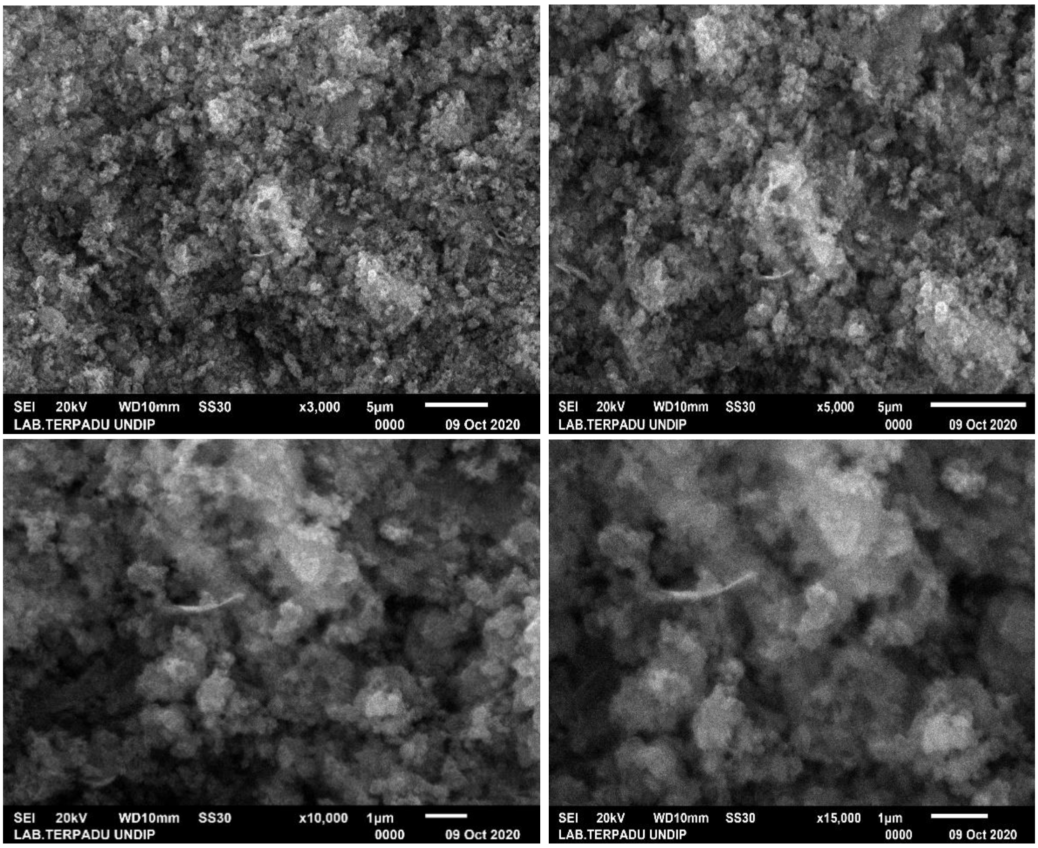
E-mail : labterpadu@live.undip.ac.id

3. MCM-48 C2



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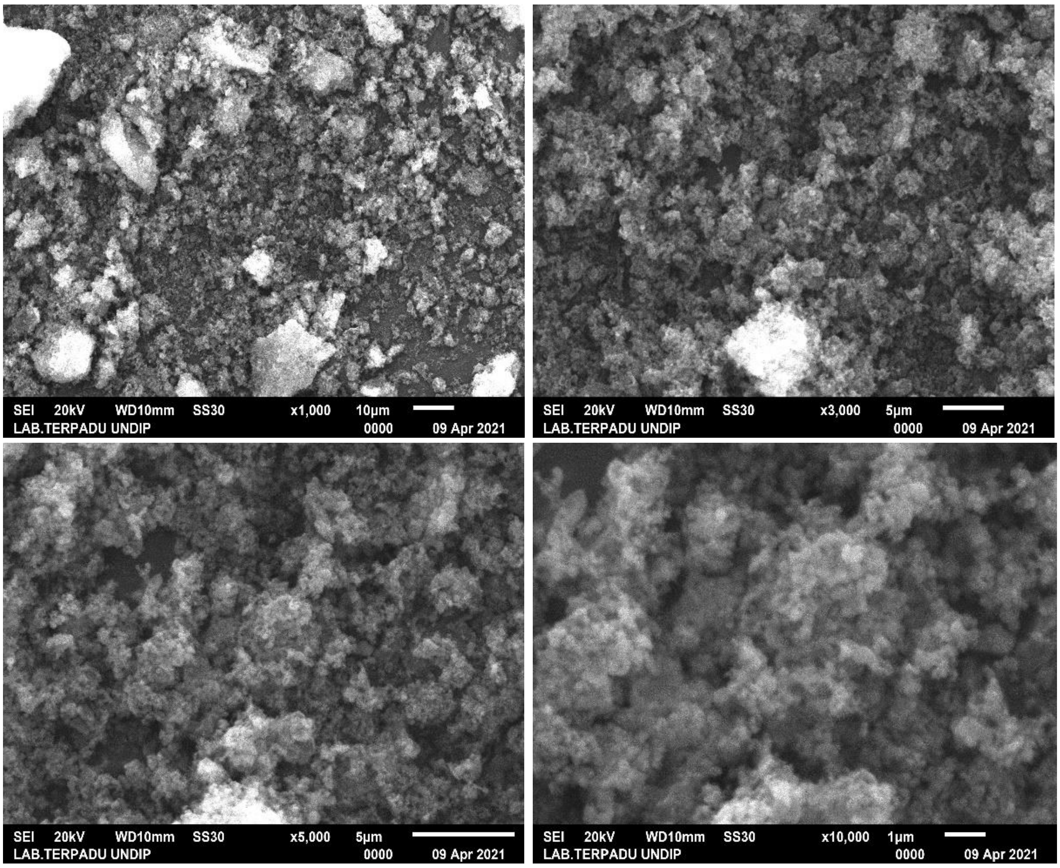
4. MCM-48 TC setelah adsopsi dengan zat warna MG



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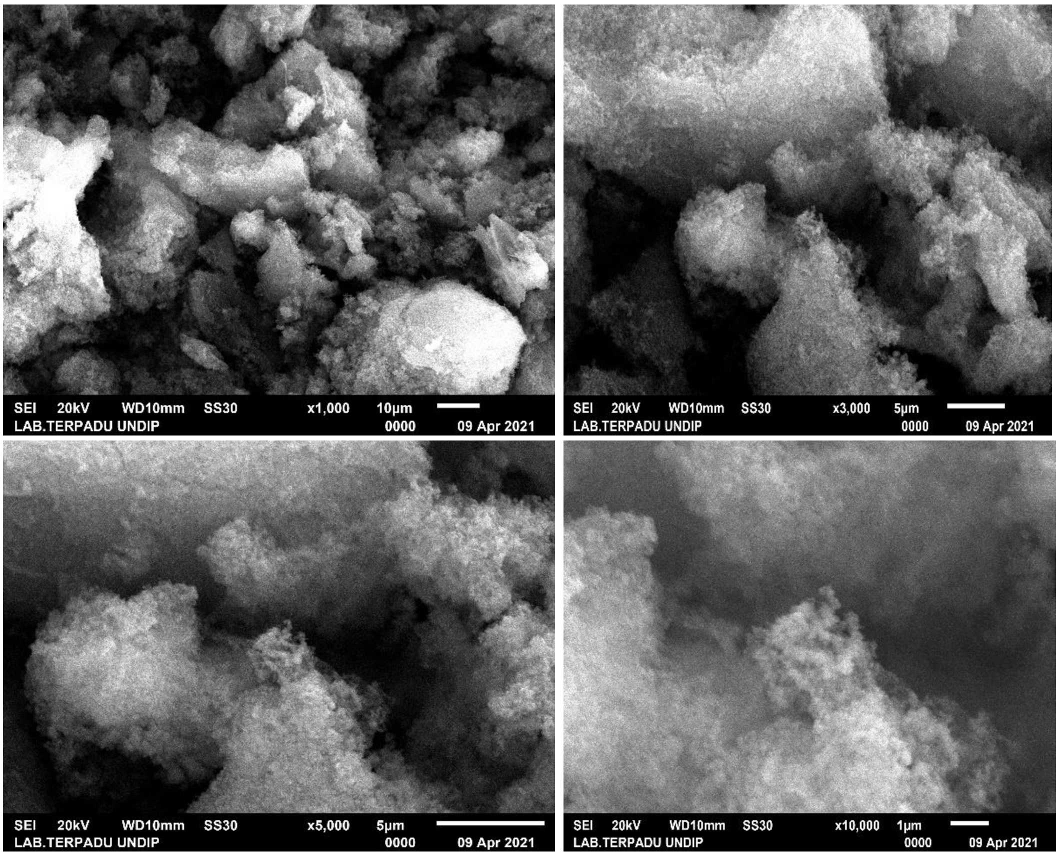
5. MCM-48 TC setelah adsopsi dengan zat warna CR



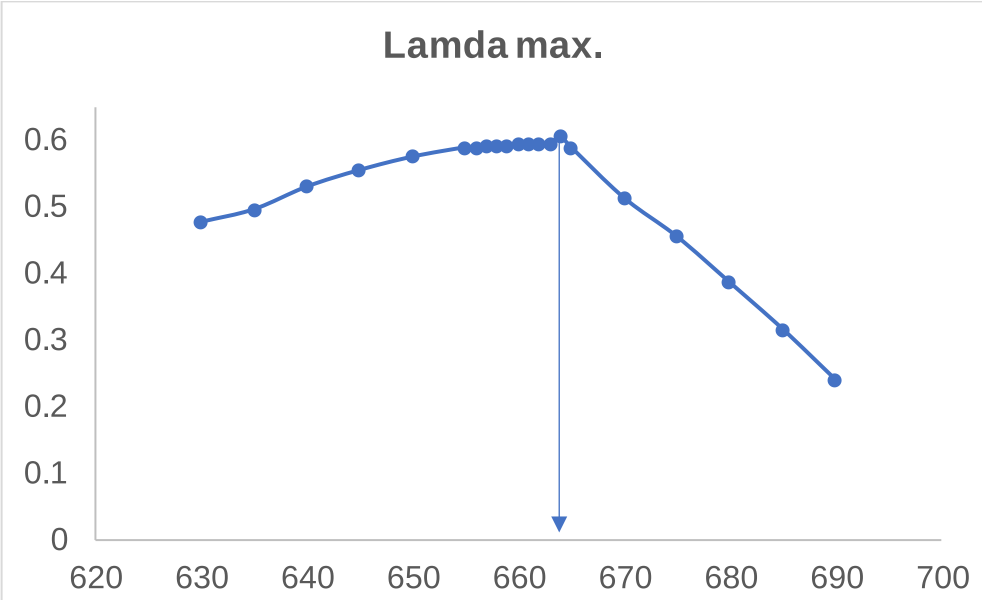
Lampiran 5. Penentuan Luas Permukaan dengan Metilen Biru

1. **Penentuan Panjang gelombang maksimum**

Hubungan antara Absorbansi dan Panjang Gelombang metilen biru dengan konsentrasi 6 mg/L

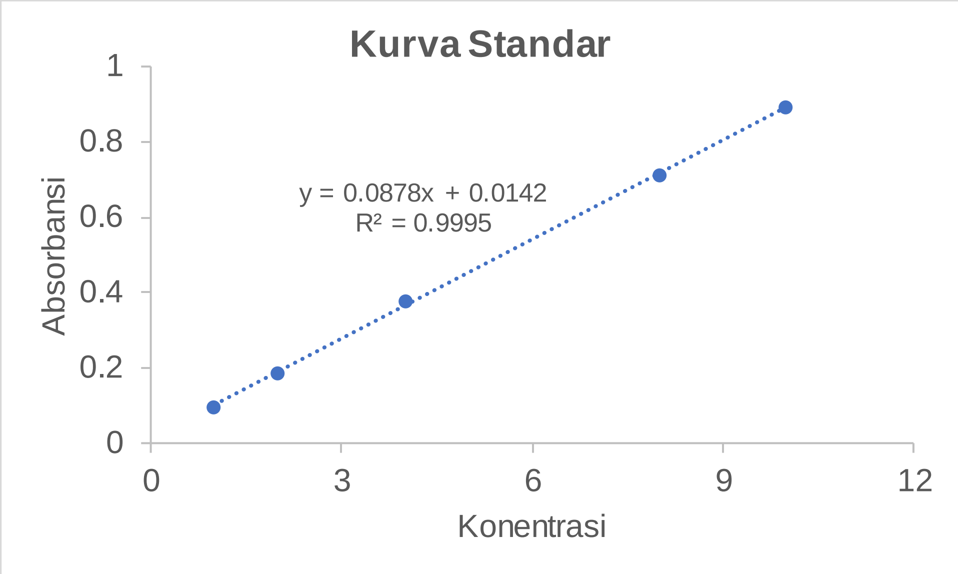
Panjang Gelombong	Absorbansi
630	0.478
635	0.497
640	0.531
645	0.556
650	0.576
655	0.59
656	0.59
657	0.591
658	0.591
659	0.591
660	0.595
661	0.595
662	0.596
663	0.596
664	**0.606**
665	0.59
670	0.514
675	0.456
680	0.387
685	0.317
690	0.241

Kurva hubungan antar absorbansi dan panjang gelombang metilen biru dengan konsentrasi 6 mg/L



2. Data Kurva Standar Metilen Biru

Konsentrasi	Absorbansi
1	0.097
2	0.188
4	0.378
8	0.71
10	0.894



3. Data Penentuan Luas Permukaan Silika Mesopori MCM-48

Data penentuan luas permukaan dengan larutan metilen biru menggunakan volume 50 mL.

