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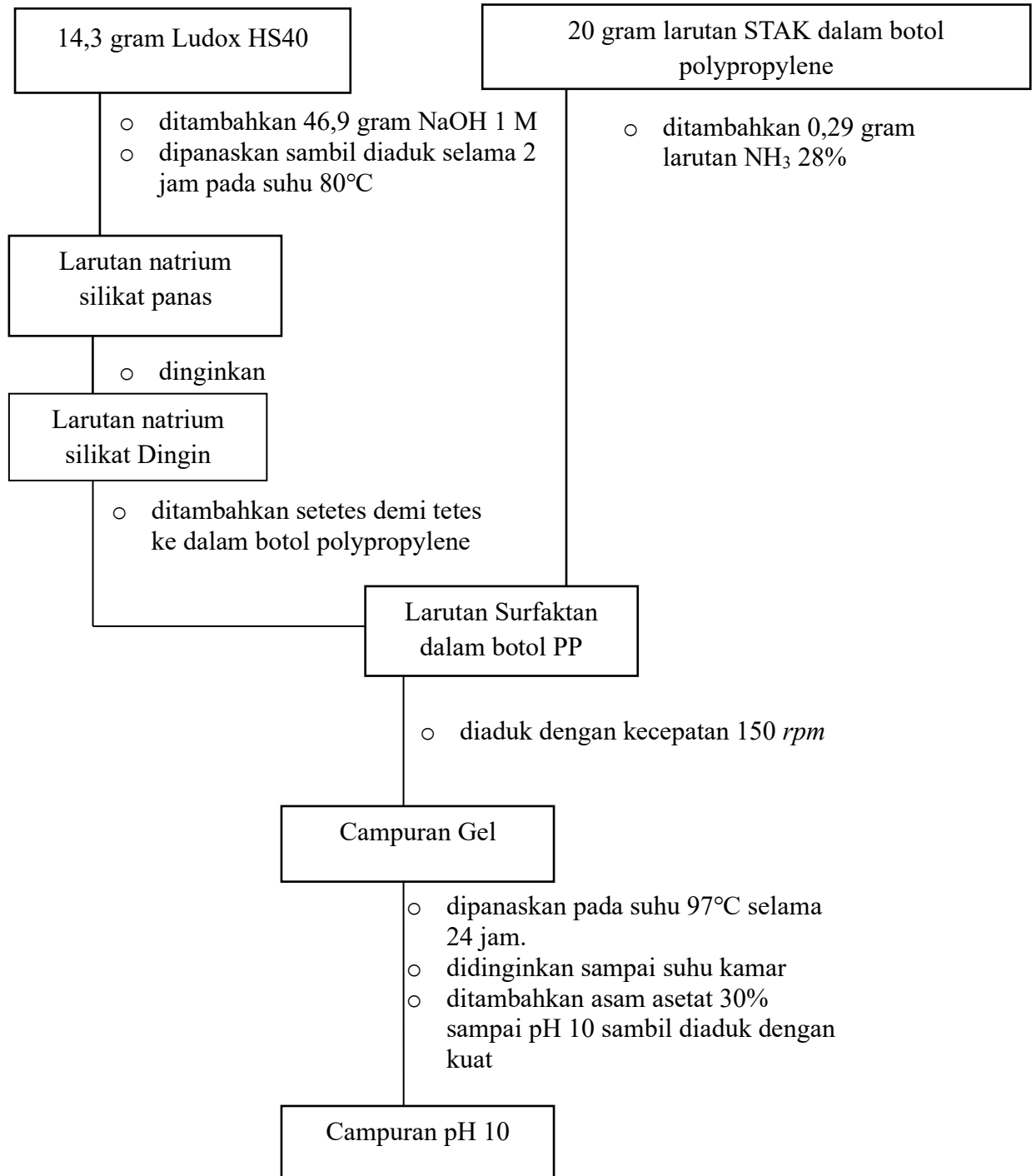
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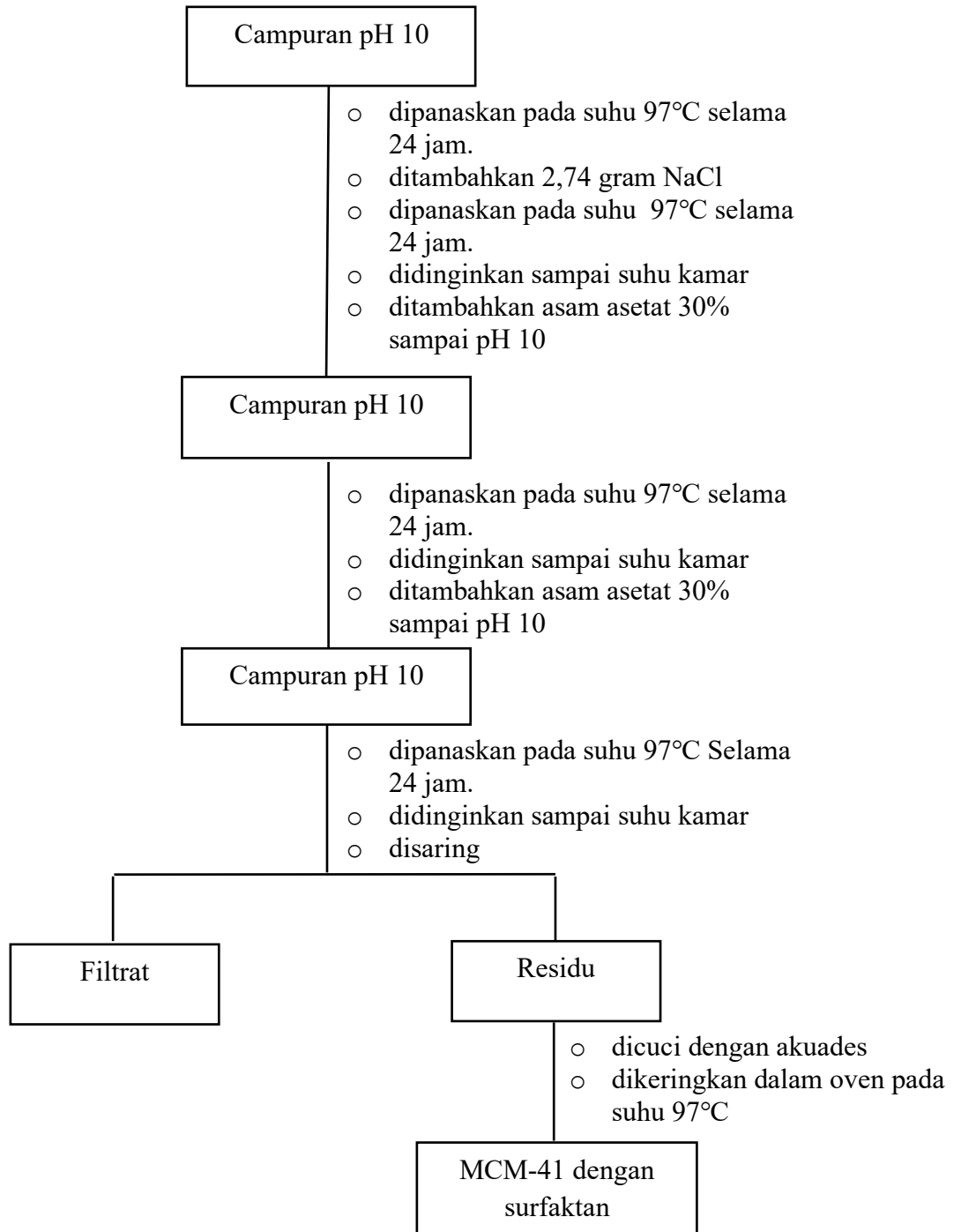