Sampel	FP	Abs	C_e	C_o	Wa	q_e	S
MCM-48 TC	100	1.286	1464.53	2932.64	0.3072	238.950	884
MCM-48 C1	100	1.244	1416.69	2932.64	0.3003	252.405	934
MCM-48 C2	100	1.058	1204.84	2932.64	0.3008	287.199	1063

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

Contoh perhitungan jumlah metilen biru yang diadsorpsi (q_e) pada:

$$qe = \frac{(2932.64\text{-}1464.53)\frac{mg}{L}}{0{,}3072\ g} \times 0{,}05\ L$$

$$=238.950\ mg/g$$

$$S = \frac{X_m \; . \; N \; . \; a}{Mr}$$

Contoh perhitungan luas permukaan adsorben (S) pada:

$$S = \frac{(238.950 \text{ X } 6{,}02 \text{ X } 197)}{320.5 \text{ g/mol}}$$

$=884.18$ (m^2/g).

Lampiran 6. Hasil Data BJH

1. Material MCM-48 TC

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Analysis			**Report**			
Operator:	UNDIP	Date:2021/01/06	**Operator:**	UNDIP	Date:2021/01/12	
Sample ID:	01160	**Filename:**	20210106 MCM 48TC.qps			
Sample Desc:		**Comment:**				
Sample Weight:	0.0381 g	**Instrument:**	Autosorb IQ Station 1			
Outgas Time:	3.0 hrs	**Outgas Temp.:**	300 °C			
Analysis gas:	Nitrogen	**Non-ideality:**	6.58e-05 1/Torr	**CellType:**	9mm w/o rod	
Analysis Time:	4:40 hr:min	**Bath temp.:**	77.35 K			
Analysis Mode:	Standard			**VoidVol Remeasure:**	off	
VoidVol. Mode:	He Measure	**Cold Zone V:**	1.6226 cc	**Warm Zone V:**	18.0154 cc	

Raw Analysis Data

Raw Analysis Data

Press [Torr]	P0 [Torr]	Volume @ STP [cc]	Time [min]	Tol	Equ
38.7915	760.00	4.59581	12.6	0	1
75.4408	760.00	5.60007	17.1	0	1
116.268	760.00	6.48742	23.1	0	1
154.072	760.00	7.29142	29.1	0	1
190.792	760.00	8.47783	38.0	0	1
227.885	760.00	10.8247	51.7	0	1
266.637	760.00	12.8487	64.8	0	1
304.099	760.00	13.3411	72.0	0	1
342.347	760.00	13.5414	77.3	0	1
379.361	760.00	13.7114	80.8	0	1
417.646	760.00	13.8619	84.2	0	1
455.884	760.00	14.0006	88.0	0	1
493.931	760.00	14.131	91.9	0	1
531.943	760.00	14.2639	96.0	0	1
569.583	760.00	14.4128	100.0	0	1
608.055	760.00	14.6622	105.3	0	1
645.584	760.00	14.9087	109.7	0	1
684.869	760.00	15.4223	117.5	0	1
722.542	760.00	16.449	128.5	0	1
755.985	760.00	18.7944	148.2	0	1
754.548	760.00	18.816	150.4	0	1
722.323	760.00	17.5403	161.6	0	1
683.498	760.00	16.7858	169.4	0	1
646.311	760.00	16.4347	175.1	0	1
606.895	760.00	16.2184	181.2	0	1
569.202	760.00	16.1021	185.9	0	1
531.475	760.00	15.9697	189.6	0	1
493.356	760.00	15.8413	194.1	0	1
455.351	760.00	15.7069	199.1	0	1
417.585	760.00	15.5662	203.8	0	1
379.582	760.00	15.3094	210.5	0	1
338.213	760.00	13.6626	222.6	0	1
304.167	760.00	13.4831	227.3	0	1
266.545	760.00	13.1784	231.4	0	1
227.107	760.00	11.9295	240.0	0	1
189.564	760.00	9.4904	252.7	0	1
150.381	760.00	7.94191	260.3	0	1
111.491	760.00	6.99264	268.1	0	1
75.6987	760.00	6.16008	273.5	0	1
38.7338	760.00	5.0786	280.1	0	1

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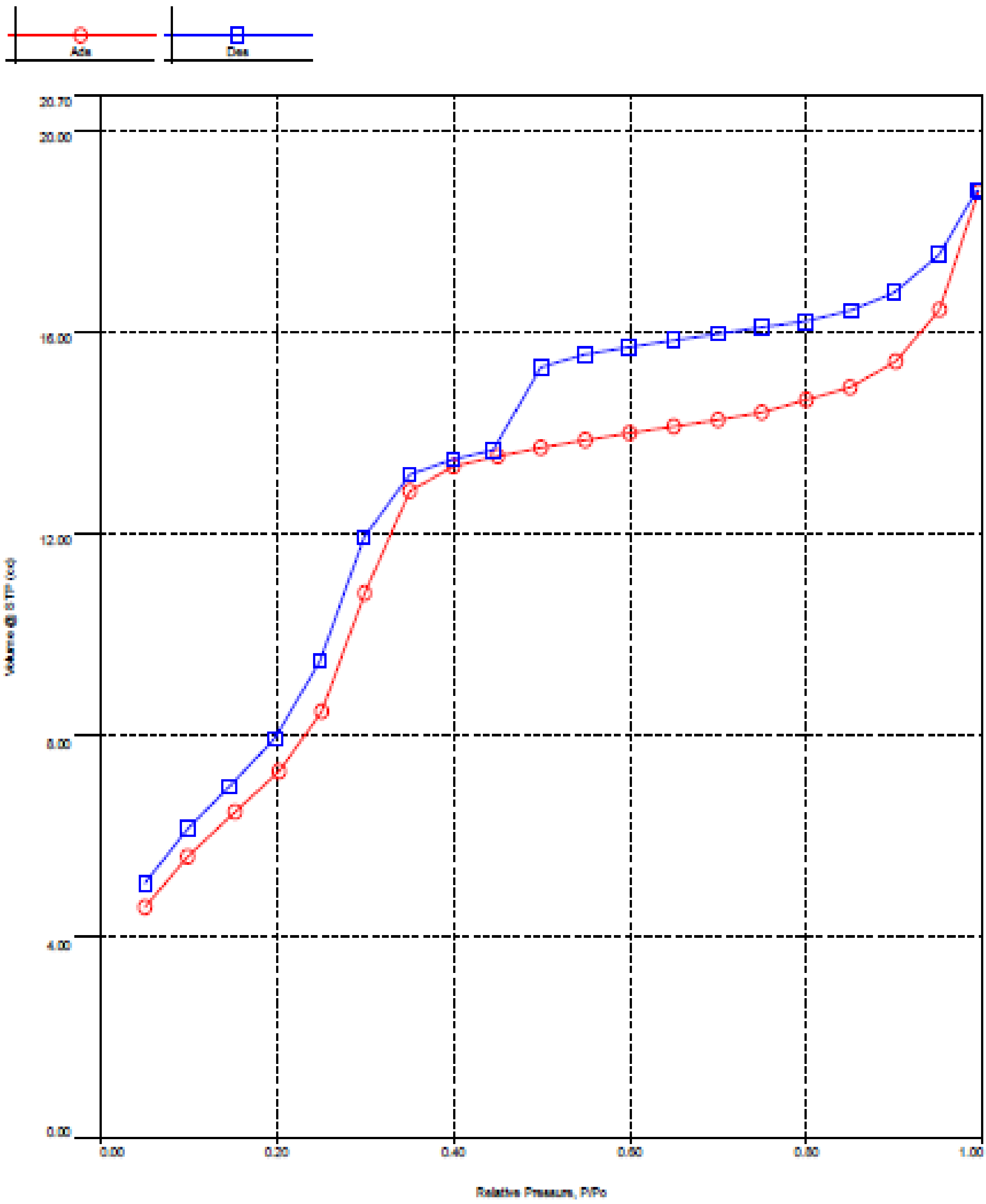
Analysis			**Report**		
Operator:	UNDIP	**Date:**2021/01/08	**Operator:** UNDIP		**Date:**2021/01/12
Sample ID:	01160	**Filename:**	20210108 MCM 48TC.qps		
Sample Desc:		**Comment:**			
Sample Weight:	0.0381 g	**Instrument:**	Autosorb iQ Station 1		
Outgas Time:	3.0 hrs	**Outgas Temp.:**	300 °C		
Analysis gas:	Nitrogen	**Non-ideality:**	6.58e-05 1/Torr	**CellType:**	9mm w/o rod
Analysis Time:	4:40 hr:min	**Bath temp.:**	77.35 K		
Analysis Mode:	Standard			**VoidVol Remeasure:**	off
VoidVol. Mode:	He Measure	**Cold Zone V:**	1.6226 cc	**Warm Zone V:**	18.0154 cc

Raw Data : Raw Linear



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version 3.01

Analysis Report

Operator:	UNDIP	**Date:** 2021/01/06		**Operator:**	UNDIP
	Date: 2021/01/12				
Sample ID:	01160		**Filename:**	20210106 MCM 48TC.qps	
Sample Desc:			**Comment:**		
Sample Weight:	0.0381 g		**Instrument:**	Autosorb iQ Station 1	
Outgas Time:	3.0 hrs		**Outgas Temp.:**	300 °C	
Analysis gas:	Nitrogen		**Non-ideality:**	6.58e-05 1/Torr	
	CellType:		9mm w/o rod		
Analysis Time:	4:40 hr:min		**Bath temp.:**	77.35 K	
Analysis Mode:	Standard			**VoidVol Remeasure:** off	
VoidVol. Mode:	He Measure		**Cold Zone V:**	1.6226 cc	
	Warm Zone V:		18.0154 cc		

BJH Pore Size Distribution Adsorption

Data Reduction Parameters Data

	Thermal Transpiration: on	**Eff. mol. diameter (D):** 3.54 Å	**Eff. cell stem diam. (d):** 4.0000 mm
t-Method	**Calc. method:** de Boer		
BJH/DH method	**Moving pt. avg.:** off	**Ignoring P-tags below 0.35 P/Po**	
Adsorbate	Nitrogen	**Temperature** 77.350K	**Liquid Density:** 0.808 g/cc
	Molec. Wt.: 28.013	**Cross Section:** 16.200 Å²	

BJH Pore Size Distribution Adsorption Data

Radius [Å]	Pore Volume [cc/g]	Pore Surf Area [m²/g]	dV(r) [cc/Å/g]	dS(r) [m²/Å/g]	dV(logr) [cc/g]	dS(logr) [cc/g]
15.2842	4.2170e-02	5.5181e+01	2.5555e-02	3.3440e+01	8.9848e-01	1.1757e+03
17.0694	5.6145e-02	7.1555e+01	7.2773e-03	8.5267e+00	2.8572e-01	3.3478e+02
19.1085	6.7357e-02	8.3291e+01	5.1960e-03	5.4384e+00	2.2838e-01	2.3903e+02
21.5118	7.6522e-02	9.1812e+01	3.4603e-03	3.2171e+00	1.7118e-01	1.5915e+02
24.4495	8.4415e-02	9.8268e+01	2.4461e-03	2.0010e+00	1.3751e-01	1.1248e+02
28.0797	9.1323e-02	1.0319e+02	1.7125e-03	1.2197e+00	1.1053e-01	7.8726e+01
32.7226	9.7985e-02	1.0726e+02	1.2684e-03	7.7526e-01	9.5366e-02	5.8288e+01
38.9025	1.0528e-01	1.1101e+02	1.0260e-03	5.2749e-01	9.1652e-02	4.7119e+01
47.7869	1.1849e-01	1.1654e+02	1.2389e-03	5.1850e-01	1.3575e-01	5.6815e+01
61.5741	1.3066e-01	1.2049e+02	7.1978e-04	2.3379e-01	1.0141e-01	3.2938e+01
87.4942	1.5654e-01	1.2641e+02	7.4104e-04	1.6939e-01	1.4729e-01	3.3668e+01
154.7788	2.0584e-01	1.3278e+02	4.9479e-04	6.3935e-02	1.7007e-01	2.1976e+01
1012.7923	3.0411e-01	1.3472e+02	6.0792e-05	1.2005e-03	1.0350e-01	2.0439e+00

BJH adsorption summary

Surface Area =	134.719 m²/g
Pore Volume =	0.304 cc/g
Pore Radius Dv(r) =	21.511 Å

2. Material MCM-48 C1

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Analysis			**Report**		
Operator:	UNDIP	Date:2021/01/07	**Operator:** UNDIP		Date:2021/01/12
Sample ID:	01161	**Filename:**	20210107 MCM 48C2.qps		
Sample Desc:		**Comment:**			
Sample Weight:	0.0289 g	**Instrument:**	Autosorb IQ Station 1		
Outgas Time:	3.0 hrs	**Outgas Temp.:**	300 °C		
Analysis gas:	Nitrogen	**Non-ideality:**	6.58e-05 1/Torr	**CellType:**	9mm w/o rod
Analysis Time:	5:14 hr:min	**Bath temp.:**	77.35 K		
Analysis Mode:	Standard			**VoidVol Remeasure:**	off
VoidVol. Mode:	He Measure	**Cold Zone V:**	1.50991 cc	**Warm Zone V:**	17.0846 cc

Raw Analysis Data

Raw Analysis Data

Press [Torr]	P0 [Torr]	Volume @ STP [cc]	Time [min]	Tol	Equ
37.4715	760.00	1.251	5.2	0	1
76.7405	760.00	1.51874	8.5	0	1
113.323	760.00	1.71668	10.8	0	1
151.356	760.00	1.90318	13.0	0	1
190.675	760.00	2.10834	16.7	0	1
228.431	760.00	2.3276	21.1	0	1
267.248	760.00	2.54558	27.0	0	1
304.715	760.00	2.761	33.2	0	1
341.431	760.00	2.9353	36.5	0	1
380.266	760.00	3.18328	42.2	0	1
417.77	760.00	3.44124	46.5	0	1
455.476	760.00	3.72982	51.6	0	1
494.225	760.00	4.07836	58.3	0	1
532.082	760.00	4.45924	65.4	0	1
570.046	760.00	4.90792	72.7	0	1
607.444	760.00	5.4022	79.4	0	1
648.017	760.00	6.21655	89.4	0	1
684.392	760.00	7.33287	99.9	0	1
721.697	760.00	10.5698	126.5	0	1
755.587	760.00	17.9289	165.2	0	1
754.39	760.00	17.9442	167.3	0	1
722.469	760.00	14.6629	189.5	0	1
684.749	760.00	9.86478	218.1	0	1
645.07	760.00	7.46285	236.1	0	1
606.708	760.00	6.24192	247.5	0	1
569.207	760.00	5.54972	254.7	0	1
531.601	760.00	5.05562	261.4	0	1
494.142	760.00	4.67779	266.7	0	1
455.786	760.00	4.35032	271.9	0	1
417.418	760.00	4.05619	277.2	0	1
379.631	760.00	3.77046	282.2	0	1
341.576	760.00	3.46151	287.4	0	1
304.346	760.00	3.22226	291.9	0	1
265.56	760.00	2.98241	295.9	0	1
228.365	760.00	2.76083	298.7	0	1
190.725	760.00	2.50065	301.1	0	1
152.577	760.00	2.24656	303.4	0	1
114.484	760.00	1.99841	305.9	0	1
75.2764	760.00	1.70658	310.7	0	1
37.929	760.00	1.37959	314.7	0	1

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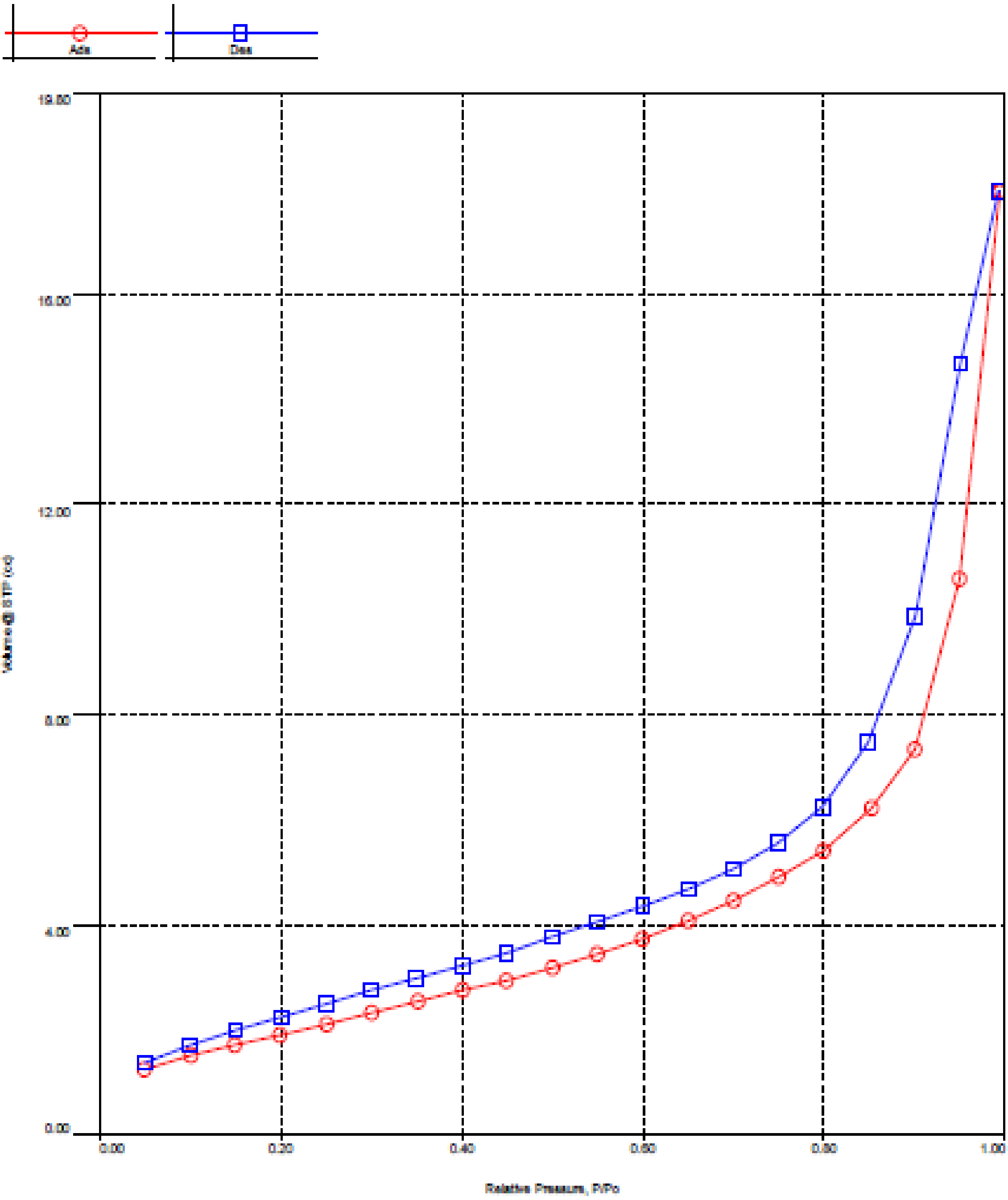
Analysis			**Report**			
Operator:	UNDIP	Date:2021/01/07	**Operator:** UNDIP		Date:2021/01/12	
Sample ID:	01161	**Filename:**	20210107 MCM 48C2.qps			
Sample Desc:		**Comment:**				
Sample Weight:	0.0289 g	**Instrument:**	Autosorb iQ Station 1			
Outgas Time:	3.0 hrs	**Outgas Temp.:**	300 °C			
Analysis gas:	Nitrogen	**Non-ideality:**	6.58e-05 1/Torr	**CellType:**	9mm w/o rod	
Analysis Time:	5:14 hr:min	**Bath temp.:**	77.35 K			
Analysis Mode:	Standard			**VoidVol Remeasure:**	off	
VoidVol. Mode:	He Measure	**Cold Zone V:**	1.50901 cc	**Warm Zone V:**	17.0848 cc	

Raw Data : Raw Linear



Analysis Report

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Operator:	UNDIP	**Date:** 2020/12/02	**Operator:** UNDIP
Date: 2020/12/03			
Sample ID:	01134	**Filename:**	20201202 MCM 48 C1.qps
Sample Desc:		**Comment:**	
Sample Weight:	0.0441 g	**Instrument:**	Autosorb iQ Station 1
Outgas Time:	3.0 hrs	**Outgas Temp.:**	300 °C
Analysis gas:	Nitrogen	**Non-ideality:** 6.58e-05 1/Torr	**CellType:** 9mm w/o rod
Analysis Time:	13:16 hr:min	**Bath temp.:**	77.35 K
Analysis Mode:	Standard	**VoidVol Remeasure:**	off
VoidVol. Mode:	He Measure	**Cold Zone V:**	1.61454 cc

cc

BJH Pore Size Distribution Adsorption

Data Reduction Parameters Data

	Thermal Transpiration: on	**Eff. mol. diameter (D):** 3.54 Å	**Eff. cell stem diam. (d):** 4.0000 mm
t-Method	**Calc. method:** de Boer		
BJH/DH method	**Moving pt. avg.:** off	**Ignoring P-tags below** 0.35 P/Po	
Adsorbate	**Nitrogen** **Molec. Wt.:** 28.013	**Temperature** 77.350K **Cross Section:** 16.200 Å²	**Liquid Density:** 0.808 g/cc

BJH Pore Size Distribution Adsorption Data

Radius	Pore Volume	Pore Surf Area	dV(r)	dS(r)	dV(logr)	dS(logr)
[Å]	[cc/g]	[m²/g]	[cc/Å/g]	[m²/Å/g]	[cc/g]	[cc/g]
15.2694	2.2125e-02	2.8980e+01	1.3704e-02	1.7950e+01	4.8138e-01	6.3052e+02
17.0491	4.5754e-02	5.6699e+01	1.2148e-02	1.4251e+01	4.7638e-01	5.5883e+02
19.1044	6.4097e-02	7.5901e+01	8.4708e-03	8.8679e+00	3.7222e-01	3.8967e+02
21.5333	8.5948e-02	9.6197e+01	8.1155e-03	7.5376e+00	4.0186e-01	3.7325e+02
24.4833	1.0945e-01	1.1540e+02	7.3287e-03	5.9867e+00	4.1256e-01	3.3702e+02
28.0843	1.3428e-01	1.3308e+02	6.2139e-03	4.4252e+00	4.0116e-01	2.8568e+02
32.6998	1.5917e-01	1.4830e+02	4.7532e-03	2.9072e+00	3.5712e-01	2.1842e+02
38.8951	1.8346e-01	1.6079e+02	3.3958e-03	1.7461e+00	3.0326e-01	1.5594e+02
47.9270	2.1333e-01	1.7326e+02	2.7383e-03	1.1427e+00	3.0088e-01	1.2556e+02
61.6515	2.5480e-01	1.8671e+02	2.5069e-03	8.1326e-01	3.5373e-01	1.1475e+02
86.5988	3.2201e-01	2.0223e+02	2.0150e-03	4.6536e-01	3.9677e-01	9.1635e+01
152.0701	4.6380e-01	2.2088e+02	1.4530e-03	1.9110e-01	4.9081e-01	6.4551e+01
949.5892	6.8267e-01	2.2549e+02	1.4616e-04	3.0784e-03	2.3608e-01	4.9722e+00

BJH adsorption summary

Surface Area = 225.488 m²/g
Pore Volume = 0.683 cc/g
Pore Radius Dv(r) = 21.533 Å

3. Material MCM-48 C2

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Analysis			**Report**		
Operator:	UNDIP	Date:2020/12/02	**Operator:** UNDIP		Date:2020/12/03
Sample ID:	01134	**Filename:**	20201202 MCM 48 C1.qps		
Sample Desc:		**Comment:**			
Sample Weight:	0.0441 g	**Instrument:**	Autosorb IQ Station 1		
Outgas Time:	3.0 hrs	**Outgas Temp.:**	300 °C		
Analysis gas:	Nitrogen	**Non-ideality:**	6.58e-05 1/Torr	**CellType:**	9mm w/o rod
Analysis Time:	13:16 hr:min	**Bath temp.:**	77.35 K		
Analysis Mode:	Standard			**VoidVol Remeasure:**	off
VoidVol. Mode:	He Measure	**Cold Zone V:**	1.61454 cc	**Warm Zone V:**	16.9532 cc

Raw Analysis Data

Raw Analysis Data

Press [Torr]	P0 [Torr]	Volume @ STP [cc]	Time [min]	Tol	Equ
38.9538	760.00	3.10026	31.6	0	1
76.6729	760.00	3.86804	90.1	0	1
113.609	760.00	4.41043	95.7	0	1
152.988	760.00	5.05929	103.0	0	1
190.721	760.00	5.70642	109.2	0	1
227.398	760.00	6.22536	117.0	0	1
266.71	760.00	6.7193	129.7	0	1
303.401	760.00	7.13884	140.1	0	1
342.201	760.00	7.58875	153.1	0	1
379.354	760.00	7.97197	161.4	0	1
418.219	760.00	8.41781	171.9	0	1
456.141	760.00	8.89547	184.5	0	1
493.808	760.00	9.40666	196.2	0	1
531.749	760.00	9.93907	209.2	0	1
569.655	760.00	10.4863	222.9	0	1
608.821	760.00	11.1698	240.4	0	1
645.399	760.00	12.1074	265.2	0	1
683.592	760.00	13.6506	299.8	0	1
721.818	760.00	17.0536	357.5	0	1
755.692	760.00	23.0884	454.4	0	1
753.437	760.00	23.1553	462.2	0	1
721.352	760.00	20.3195	526.5	0	1
683.472	760.00	16.5315	593.9	0	1
643.75	760.00	14.2977	636.8	0	1
608.239	760.00	13.2346	660.5	0	1
569.056	760.00	12.3842	677.8	0	1
532.252	760.00	11.7637	689.7	0	1
494.256	760.00	11.1544	700.6	0	1
456.105	760.00	10.6003	710.0	0	1
418.109	760.00	10.0201	718.7	0	1
379.522	760.00	9.47029	731.5	0	1
341.69	760.00	8.51434	745.3	0	1
304.071	760.00	7.83567	755.7	0	1
266.433	760.00	7.3984	762.0	0	1
227.523	760.00	6.91578	766.2	0	1
189.769	760.00	6.39805	770.3	0	1
152.603	760.00	5.78633	773.9	0	1
114.346	760.00	5.06066	784.1	0	1
76.6925	760.00	4.37185	791.0	0	1
37.1356	760.00	3.54278	796.3	0	1