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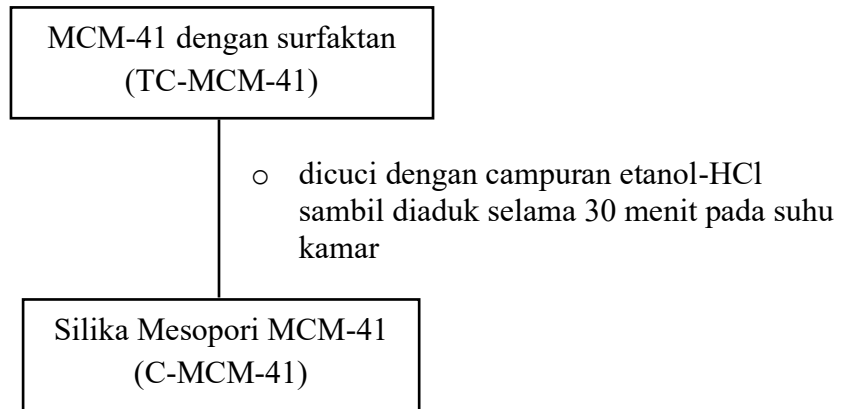
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Lampiran 1. Diagram Alir Penelitian

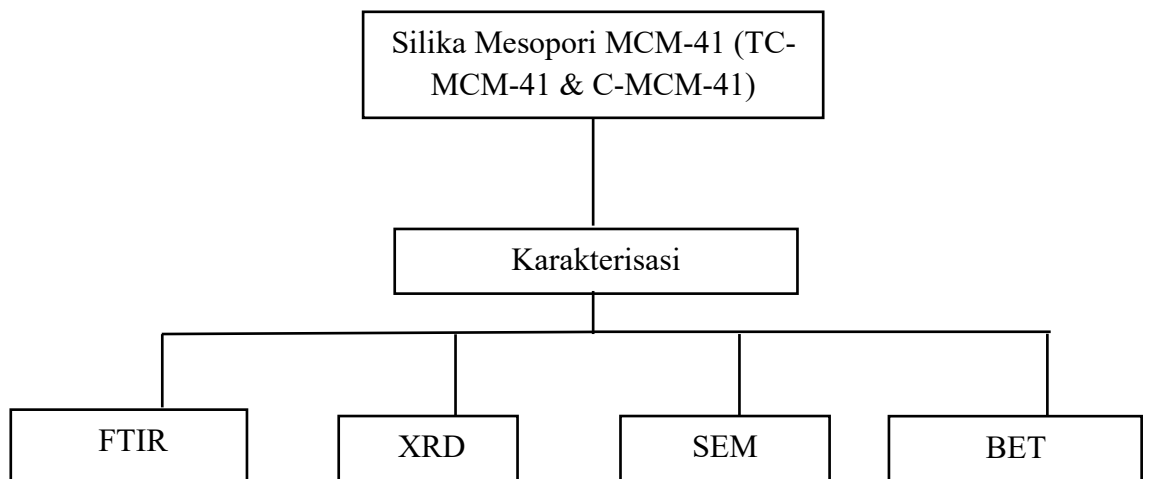
1. Sintesis Silika Mesopori MCM-41



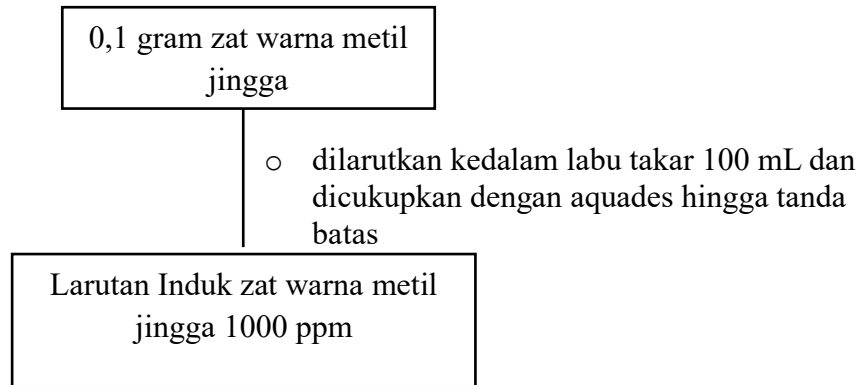