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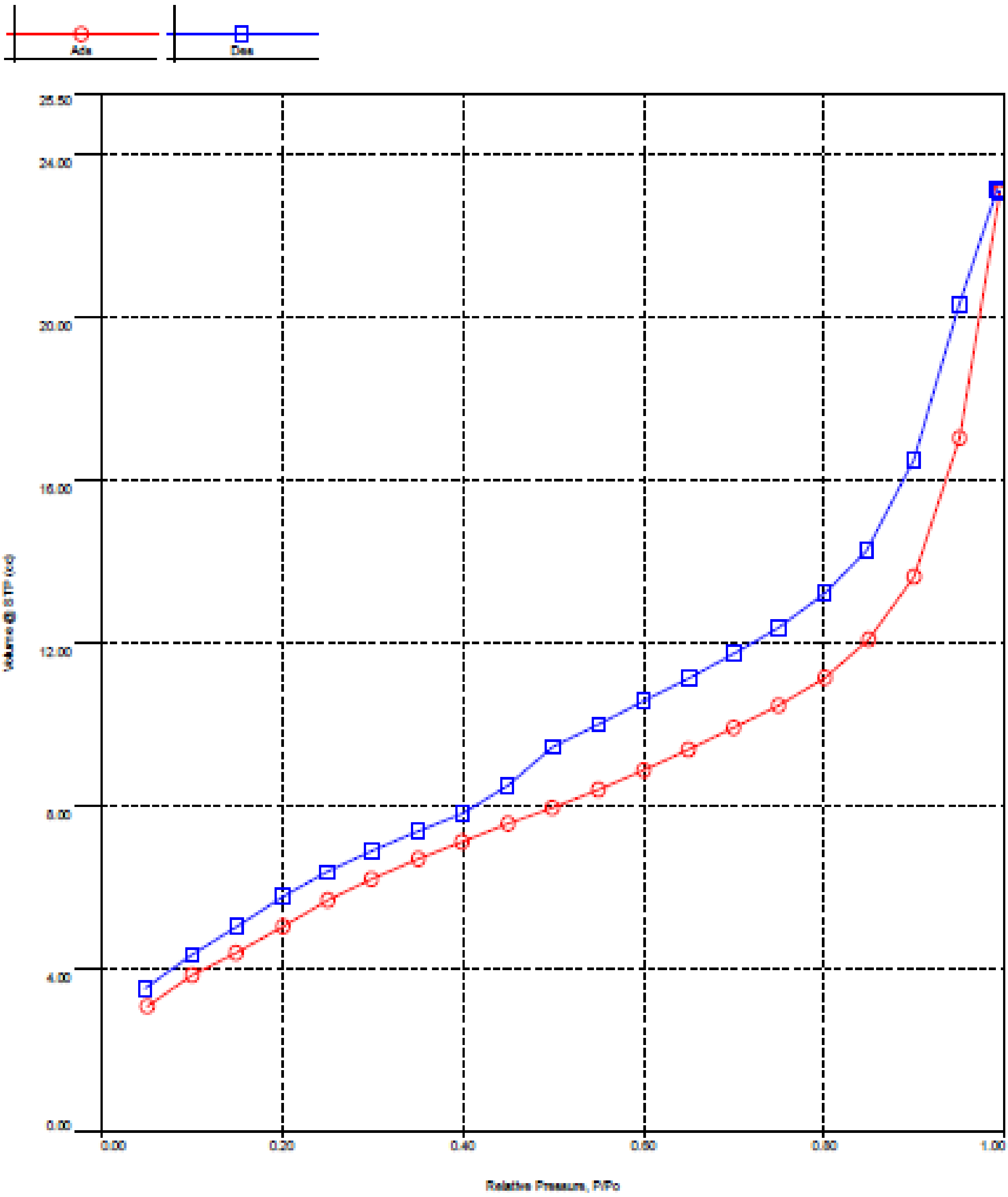
Analysis			**Report**		
Operator:	UNDIP	**Date:**2020/12/02	**Operator:** UNDIP		**Date:**2020/12/03
Sample ID:	01134	**Filename:**	20201202 MCM 48 C1.qps		
Sample Desc:		**Comment:**			
Sample Weight:	0.0441 g	**Instrument:**	Autosorb iQ Station 1		
Outgas Time:	3.0 hrs	**Outgas Temp.:**	300 °C		
Analysis gas:	Nitrogen	**Non-ideality:**	6.58e-05 1/Torr	**CellType:**	9mm w/o rod
Analysis Time:	13:16 hr:min	**Bath temp.:**	77.35 K		
Analysis Mode:	Standard			**VoidVol Remeasure:**	off
VoidVol. Mode:	He Measure	**Cold Zone V:**	1.61454 cc	**Warm Zone V:**	16.9532 cc

<u>Raw Data : Raw Linear</u>



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Analysis				**Report**	
Operator:	UNDIP	**Date:** 2021/01/07		**Operator:**	UNDIP
Date: 2021/01/12					
Sample ID:	01161	**Filename:**	20210107 MCM 48C2.qps		
Sample Desc:		**Comment:**			
Sample Weight:	0.0289 g	**Instrument:**	Autosorb iQ Station 1		
Outgas Time:	3.0 hrs	**Outgas Temp.:**	300 °C		
Analysis gas:	Nitrogen	**Non-ideality:**	6.58e-05 1/Torr		
CellType:	9mm w/o rod				
Analysis Time:	5:14 hr:min	**Bath temp.:**	77.35 K		
Analysis Mode:	Standard	**VoidVol Remeasure:**	off		
VoidVol. Mode:	He Measure	**Cold Zone V:**	1.50991 cc		
Warm Zone V:	17.0846 cc				

BJH Pore Size Distribution Adsorption
Data Reduction Parameters Data

t-Method	**Thermal Transpiration:** on **Calc. method:** de Boer	**Eff. mol. diameter (D):** 3.54 Å	**Eff. cell stem diam. (d):** 4.0000 mm
BJH/DH method	**Moving pt. avg.:** off	**Ignoring P-tags below 0.35 P/Po**	
Adsorbate	**Nitrogen** **Molec. Wt.:** 28.013	**Temperature** 77.350K **Cross Section:** 16.200 Å²	**Liquid Density:** 0.808 g/cc

BJH Pore Size Distribution Adsorption Data

Radius [Å]	Pore Volume [cc/g]	Pore Surf Area [m²/g]	dV(r) [cc/Å/g]	dS(r) [m²/Å/g]	dV(logr) [cc/g]	dS(logr) [cc/g]
15.3113	1.4249e-02	1.8612e+01	8.6165e-03	1.1255e+01	3.0349e-01	3.9642e+02
17.0592	2.3032e-02	2.8909e+01	4.7680e-03	5.5900e+00	1.8711e-01	2.1936e+02
19.1125	3.9312e-02	4.5945e+01	7.1893e-03	7.5231e+00	3.1602e-01	3.3069e+02
21.5451	5.6300e-02	6.1715e+01	6.5320e-03	6.0636e+00	3.2366e-01	3.0045e+02
24.4351	7.5531e-02	7.7455e+01	6.0489e-03	4.9510e+00	3.3986e-01	2.7817e+02
28.0781	9.9374e-02	9.4439e+01	5.8055e-03	4.1353e+00	3.7467e-01	2.6688e+02
32.7512	1.2508e-01	1.1013e+02	4.9057e-03	2.9957e+00	3.6916e-01	2.2543e+02
38.9655	1.5514e-01	1.2556e+02	4.1815e-03	2.1462e+00	3.7410e-01	1.9202e+02
47.7341	1.8696e-01	1.3890e+02	3.0754e-03	1.2885e+00	3.3669e-01	1.4107e+02
62.2050	2.4050e-01	1.5611e+02	2.8794e-03	9.2577e-01	4.0933e-01	1.3161e+02
87.9122	3.1267e-01	1.7253e+02	2.1990e-03	5.0028e-01	4.3992e-01	1.0008e+02
152.2902	5.1799e-01	1.9949e+02	2.1402e-03	2.8107e-01	7.2497e-01	9.5208e+01
929.2288	9.2556e-01	2.0827e+02	2.7955e-04	6.0168e-03	4.4395e-01	9.5552e+00

BJH adsorption summary

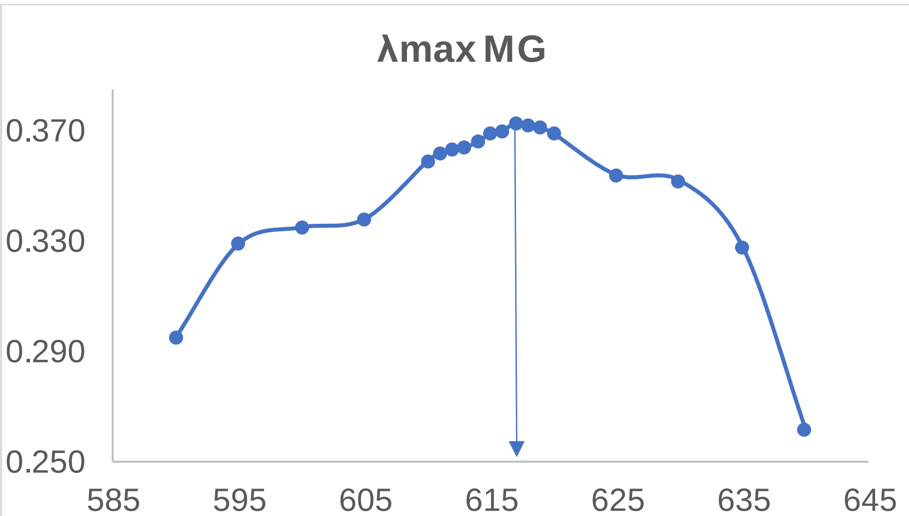
Surface Area =	208.267 m²/g
Pore Volume =	0.926 cc/g
Pore Radius Dv(r) =	21.545 Å

Lampiran 7. Data Penentuan Panjang Gelombang Maksimum

1. Data Lamda Max. Zat Warna MG dengan Konsentrasi 6 mg/L

Panjang Gelombang	Absorbansi
590	0.295
595	0.329
600	0.335
605	0.338
610	0.359
611	0.362
612	0.363
613	0.364
614	0.366
615	0.369
616	0.370
617	**0.373**
618	0.372
619	0.371
620	0.369
625	0.354
630	0.352
635	0.328
640	0.262

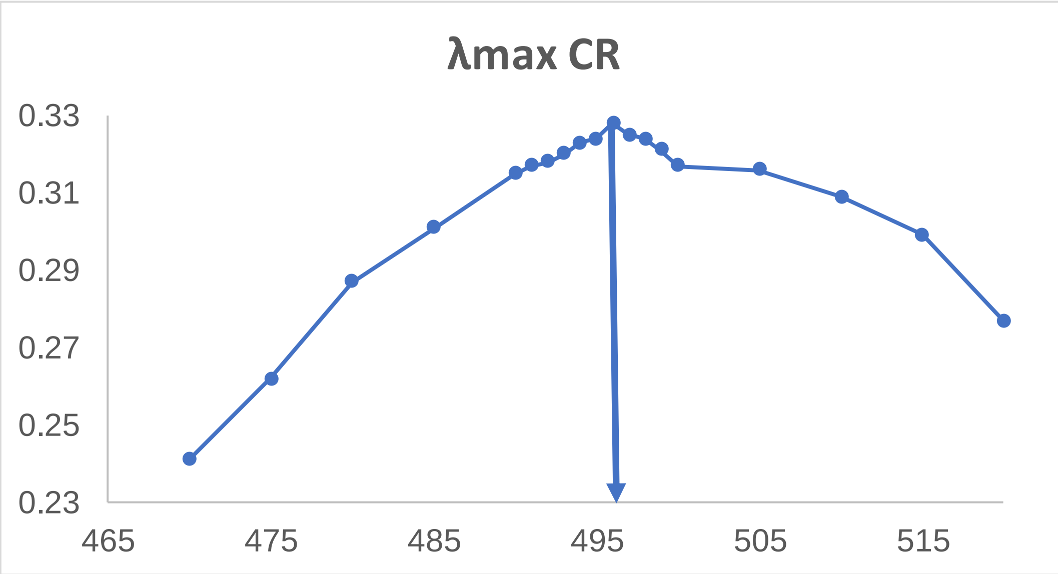
Kurva hubungan antar absorbansi dan panjang gelombang zat warna MG dengan konsentrasi 6 mg/L



2. Data Lamda Max. Zat Warna CR dengan Konsentrasi 12 mg/L

Panjang Gelombang	Absorbansi
470	0.241
475	0.262
480	0.287
485	0.301
490	0.315
491	0.317
492	0.318
493	0.32
494	0.323
495	0.324
496	**0.328**
497	0.325
498	0.324
499	0.321
500	0.317
505	0.316
510	0.309
515	0.299
520	0.277

Kurva hubungan antar absorbansi dan panjang gelombang zat warna CR dengan konsentrasi 12 mg/L.

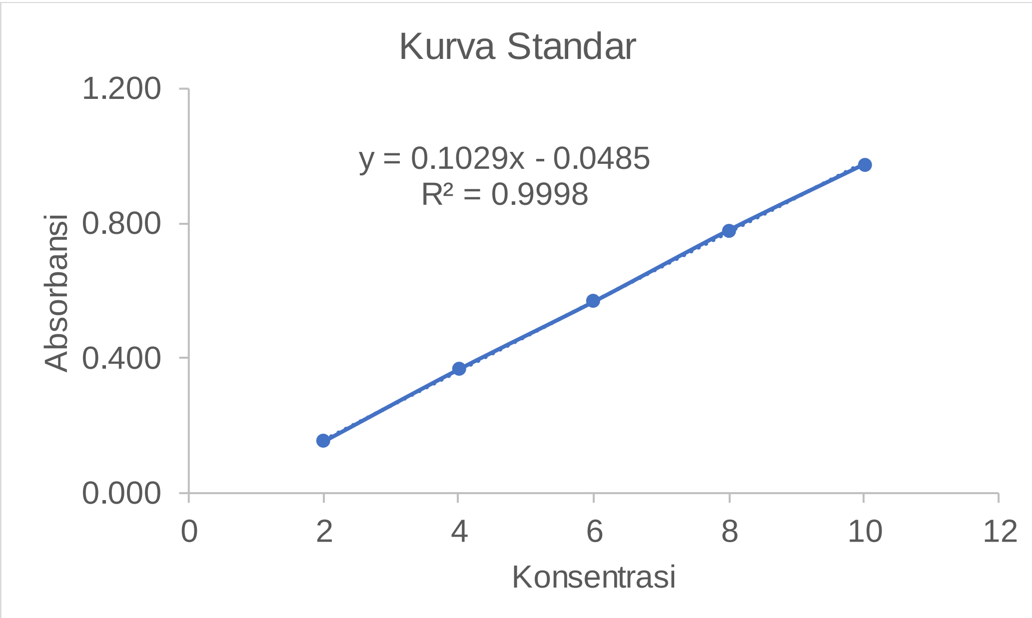


Lampiran 8. Data Absorbansi Kurva Standar Zat Warna

1. **Data deret standar larutan zat warna MG**

Konsentrasi	Absorbansi
2	0.153
4	0.367
6	0.568
8	0.780
10	0.975

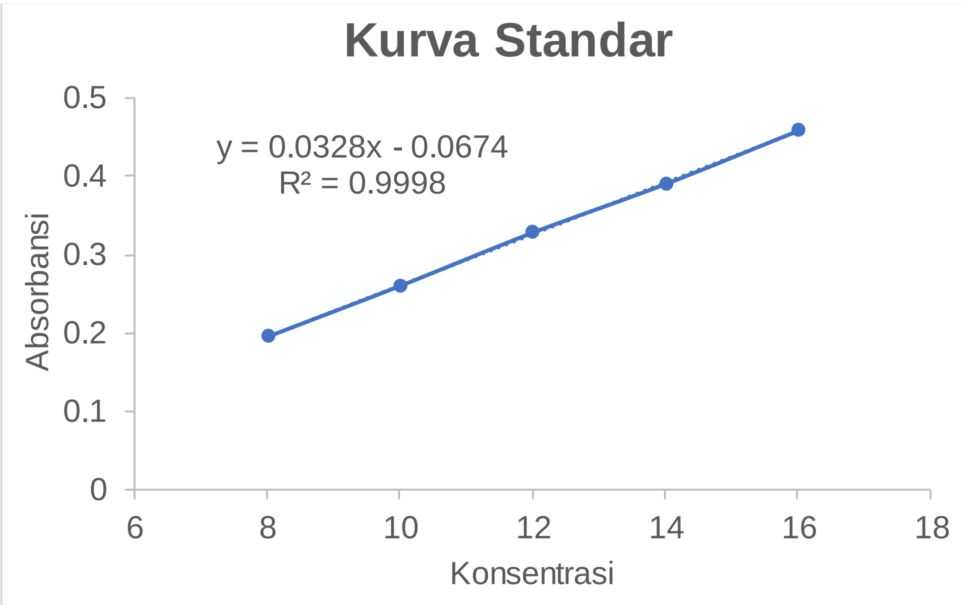
Kurva standar penentuan larutan MG dengan Spektrofotemeter UV-Vis



2. Data deret standar larutan zat warna

Konsentrasi	Absorbansi
8	0.195
10	0.260
12	0.328
14	0.390
16	0.458

Kurva standar penentuan larutan CR dengan Spektrofotemeter UV-Vis



Lampiran 9. Penentuan Waktu Optimum Adsorpsi MG oleh MCM-48 TC

Waktu (menit)	Adsorbansi	C_o (mg/L)	C_e (mg/L)	W (g)	Jumlah MG yang diadsorpsi, x/m (mg/g)
5	1.2700	40.0146	12.8134	0.1074	12.6635
10	1.0500	40.0146	10.6754	0.1066	13.7613
15	0.7960	40.0146	8.2070	0.1032	15.4106
30	0.3880	40.0146	4.2420	0.1019	17.5528
45	0.1700	40.0146	2.1234	0.1014	18.6840
60	0.0990	40.0146	1.4334	0.1008	19.1375
75	**0.0490**	**40.0146**	**0.9475**	**0.1002**	**19.4945**
90	0.0330	40.0146	0.7920	0.1007	19.4749
105	0.0140	40.0146	0.6074	0.1022	19.2794
120	0.0450	40.0146	0.9086	0.1026	19.0575
150	0.012	40.0146	0.5879	0.1044	18.8825

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Contoh perhitungan jumlah MG yang diadsorpsi (x/m) pada t = 75 menit dengan volume 0,05 L

$$x/m = \frac{(40,0146-0.9475)\frac{mg}{L}}{0,1002\ g} \times 0,05\ L$$

$$= 19,4945\ mg/g$$

Lampiran 10. Data Kinetika Reaksi Orde Satu dan Orde Dua Semu Adsorpsi MG oleh MCM-48 TC

Waktu (menit)	**q_t (mg/g)**	**q_e (mg/g)**	**(q_e-q_t)**	**log (q_e-q_t)**	**t/q_t**
5	12.6635	19.4945	6.8311	1.9215	0.3948
10	13.7613	19.4945	5.7332	1.7463	0.7267
15	15.4106	19.4945	4.0839	1.4070	0.9734
30	17.5528	19.4945	1.9417	0.6636	1.7091
45	18.6840	19.4945	0.8105	-0.2101	2.4085
60	19.1375	19.4945	0.3571	-1.0298	3.1352
75	**19.4945**	**19.4945**	**0.0000**	**0.0000**	**3.8472**
90	19.4749	19.4945	0.0196	-3.9327	4.6213
105	19.2794	19.4945	0.2151	-1.5367	5.4462
120	19.0575	19.4945	0.4371	-0.8277	6.2967
150	18.8825	19.4945	0.6121	-0.4909	7.9439

Rumus kinetika orde satu semu

$\ln (q_e - q_t) = -kt + \ln q_e$

Dari grafik kinetika orde satu semu senyawa MG diperoleh persamaan garis

y = -0.0233x + 1.2875.

Nilai k_1 dapat dihitung sebagai berikut:

k_1 = 0,0233 $menit^{-1}$

$\ln q_e$ = intercept

$\ln q_e$ = (1.2875)

q_e = 3.6237 L/mg

R^2 = 0,4453

Rumus kinetika orde dua semu:

$t\frac{1}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e}$

Dari grafik kinetika orde dua semu zat warna MG diperoleh persamaan garis y = 0.051x + 0.1377, dimana nilai slope (a) sebesar 0,051 dan intercept (b) sebesar 0,1377.

Nilai k_2 dapat dihitung sebagai berikut: Orde dua semu:

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

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

$q_e = \frac{1}{0{,}051}$

q_e = 19,6078 mg/g

$intercept = \frac{1}{k_2 q_e^2}$

$k_2 = \frac{1}{(0{,}1377) \times (19{,}6078)^2}$

$= 0{,}0188\ g.mg^{-1}.menit^{-1}$

$R^2 = 0{,}9989$

Lampiran 11. Penentuan Waktu Optimum Adsorpsi MG oleh MCM-48 C1

Waktu (menit)	Adsorbansi	C_o (mg/L)	C_e (mg/L)	W (g)	Jumlah MG yang diadsorpsi, x/m (mg/g)
5	1.7250	40.0146	17.2352	0.1006	11.3218
10	1.5750	40.0146	15.7775	0.1035	11.7088
15	1.4520	40.0146	14.5821	0.1013	12.5530
30	1.3410	40.0146	13.5034	0.1005	13.1896
45	1.2200	40.0146	12.3275	0.1007	13.7473
60	0.9400	40.0146	9.6064	0.1041	14.6053
75	**0.5880**	**40.0146**	**6.1856**	**0.1029**	**16.4378**
90	0.6850	40.0146	7.1283	0.1019	16.1366
105	0.7620	40.0146	7.8766	0.102	15.7539
120	0.8850	40.0146	9.0719	0.1	15.4713
150	0.6740	40.0146	7.0214	0.1067	15.4607

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Contoh perhitungan jumlah MG yang diadsorpsi (x/m) pada t = 75 menit dengan volume 0,05 L

$$x/m = \frac{(40{,}0146 - 6.1856)\,\frac{mg}{L}}{0{,}1029\ g} \times 0{,}05\ L$$

$$= 16.4378\ mg/g$$

Lampiran 12. Data Kinetika Reaksi Orde Satu dan Orde Dua Semu Adsorpsi MG oleh MCM-48 C1

Waktu (menit)	**q_t (mg/g)**	**q_e (mg/g)**	**(q_e-q_t)**	**log (q_e-q_t)**	**t/q_t**
5	11.3218	16.4378	5.1160	1.6324	0.4416
10	11.7088	16.4378	4.7290	1.5537	0.8541
15	12.5530	16.4378	3.8847	1.3571	1.1949
30	13.1896	16.4378	3.2481	1.1781	2.2745
45	13.7473	16.4378	2.6905	0.9897	3.2734
60	14.6053	16.4378	1.8325	0.6057	4.1081
75	**16.4378**	**16.4378**	**0.0000**	**0.0000**	**4.5627**
90	16.1366	16.4378	0.3012	-1.1999	5.5774
105	15.7539	16.4378	0.6839	-0.3800	6.6650
120	15.4713	16.4378	0.9665	-0.0341	7.7563
150	15.4607	16.4378	0.9771	-0.0232	9.7020

Rumus kinetika orde satu semu

$\ln (q_e-q_t) = -kt + \ln q_e$

Dari grafik kinetika orde satu semu senyawa MG diperoleh persamaan garis

y = -0.0154x + 1.5026.

Nilai k_1 dapat dihitung sebagai berikut:

k_1 = 0,0154 menit^{-1}

$\ln q_e$ = intercept

$\ln q_e$ = (1.5026)

q_e = 4.4933 L/mg

R^2 = 0,6653

Rumus kinetika orde dua semu:

$t\frac{1}{q_t} = \frac{1}{k_2 q_e{}^2} + \frac{1}{q_e}$

Dari grafik kinetika orde dua semu zat warna MG diperoleh persamaan garis y = 0.062x + 0.2478, dimana nilai slope (a) sebesar 0,062 dan intercept (b) sebesar 0,2478.

Nilai k_2 dapat dihitung sebagai berikut: Orde dua semu:

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

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

$q_e = \frac{1}{0{,}062}$

q_e = 16,1290 mg/g

$intercept = \frac{1}{k_2 q_e{}^2}$

$k_2 = \frac{1}{(0{,}2478)\ x\ (16.1290)^2}$

= 0,0155 $g.mg^{-1}.menit^{-1}$

R2 = 0,9963

Lampiran 13. Penentuan Waktu Optimum Adsorpsi MG oleh MCM-48 C2

Waktu (menit)	Adsorbansi	C_o (mg/L)	C_e (mg/L)	W (g)	Jumlah MG yang diadsorpsi, x/m (mg/g)
5	1.7200	40.0146	17.1866	0.1013	11.2675
10	1.4600	40.0146	14.6599	0.1021	12.4166
15	1.3100	40.0146	13.2021	0.1039	12.9030
30	1.2700	40.0146	12.8134	0.1	13.6006
45	0.9800	40.0146	9.9951	0.1043	14.3909
60	0.9400	40.0146	9.6064	0.1006	15.1134
75	0.9250	40.0146	9.4606	0.1001	15.2617
90	**0.8350**	**40.0146**	**8.5860**	**0.1017**	**15.4516**
105	0.6900	40.0146	7.1769	0.1068	15.3735
120	0.8500	40.0146	8.7318	0.1024	15.2748
150	0.7210	40.0146	7.4781	0.1088	14.9524

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Contoh perhitungan jumlah MG yang diadsorpsi (x/m) pada t = 90 menit dengan volume 0,05 L

$$x/m = \frac{(40{,}0146 - 8.5860)\frac{mg}{L}}{0{,}1017\ g} \times 0{,}05\ L$$

$$= 15.4516\ mg/g$$

Lampiran 14. Data Kinetika Reaksi Orde Satu dan Orde Dua Semu Adsorpsi MG oleh MCM-48 C2

Waktu (menit)	q_t (mg/g)	q_e (mg/g)	(q_e-q_t)	log (q_e-q_t)	t/q_t
5	11.2675	15.4516	4.1841	1.4313	0.4438
10	12.4166	15.4516	3.0350	1.1102	0.8054
15	12.9030	15.4516	2.5486	0.9355	1.1625
30	13.6006	15.4516	1.8510	0.6157	2.2058
45	14.3909	15.4516	1.0607	0.0589	3.1270
60	15.1134	15.4516	0.3382	-1.0841	3.9700
75	15.2617	15.4516	0.1899	-1.6612	4.9143
90	15.4516	15.4516	0.0000	0.0000	5.8246
105	15.3735	15.4516	0.0782	-2.5491	6.8300
120	15.2748	15.4516	0.1768	-1.7327	7.8561
150	14.9524	15.4516	0.4992	-0.6948	10.0318

Rumus kinetika orde satu semu

$\ln (q_e - q_t) = -kt + \ln q_e$

Dari grafik kinetika orde satu semu senyawa MG diperoleh persamaan garis

y = -0.0209x + 1.0132.

k_1 = 0,0209 $menit^{-1}$

ln q_e = intercept

ln q_e = (1.0132)

q_e = 2,7544 L/mg

R^2 = 0,5879

Rumus kinetika orde dua semu:

$t\frac{1}{q_t} = \frac{1}{k_2 q_e{}^2} + \frac{1}{q_e}$

Dari grafik kinetika orde dua semu zat warna MG diperoleh persamaan garis y = 0.0646x + 0.1503, dimana nilai slope (a) sebesar 0,0646 dan intercept (b) sebesar 0,1503.