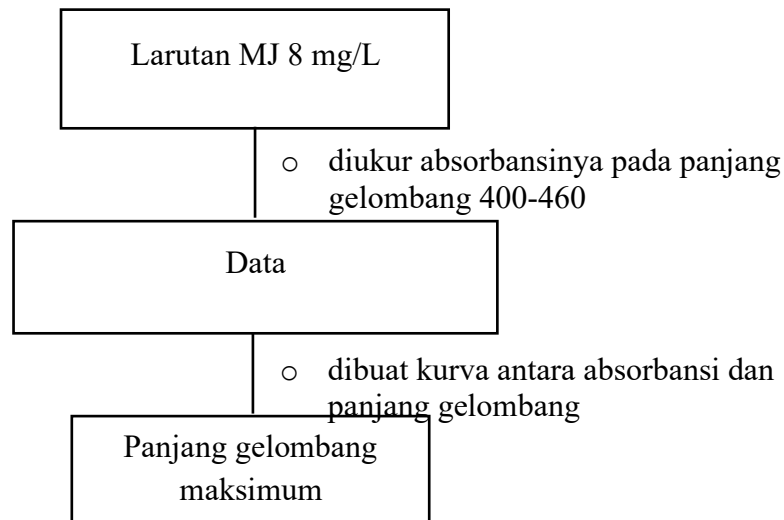
2. Karakterisasi Silika Mesopori MCM-41



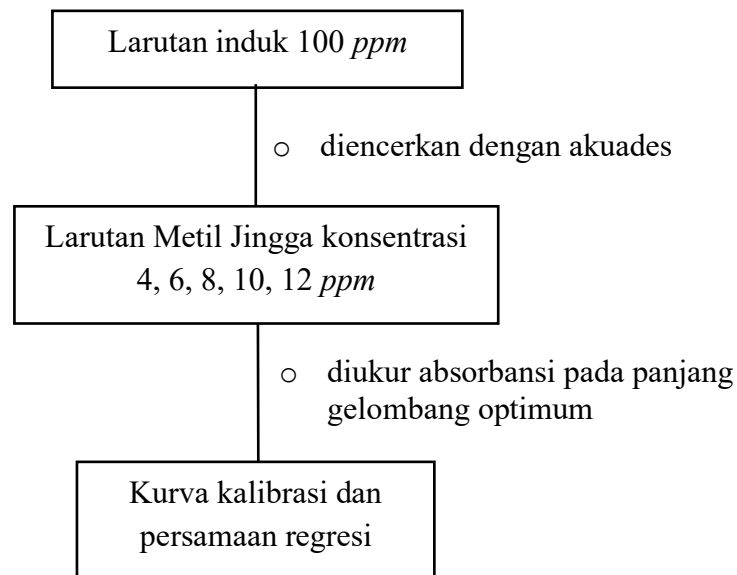
3. Pembuatan Larutan Induk Metil Jingga



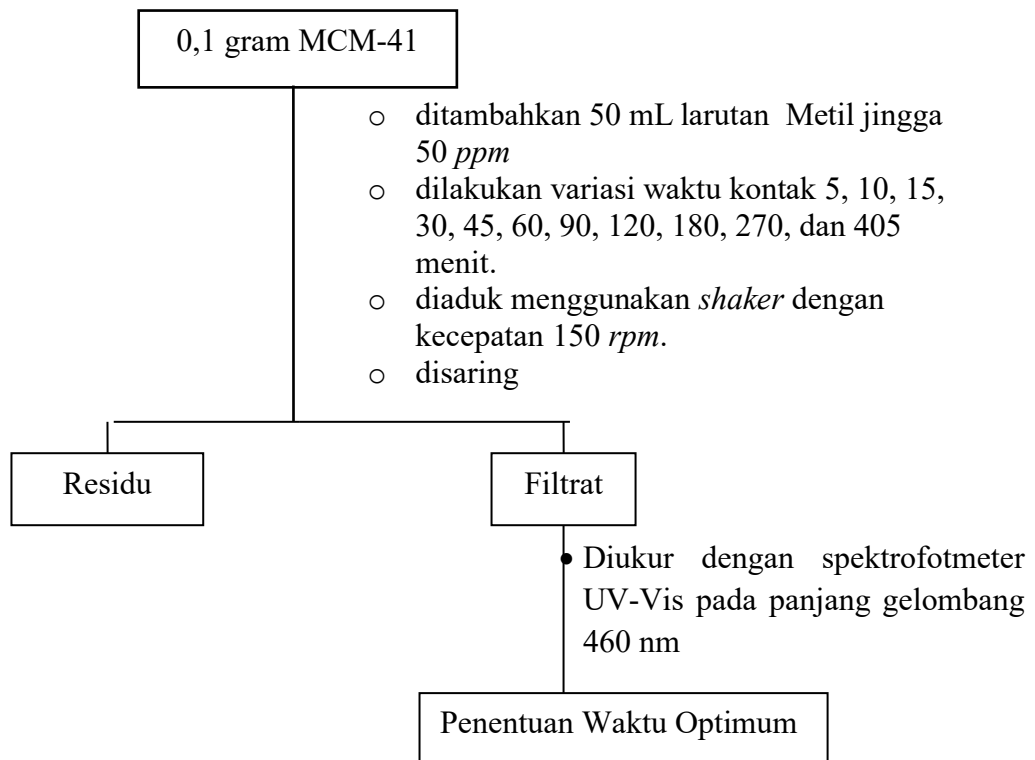