Nilai k_2 dapat dihitung sebagai berikut:

Orde dua semu:

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

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

$q_e = \frac{1}{0{,}0646}$

q_e = 15,4798 mg/g

$intercept = \frac{1}{k_2 q_e{}^2}$

$k_2 = \frac{1}{(0{,}1503)\ x\ (15{,}4798)^2}$

= 0,0277 $g.mg^{-1}.menit^{-1}$

R^2 = 0,999

Lampiran 15. Penentuan Waktu Optimum Adsorpsi CR oleh MCM-48 TC

Waktu (menit)	**Ads**	**C_o (mg/L)**	**C_e (mg/L)**	**W (g)**	**Jumlah CR yang diadsorpsi, x/m (mg/g)**
3	0.450	229.9390	15.7744	0.1011	105.9172
5	0.264	229.9390	10.1037	0.1018	107.9741
7	0.226	229.9390	8.9451	0.1011	109.2947
10	0.204	229.9390	8.2744	0.1008	109.9527
15	0.056	229.9390	3.7622	0.1024	110.4379
20	**0.033**	**229.9390**	**3.0610**	**0.1006**	**112.7624**
25	0.040	229.9390	3.2744	0.1018	111.3284
30	0.019	229.9390	2.6341	0.1022	111.2059
35	0.011	229.9390	2.3902	0.1037	109.7149
40	0.014	229.9390	2.4817	0.1045	108.8313

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Contoh perhitungan jumlah CR yang diadsorpsi (x/m) pada t = 20 menit dengan volume 0,05 L

$$x/m = \frac{(229.9390-3.0610)\frac{mg}{L}}{0,1006\ g} \times 0,05\ L$$

$$= 112.7624\ mg/g$$

Lampiran 16. Data Kinetika Reaksi Orde Satu dan Orde Dua Semu Adsorpsi CR oleh MCM-48 TC

Waktu (menit)	q_t (mg/g)	q_e (mg/g)	(q_e-q_t)	log (q_e-q_t)	t/q_t
3	105.9172	112.7624	6.8452	1.9236	0.0283
5	107.9741	112.7624	4.7883	1.5662	0.0463
7	109.2947	112.7624	3.4677	1.2435	0.0640
10	109.9527	112.7624	2.8098	1.0331	0.0909
15	110.4379	112.7624	2.3245	0.8435	0.1358
20	**112.7624**	**112.7624**	**0.0000**	**0.0000**	**0.1774**
25	111.3284	112.7624	1.4340	0.3605	0.2246
30	111.2059	112.7624	1.5565	0.4425	0.2698
35	109.7149	112.7624	3.0475	1.1143	0.3190
40	108.8313	112.7624	3.9312	1.3689	0.3675

Rumus kinetika orde satu semu

$\ln (q_e-q_t) = -kt + \ln q_e$

Dari grafik kinetika orde satu semu senyawa CR diperoleh persamaan garis

y = -0.0172x + 1.3172

k_1 = 0,0172 $menit^{-1}$

$\ln q_e$ = intercept

$\ln q_e$ = (1.3172)

q_e = 3.7329 L/mg

R^2 = 0,1472

Rumus kinetika orde dua semu:

$t\frac{1}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e}$

Dari grafik kinetika orde dua semu zat warna MG diperoleh persamaan garis y = 0.0091x - 0.0005, dimana nilai slope (a) sebesar 0,0091 dan intercept (b) sebesar 0,0005.

Nilai k_2 dapat dihitung sebagai berikut:

Orde dua semu:

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

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

$q_e = \frac{1}{0,0091}$

q_e = 109.890 mg/g

$intercept = \frac{1}{k_2 q_e^2}$

$k_2 = \frac{1}{(0,0005) \times (109.890)^2}$

= 0.1656 $g.mg^{-1}.menit^{-1}$

R^2 = 0,9996

Lampiran 17. Penentuan Waktu Optimum Adsorpsi CR oleh MCM-48 C1

Waktu (menit)	Adsorbansi	C_o (mg/L)	C_e (mg/L)	W (g)	Jumlah CR yang diadsorpsi, x/m (mg/g)
3	1.5050	229.9390	47.9390	0.1006	90.4573
5	0.7140	229.9390	23.8232	0.1005	102.5452
7	0.2790	229.9390	10.5610	0.1007	108.9265
10	0.2490	229.9390	9.6463	0.1009	109.1639
15	0.2240	229.9390	8.8841	0.1011	109.3249
20	0.1590	229.9390	6.9024	0.1010	110.4142
25	**0.0970**	**229.9390**	**5.0122**	**0.1015**	**110.8014**
30	0.0570	229.9390	3.7927	0.1027	110.1005
35	0.0780	229.9390	4.4329	0.1033	109.1511
40	0.0920	229.9390	4.8598	0.1034	108.8391

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Contoh perhitungan jumlah CR yang diadsorpsi (x/m) pada t = 25 menit dengan volume 0,05 L

$$x/m = \frac{(229.9390 - 5.0122)\,\frac{mg}{L}}{0,1015\ g} \times 0,05\ L$$

$$= 110.8014\ mg/g$$

Lampiran 18. Data Kinetika Reaksi Orde Satu dan Orde Dua Semu Adsorpsi CR oleh MCM-48 C1

Waktu (menit)	q_t (mg/g)	q_e (mg/g)	(q_e-q_t)	log (q_e-q_t)	t/q_t
3	90.4573	110.8014	20.3441	3.0128	0.0332
5	102.5452	110.8014	8.2562	2.1110	0.0488
7	108.9265	110.8014	1.8749	0.6285	0.0643
10	109.1639	110.8014	1.6375	0.4932	0.0916
15	109.3249	110.8014	1.4765	0.3897	0.1372
20	110.4142	110.8014	0.3872	-0.9487	0.1811
25	**110.8014**	**110.8014**	**0.0000**	**0.0000**	**0.2256**
30	110.1005	110.8014	0.7009	-0.3553	0.2725
35	109.1511	110.8014	1.6503	0.5010	0.3207
40	108.8391	110.8014	1.9623	0.6741	0.3675

Rumus kinetika orde satu semu

$\ln (q_e - q_t) = -kt + \ln q_e$

Dari grafik kinetika orde satu semu senyawa CR diperoleh persamaan garis

y =-0.0478x + 1.5587

k_1 = 0,0478 menit^{-1}

$\ln q_e$ = intercept

$\ln q_e$ = (1.5587)

q_e = 4.7526 L/mg

R^2 = 0,2991

Rumus kinetika orde dua semu:

$t\frac{1}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e}$

Dari grafik kinetika orde dua semu zat warna MG diperoleh persamaan garis y = 0.0091x + 0.0021, dimana nilai slope (a) sebesar 0,0091 dan intercept (b) sebesar 0,0021.

Nilai k_2 dapat dihitung sebagai berikut:

Orde dua semu:

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

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

$q_e = \frac{1}{0,0091}$

q_e = 109.8901 mg/g

$intercept = \frac{1}{k_2 {q_e}^2}$

$k_2 = \frac{1}{(0,0021) \text{ x } (109.8901)^2}$

= 0.0394 g.mg^{-1}.menit^{-1}

R^2 = 0,9996

Lampiran 19. Penentuan Waktu Optimum Adsorpsi CR oleh MCM-48 C2

Waktu (menit)	Ads	C_o (mg/L)	C_e (mg/L)	W (g)	Jumlah CR yang diadsorpsi, x/m (mg/g)
3	1.3100	229.9390	41.9939	0.1009	93.1344
5	0.8450	229.9390	27.8171	0.1008	100.2589
7	0.7730	229.9390	25.6220	0.1007	101.4484
10	0.5480	229.9390	18.7622	0.1013	104.2334
15	0.4690	229.9390	16.3537	0.1016	105.1109
20	0.3030	229.9390	11.2927	0.1012	108.0268
25	**0.2310**	**229.9390**	**9.0976**	**0.1008**	**109.5444**
30	0.2960	229.9390	11.0793	0.1006	108.7772
35	0.3240	229.9390	11.9329	0.1007	108.2453
40	0.1590	229.9390	6.9024	0.1032	108.0604

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Contoh perhitungan jumlah CR yang diadsorpsi (x/m) pada t = 25 menit dengan volume 0,05 L

$$x/m = \frac{(229.9390-9.0976)\frac{mg}{L}}{0,1008\ g} \times 0,05\ L$$

$$= 109.5444\ mg/g$$

Lampiran 20. Data Kinetika Reaksi Orde Satu dan Orde Dua Semu Adsorpsi CR oleh MCM-48 C2

Waktu (menit)	q_t (mg/g)	q_e (mg/g)	(q_e-q_t)	log (q_e-q_t)	t/q_t
3	93.1344	109.5444	16.4100	2.7979	0.0322
5	100.2589	109.5444	9.2855	2.2285	0.0499
7	101.4484	109.5444	8.0960	2.0914	0.0690
10	104.2334	109.5444	5.3110	1.6698	0.0959
15	105.1109	109.5444	4.4335	1.4892	0.1427
20	108.0268	109.5444	1.5175	0.4171	0.1851
25	109.5444	109.5444	0.0000	0.0000	0.2282
30	108.7772	109.5444	0.7672	-0.2651	0.2758
35	108.2453	109.5444	1.2990	0.2616	0.3233
40	108.0604	109.5444	1.4840	0.3948	0.3702

Rumus kinetika orde satu semu

$\ln (q_e - q_t) = -kt + \ln q_e$

Dari grafik kinetika orde satu semu senyawa CR diperoleh persamaan garis

y = -0.0724x + 2.484

k_1 = 0,0724 menit^{-1}

ln q_e = intercept

ln q_e = (2.484)

q_e = 11.9891 L/mg

R^2 = 0,7836

Rumus kinetika orde dua semu:

$$t\frac{1}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e}$$

Dari grafik kinetika orde dua semu zat warna MG diperoleh persamaan garis y = 0.0091x + 0.0047, dimana nilai slope (a) sebesar 0,0091 dan intercept (b) sebesar 0,0047.

Nilai k_2 dapat dihitung sebagai berikut:

Orde dua semu:

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

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

$$q_e = \frac{1}{0{,}0091}$$

q_e = 109.8901 mg/g

$$intercept = \frac{1}{k_2 q_e^2}$$

$$k_2 = \frac{1}{(0{,}0047)\ x\ (109.8901)^2}$$

= 0.0176 $g.mg^{-1}.menit^{-1}$

R^2 = 0,9998

Lampiran 21. Penentuan Kapasitas Adsorpsi MG oleh MCM-48 TC

C_o (mg/L)	Abs	FP	C_e (mg/L)	Wa (g)	x/m (mg/g)	C_e/q_e	Log C_e	Log q_e
36.1856	0.090		1.3460	0.1012	17.2133	2.1022	0.1290	1.2359
70.9281	0.168		2.1040	0.1022	33.6713	2.1065	0.3230	1.5273
87.6919	0.345		3.8241	0.1017	41.2330	2.1267	0.5825	1.6152
110.7726	0.660		6.8853	0.1012	51.3277	2.1581	0.8379	1.7104
151.5889	1.500		15.0486	0.1007	67.7956	2.2360	1.1775	1.8312
211.8416	1.800	2	35.4568	0.1017	86.7182	2.4429	1.5497	1.9381
254.3586	0.630	10	61.6958	0.1001	96.2352	2.6431	1.7903	1.9833

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Dimana x/m = jumlah metanil kuning yang diadsorpsi (mg/g)

C_o = konsentrasi metanil kuning sebelum adsorpsi (mg/L)

C_e = konesntrasi metanil kuning setelah adsorpsi (mg/L)

V = volume larutan metanil kuning (L)

W = jumlah adsorben (gram)

Contoh perhitungan jumlah MG yang diadsorpsi (q_e) pada konsentrasi 254.3586 dan volume 0.05 L.

$$\frac{x}{m} = \frac{(254.3586\text{-}61.6958)\frac{\text{mg}}{\text{L}}}{0.1001\text{ g}} \text{ x } 0.05\text{ L}$$

$$= 96.2352 \text{ mg/g}$$

1. Persamaan isoterm adsorpsi Langmuir

$$\frac{C_e}{q_e} = \frac{1}{Q_o b} + \frac{C_e}{Q_o}$$

Dimana: C_e = konsentrasi kesetimbangan larutan (mg/L)

q_e = jumlah zat yang diadsorpsi per gram adsorben (mg/g)

Q_o = kapasitas adsorpsi (mg/g)

b = intensitas adsorpsi (L/mg)

Contoh Perhitungan nilai Q_o dan b

Berdasarkan model isoterm Langmuir diperoleh persamaan garis :

y = 0.0091x + 2.0946

Dari persamaan garis tersebut, nilai *slope* = 0.0091 dan *intercept* 2.0946

$$slope = \frac{1}{Q_o}$$

$$Q_o = \frac{1}{slope}$$

$$= \frac{1}{0{,}0091}$$

= 109.8901 mg/g

$$intercept = \frac{1}{Q_o b}$$

$$b = \frac{1}{Q_o \times intercept}$$

$$= \frac{1}{109.8901 \times 2.0946}$$

= 0,0043 L/mg

2. Persamaan isoterm adsorpsi Freundlich :

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log C_e$$

Dimana: x = jumlah zat terlarut yang diserap (mg)

m = gram adsorben yang digunakan (g)

C_e = konsentrasi keseimbangan larutan (mg/L)

k = kapasitas adsorpsi (mg/g)

n = intensitas adsorpsi (L/g)

Contoh Perhitungan nilai k dan n

Berdasarkan model isoterm Freundlich diperoleh persamaan garis :

y = 0.3995x + 1.3269

Dari persamaan garis tersebut, nilai *slope* = 0.3995 dan *intercept* = 1.3269

log k = *intercept*

k = *invers* log *intercept*

= *invers* $\log^{-1}$ (1,3269)

= 21.2275 mg/g

$$slope = \frac{1}{n}$$

$$n = \frac{1}{slope}$$

$$= \frac{1}{0,3995}$$

= 2,5031 g/L

Lampiran 22. Penentuan Kapasitas Adsorpsi MG oleh MCM-48 C1

C_o (mg/L)	Abs	FP	C_e (mg/L)	Wa (g)	x/m (mg/g)	C_e/q_e	Log C_e	Log q_e
62.1817	0.400	10	39.3440	0.1007	11.3395	5.4837	1.5949	1.0546
79.6744	0.535	10	52.4636	0.1003	13.5647	5.8736	1.7199	1.1324
98.3819	0.680	10	66.5549	0.1001	15.8976	6.1885	1.8232	1.2013
122.4344	0.875	10	85.5053	0.1003	18.4093	6.6507	1.9320	1.2650
135.5539	0.985	10	96.1953	0.1008	19.5231	6.9433	1.9832	1.2905
161.7930	1.203	10	117.3810	0.1012	21.9427	7.3734	2.0696	1.3413
184.6307	1.420	10	138.4694	0.1009	22.8748	8.0714	2.1414	1.3594

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Dimana x/m = jumlah metanil kuning yang diadsorpsi (mg/g)

C_o = konsentrasi metanil kuning sebelum adsorpsi (mg/L)

C_e = konesntrasi metanil kuning setelah adsorpsi (mg/L)

V = volume larutan metanil kuning (L)

W = jumlah adsorben (gram)

Contoh perhitungan jumlah MG yang diadsorpsi (x/m) pada konsentrasi 184.6307 dan volume 0.05 L.

$$\frac{x}{m} = \frac{(184.6307 - 138.4694)\frac{\text{mg}}{\text{L}}}{0.1009\ \text{g}} \times 0.05\ \text{L}$$

$$= 22.8748\ \text{mg/g}$$

1. **Persamaan isoterm adsorpsi Langmuir**

$$\frac{C_e}{q_e} = \frac{1}{Q_o b} + \frac{C_e}{Q_o}$$

Dimana: C_e = konsentrasi kesetimbangan larutan (mg/L)

q_e = jumlah zat yang diadsorpsi per gram adsorben (mg/g)

Q_o = kapasitas adsorpsi (mg/g)

b = intensitas adsorpsi (L/mg)

Contoh Perhitungan nilai Q_o dan b

Berdasarkan model isoterm Langmuir diperoleh persamaan garis :

y = 0.0252x + 4.506

Dari persamaan garis tersebut, nilai *slope* = 0.0252 dan *intercept* 4.506

$$slope = \frac{1}{Q_o}$$

$$Q_o = \frac{1}{slope}$$

$$= \frac{1}{0{,}0252}$$

= 39.6825 mg/g

$$intercept = \frac{1}{Q_o b}$$

$$b = \frac{1}{Q_o \times intercept}$$

$$= \frac{1}{39.6825 \times 4.506}$$

= 0,0055 L/mg

2. Persamaan isoterm adsorpsi Freundlich:

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log C_e$$

Dimana: x = jumlah zat terlarut yang diserap (mg)

m = gram adsorben yang digunakan (g)

C_e = konsentrasi keseimbangan larutan (mg/L)

k = kapasitas adsorpsi (mg/g)

n = intensitas adsorpsi (L/g)

Contoh Perhitungan nilai k dan n

Berdasarkan model isoterm Freundlich diperoleh persamaan garis :

y = 0.5735x + 0.1483

Dari persamaan garis tersebut, nilai *slope* = 0.5735 dan *intercept* =0.1483

log k = *intercept*

k = *invers* log *intercept*

= *invers* $\log^{-1}$ (0.1483)

= 1.4070 mg/g

$$slope = \frac{1}{n}$$

$$n = \frac{1}{slope}$$

$$= \frac{1}{0{,}5735}$$

= 1.7436 g/L

Lampiran 23. Penentuan Kapasitas Adsorpsi MG oleh MCM-48 C2

C_o (mg/L)	Abs	FP	C_e (mg/L)	Wa (g)	x/m (mg/g)	C_e/q_e	Log C_e	Log q_e
36.1856	1.380		13.8824	0.1004	11.1072	3.2579	1.1425	1.0456
73.3576	0.830	5	40.8017	0.1012	16.0849	4.5606	1.6107	1.2064
82.3469	0.975	5	47.8474	0.1009	17.0959	4.8168	1.6799	1.2329
98.8678	1.280	5	62.6676	0.1006	17.9921	5.4951	1.7970	1.2551
111.2585	1.480	5	72.3858	0.1003	19.3782	5.7414	1.8597	1.2873
119.2760	1.625	5	79.4315	0.1012	19.6860	6.0589	1.9000	1.2942
137.0117	1.950	5	95.2235	0.1015	20.5853	6.6558	1.9787	1.3136

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Dimana x/m = jumlah metanil kuning yang diadsorpsi (mg/g)

C_o = konsentrasi metanil kuning sebelum adsorpsi (mg/L)

C_e = konesntrasi metanil kuning setelah adsorpsi (mg/L)

V = volume larutan metanil kuning (L)

W = jumlah adsorben (gram)

Contoh perhitungan jumlah MG yang diadsorpsi (x/m) pada konsentrasi 137.0117dan volume 0.05 L.

$$\frac{x}{m} = \frac{(137.0117 - 95.2235)\frac{mg}{L}}{0.1015\ g} \times 0.05\ L$$

$$= 20.5853\ mg/g$$

1. Persamaan isoterm adsorpsi Langmuir

$$\frac{C_e}{q_e} = \frac{1}{Q_o b} + \frac{C_e}{Q_o}$$

Dimana: C_e = konsentrasi kesetimbangan larutan (mg/L)

q_e = jumlah zat yang diadsorpsi per gram adsorben (mg/g)

Q_o = kapasitas adsorpsi (mg/g)

b = intensitas adsorpsi (L/mg)

Contoh Perhitungan nilai Q_o dan b

Berdasarkan model isoterm Langmuir diperoleh persamaan garis :

y = 0.0413x + 2.7906

Dari persamaan garis tersebut, nilai *slope* = 0.0413 dan *intercept*=2.7906

$$slope = \frac{1}{Q_o}$$

$$Q_o = \frac{1}{slope}$$

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

= 24.2130 mg/g

$$intercept = \frac{1}{Q_o b}$$

$$b = \frac{1}{Q_o \times intercept}$$

$$= \frac{1}{24.2130 \times 2.7906}$$

= 0,0147 L/mg

2. Persamaan isoterm adsorpsi Freundlich:

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log C_e$$

Dimana: x = jumlah zat terlarut yang diserap (mg)

m = gram adsorben yang digunakan (g)

C_e = konsentrasi keseimbangan larutan (mg/L)

k = kapasitas adsorpsi (mg/g)

n = intensitas adsorpsi (L/g)

Contoh Perhitungan nilai k dan n

Berdasarkan model isoterm Freundlich diperoleh persamaan garis :

y = 0.3237x + 0.6805

Dari persamaan garis tersebut, nilai *slope* = 0.3237 dan *intercept* =0.6805

log k = *intercept*

k = *invers* log *intercept*

= *invers* $\log^{-1}$ (0.6805)

= 4.7918 mg/g

$$slope = \frac{1}{n}$$

$$n = \frac{1}{slope}$$

$$= \frac{1}{0{,}3237}$$

= 3.0892 g/L

Lampiran 24. Penentuan Kapasitas Adsorpsi CR oleh MCM-48 TC

C_o (mg/L)	Abs	C_e (mg/L)	Wa (g)	x/m (mg/g)	C_e/q_e	Log C_e	Log q_e
166.6890	0.025	2.8171	0.1013	80.8845	2.0608	0.4498	1.9079
206.3232	0.037	3.1829	0.1018	99.7742	2.0679	0.5028	1.9990
244.1280	0.075	4.3415	0.1017	117.8892	2.0708	0.6376	2.0715
264.2500	0.275	10.4390	0.1002	126.6522	2.0864	1.0187	2.1026
331.3232	0.350	12.7256	0.1008	158.0345	2.0965	1.1047	2.1988
383.1524	0.430	15.1646	0.1009	182.3527	2.1012	1.1808	2.2609
471.5671	0.485	16.8415	0.1021	222.6864	2.1176	1.2264	2.3477
566.0793	0.706	23.5793	0.1017	266.7158	2.1224	1.3725	2.4260

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Dimana x/m = jumlah metanil kuning yang diadsorpsi (mg/g)

C_o = konsentrasi metanil kuning sebelum adsorpsi (mg/L)

C_e = konesntrasi metanil kuning setelah adsorpsi (mg/L)

V = volume larutan metanil kuning (L)

W = jumlah adsorben (gram)

Contoh perhitungan jumlah CR yang diadsorpsi (q_e) pada konsentrasi 566.0793 dan volume 0.05 L.

$$\frac{x}{m} = \frac{(566.0793\text{-}23.5793)\frac{\text{mg}}{\text{L}}}{0.1017\ \text{g}} \times 0.05\ \text{L}$$

$$= 266.7158\ \text{mg/g}$$

3. Persamaan isoterm adsorpsi Langmuir

$$\frac{C_e}{q_e} = \frac{1}{Q_o b} + \frac{C_e}{Q_o}$$

Dimana: C_e = konsentrasi kesetimbangan larutan (mg/L)

q_e = jumlah zat yang diadsorpsi per gram adsorben (mg/g)

Q_o = kapasitas adsorpsi (mg/g)

b = intensitas adsorpsi (L/mg)

Contoh Perhitungan nilai Q_o dan b

Berdasarkan model isoterm Langmuir diperoleh persamaan garis :

y = 0.003x + 2.0567

Dari persamaan garis tersebut, nilai *slope* = 0.003 dan *intercept* 2.0567

$$slope = \frac{1}{Q_o}$$

$$Q_o = \frac{1}{slope}$$

$$= \frac{1}{0{,}003}$$

= 333.3333 mg/g

$$intercept = \frac{1}{Q_o b}$$

$$b = \frac{1}{Q_o \times intercept}$$

$$= \frac{1}{333.3333 \times 2.0567}$$

= 0,0014 L/mg

4. Persamaan isoterm adsorpsi Freundlich:

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log C_e$$

Dimana: x = jumlah zat terlarut yang diserap (mg)

m = gram adsorben yang digunakan (g)

C_e = konsentrasi keseimbangan larutan (mg/L)

k = kapasitas adsorpsi (mg/g)

n = intensitas adsorpsi (L/g)

Contoh Perhitungan nilai k dan n

Berdasarkan model isoterm Freundlich diperoleh persamaan garis :

y = 0.4709x + 1.7232

Dari persamaan garis tersebut, nilai *slope* =0.4709 dan *intercept* = 1.7232

log k = *intercept*

k = *invers* log *intercept*

= *invers* $\log^{-1}$ (1,7232)

= 52.8688 mg/g

$$slope = \frac{1}{n}$$

$$n = \frac{1}{slope}$$

$$= \frac{1}{0,4709}$$

= 2,4384 g/L

Lampiran 25. Penentuan Kapasitas Adsorpsi CR oleh MCM-48 C1

C_o (mg/L)	Abs	FP	C_e (mg/L)	Wa (g)	x/m (mg/g)	C_e/q_e	Log C_e	Log q_e
178.2744	0.047		3.4878	0.1002	87.2189	2.0440	0.5426	1.9406
194.1280	0.069		4.1585	0.1006	94.4182	2.0560	0.6189	1.9751
220.3476	0.112		5.4695	0.1006	106.7982	2.0632	0.7379	2.0286
256.6280	0.302		11.2622	0.1009	121.5886	2.1106	1.0516	2.0849
314.5549	0.570		19.4329	0.1015	145.3803	2.1637	1.2885	2.1625
383.1524	1.380		44.1280	0.1008	168.1669	2.2784	1.6447	2.2257
444.1280	1.210	2	75.8354	0.1013	181.7832	2.4432	1.8799	2.2596
550.8354	1.520	2	94.7378	0.1023	222.9216	2.4710	1.9765	2.3482

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Dimana x/m = jumlah metanil kuning yang diadsorpsi (mg/g)

C_o = konsentrasi metanil kuning sebelum adsorpsi (mg/L)

C_e = konesntrasi metanil kuning setelah adsorpsi (mg/L)

V = volume larutan metanil kuning (L)

W = jumlah adsorben (gram)

Contoh perhitungan jumlah CR yang diadsorpsi (x/m) pada konsentrasi 550.8354 dan volume 0.05 L.

$$\frac{x}{m} = \frac{(550.8354 - 94.7378)\frac{mg}{L}}{0.1023\ g} \times 0.05\ L$$

$$= 222.9216\ mg/g$$

5. Persamaan isoterm adsorpsi Langmuir

$$\frac{C_e}{q_e} = \frac{1}{Q_o b} + \frac{C_e}{Q_o}$$

Dimana: C_e = konsentrasi kesetimbangan larutan (mg/L)

q_e = jumlah zat yang diadsorpsi per gram adsorben (mg/g)

Q_o = kapasitas adsorpsi (mg/g)

b = intensitas adsorpsi (L/mg)

Contoh Perhitungan nilai Q_o dan b

Berdasarkan model isoterm Langmuir diperoleh persamaan garis :

y = 0.0048x + 2.0474

Dari persamaan garis tersebut, nilai *slope* = 0.0048 dan *intercept* 2.0474

$$slope = \frac{1}{Q_o}$$

$$Q_o = \frac{1}{slope}$$

$$= \frac{1}{0{,}0048}$$

= 208.3333 mg/g

$$intercept = \frac{1}{Q_o b}$$

$$b = \frac{1}{Q_o \times intercept}$$

$$= \frac{1}{208.3333 \times 2.0474}$$

= 0,0023 L/mg

6. Persamaan isoterm adsorpsi Freundlich:

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log C_e$$

Dimana: x = jumlah zat terlarut yang diserap (mg)

m = gram adsorben yang digunakan (g)

C_e = konsentrasi keseimbangan larutan (mg/L)

k = kapasitas adsorpsi (mg/g)

n = intensitas adsorpsi (L/g)

Contoh Perhitungan nilai k dan n

Berdasarkan model isoterm Freundlich diperoleh persamaan garis :

y = 0.2513x + 1.8222

Dari persamaan garis tersebut, nilai *slope* = 0.2513 dan *intercept* =1.8222

log k = *intercept*

k = *invers* log *intercept*

= *invers* $\log^{-1}$ (1.8222)

= 66.4048 mg/g

$$slope = \frac{1}{n}$$

$$n = \frac{1}{slope}$$

$$= \frac{1}{0,2513}$$

=3.9793 g/L

Lampiran 26. Penentuan Kapasitas Adsorpsi CR oleh MCM-48 C2

C_o (mg/L)	Abs	FP	C_e (mg/L)	Wa (g)	x/m (mg/g)	C_e/q_e	Log C_e	Log q_e
178.2744	0.090	-	4.7988	0.1004	86.3922	2.0635	0.6811	1.9365
194.1280	0.109	-	5.3780	0.1017	92.7974	2.0920	0.7306	1.9675
220.3476	0.280	-	10.5915	0.1008	104.0457	2.1178	1.0250	2.0172
256.6280	0.357	-	12.9390	0.1011	120.5188	2.1294	1.1119	2.0811
314.5549	0.835	-	27.5122	0.1008	142.3823	2.2092	1.4395	2.1535
383.1524	1.255	2	78.5793	0.1000	152.2866	2.5160	1.8953	2.1827
444.1280	1.600	2	99.6159	0.1024	168.2188	2.6402	1.9983	2.2259
550.8354	1.170	5	180.4085	0.1008	183.7435	2.9979	2.2563	2.2642

$$\frac{x}{m} = \frac{C_o - C_e}{W} V$$

Dimana x/m = jumlah metanil kuning yang diadsorpsi (mg/g)

C_o = konsentrasi metanil kuning sebelum adsorpsi (mg/L)

C_e = konesntrasi metanil kuning setelah adsorpsi (mg/L)

V = volume larutan metanil kuning (L)

W = jumlah adsorben (gram)

Contoh perhitungan jumlah CR yang diadsorpsi (x/m) pada konsentrasi 550.8354 dan volume 0.05 L.

$$\frac{x}{m} = \frac{(550.8354\text{-}180.4085)\frac{mg}{L}}{0.1008\ g} \times 0.05\ L$$

$$= 183.7435\ mg/g$$

7. Persamaan isoterm adsorpsi Langmuir

$$\frac{C_e}{q_e} = \frac{1}{Q_o b} + \frac{C_e}{Q_o}$$

Dimana: C_e = konsentrasi kesetimbangan larutan (mg/L)

q_e = jumlah zat yang diadsorpsi per gram adsorben (mg/g)

Q_o = kapasitas adsorpsi (mg/g)

b = intensitas adsorpsi (L/mg)

Contoh Perhitungan nilai Q_o dan b

Berdasarkan model isoterm Langmuir diperoleh persamaan garis :

y = 0.0054x + 2.0641

Dari persamaan garis tersebut, nilai *slope* = 0.0054 dan *intercept*=2.0641

$$slope = \frac{1}{Q_o}$$

$$Q_o = \frac{1}{slope}$$

$$= \frac{1}{0,0054}$$

= 185.1851 mg/g

$$intercept = \frac{1}{Q_o b}$$

$$b = \frac{1}{Q_o \times intercept}$$

$$= \frac{1}{185.1851 \times 2.0641}$$

= 0,0026 L/mg

8. Persamaan isoterm adsorpsi Freundlich:

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log C_e$$

Dimana: x = jumlah zat terlarut yang diserap (mg)

m = gram adsorben yang digunakan (g)

C_e = konsentrasi keseimbangan larutan (mg/L)

k = kapasitas adsorpsi (mg/g)

n = intensitas adsorpsi (L/g)

Contoh Perhitungan nilai k dan n

Berdasarkan model isoterm Freundlich diperoleh persamaan garis :

y = 0.1987x + 1.8269

Dari persamaan garis tersebut, nilai *slope* = 0.1987 dan *intercept* =1.8269

log k = *intercept*

k = *invers* log *intercept*

= *invers* $\log^{-1}$ (1.8269)

= 67.1274 mg/g

$$slope = \frac{1}{n}$$

$$n = \frac{1}{slope}$$

$$= \frac{1}{0,1987}$$

=5.0327 g/L

Lampiran 27. Persen Efektivitas Adsorpsi Limbah Zat Warna MG dan CR

1. Persen Adsorpsi Limbah MG dan CR oleh MCM-48

Data limbah zat warna MG dan CR yang diukur pada Panjang gelombang zat warna MG yaitu 617 nm dan pada waktu optimum MG.

Sampel	Abs.	a	b	Co (mg/L)	Ce (mg/L)	% Efektivitas
TC	0.022	0.1029	0.0485	36.565	0.6851	98.1262
C1	0.566	0.1029	0.0485	36.565	5.9718	83.6678
C2	1.38	0.1029	0.0485	36.565	13.8824	62.0332

$$q\ \% = \frac{C_{awal} - C_{akhir}}{C_{awal}} \times 100$$

- Contoh perhitungan % kapasitas adsorpsi limbah zat warna MG dan CR yang diadsorpsi dengan perbandingan 1:1 untuk sampel MCM-48 TC.

$$q\ \% = \frac{36.565 - 0.6851}{36.565} \times 100$$

$$= 98.1262$$

2. Persen Adsorpsi Limbah MG dan CR oleh MCM-48

Data limbah zat warna MG dan CR yang diukur pada Panjang gelombang zat warna CR yaitu 496 nm dan pada waktu optimum CR.

Sampel	Abs.	a	b	Co (mg/L)	Ce (mg/L)	% Efektivitas
TC	0.016	0.0328	0.0674	157.378	2.5427	98.3843
C1	0.068	0.0328	0.0674	157.378	4.1280	97.3770
C2	0.106	0.0328	0.0674	157.378	5.2866	96.6408

$$q\ \% = \frac{C_{awal} - C_{akhir}}{C_{awal}} \times 100$$

- Contoh perhitungan % kapasitas adsorpsi limbah zat warna MG dan CR yang diadsorpsi dengan perbandingan 1:1 untuk sampel MCM-48 TC.

$$q\ \% = \frac{157.378 - 2.5427}{157.378} \times 100$$

$$= 98.3843$$

LAMPIRAN 28. Desorpsi

1. Data persen desorpsi zat warna MG

Data desorpsi diperoleh setelah dilakukan adsorpsi pada zat warna MG. Proses adsorpsi dilakukan dengan menggunakan konsentrasi awal 171.511 mg/L dan konsetrasi akhir sebesar 1.326 mg/L dengan berat sampel 1.5202 gram. Jumlah yang diadsorpsi sebesar **22.389 mg/g**. Dalam proses desorpsi digunakan akuades sebagai agen pendesorpsi dengan suhu divariasikan.

Suhu	X (gram) akhir	X(gram) awal	q_e adsorpsi
70	0.1521	1.5202	2.24016
60	0.154	1.5202	2.26814
50	0.1526	1.5202	2.24752
40	0.1559	1.5202	2.29612
30	0.156	1.5202	2.29760

$$q_{eakhir}\,(mg/g) = \frac{X_{akhir}\,(g)}{X_{awal}\,(g)} \times \text{jumlah MG yang diadsorpsi (mg/g)}$$

- Contoh perhitungan jumlah zat warna MG yang diadsorpsi (q_e) pada 0.1521 g sampel.

$$q_{e\ akhir}\,(mg/g) = \frac{0.1521\ g}{1.5202\ g} \times 22.389\ mg/g$$

$$= 2.24016\ mg/g$$

Suhu	Stlah Desorbsi		q_e Desorb	Rasio Desorbsi (%)
	Abs.	**Kons.**		
70	0.168	2.1040	0.6916	30.8749
60	0.094	1.3848	0.4496	19.8234
50	0.088	1.3265	0.4346	19.3388
40	0.081	1.2585	0.4036	17.5786
30	0.071	1.1613	0.3722	16.2004

$$q_{e,desorp}(mg/g) = V\left(\frac{C_f}{M}\right)$$

- Contoh perhitungan jumlah zat warna MG yang didesorpsi (q_e) pada konsentrasi 2.1040 mg/L, volume 0.05 L dan pada 0.1521 g sampel.

$$q_e = \frac{(2.1040)\frac{mg}{L}}{0,1521\ g} \times 0,05\ L$$

$$= 0.6916\ mg/g.$$

$$\%\ \text{Rasio desorpsi} = \frac{\text{jumlah zat warna yang didesorpsi}}{\text{jumlah zat warna yang teradsorpsi}} \times 100$$

- Contoh menghitung rasio desorpsi pada suhu 70 ^{O}C

$$\%\ \text{Rasio desorpsi} = \frac{0.6916\ mg/g}{2.24016\ mg/g} \times 100$$

$$= 30,8749$$

2. Data persen desorpsi zat warna CR

Data desorpsi diperoleh setelah dilakukan adsorpsi pada zat warna CR. Proses adsorpsi dilakukan dengan menggunakan konsentrasi awal 931.932 mg/L dan konsetrasi akhir sebesar 5.256 mg/L dengan berat sampel 2.0003 gram. Jumlah yang diadsorpsi sebesar **185.307 mg/g**. Dalam proses desorpsi digunakan akuades sebagai agen pendesorpsi dengan suhu divariasikan.

Suhu	X (gram) akhir	X(gram) awal	qe Adsorpsi
70	0.1505	2.0003	13.9423
60	0.1512	2.0003	14.0072
50	0.1511	2.0003	13.9979
40	0.152	2.0003	14.0813
30	0.1568	2.0003	14.5259

$$q_{e\ akhir}\ (mg/g) = \frac{X_{akhir}\ (g)}{X_{awal}\ (g)} \times \text{ jumlah MG yang diadsorpsi (mg/g)}$$

- Contoh perhitungan jumlah zat warna MG yang diadsorpsi (q_e) pada 0.1505 g sampel.

$$q_{e\ akhir}\ (mg/g) = \frac{0.1505\ g}{2.0003\ g} \times 185.307\ mg/g$$

$$= 13.9423\ mg/g$$

Suhu	Stlah Desorbsi		q_e Desorb	Rasio Desorb (%)
	Abs.	Kons.		
70	0.16	6.9329	2.3033	16.52
60	0.108	5.3476	1.7684	12.62
50	0.095	4.9512	1.6384	11.70
40	0.079	4.4634	1.4682	10.43
30	0.053	3.6707	1.1705	8.06

$$q_{e,\,desorp}(mg/g) = V\left(\frac{C_f}{M}\right)$$

- Contoh perhitungan jumlah zat warna MG yang didesorpsi (q_e) pada konsentrasi 13.9423 mg/L, volume 0.05 L dan pada 0.1505 g sampel.

$$q_e = \frac{(13.9423)\frac{mg}{L}}{0{,}1505\ g} \times 0{,}05\ L$$

$$= 2.3033\ mg/g.$$

$$\%\ \text{Rasio desorpsi} = \frac{\text{jumlah zat warna yang didesorpsi}}{\text{jumlah zat warna yang teradsorpsi}} \times 100$$

- Contoh menghitung rasio desorpsi pada suhu 70 ^{O}C

$$\%\ \text{Rasio desorpsi} = \frac{2.3033\ mg/g}{13.9423\ mg/g} \times 100$$

$$= 16.52$$