4. Penentuan Panjang Gelombang Maksimum



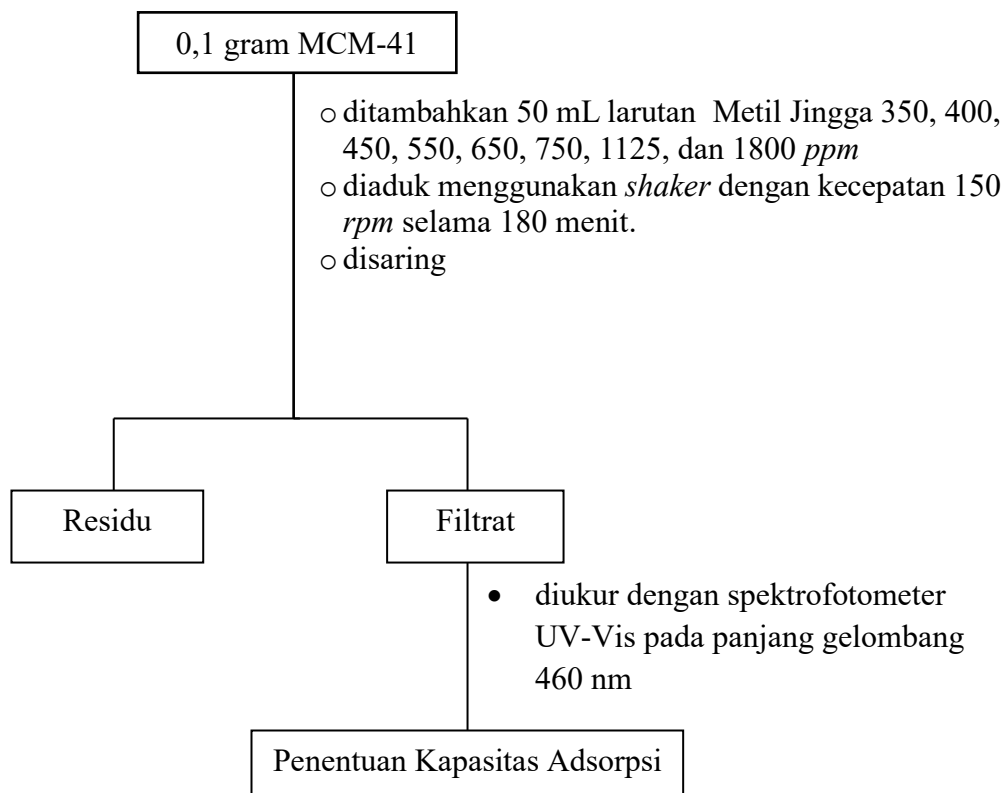
5. Pembuatan Kurva Kalibrasi Larutan Standar Zat Warna Metil jingga



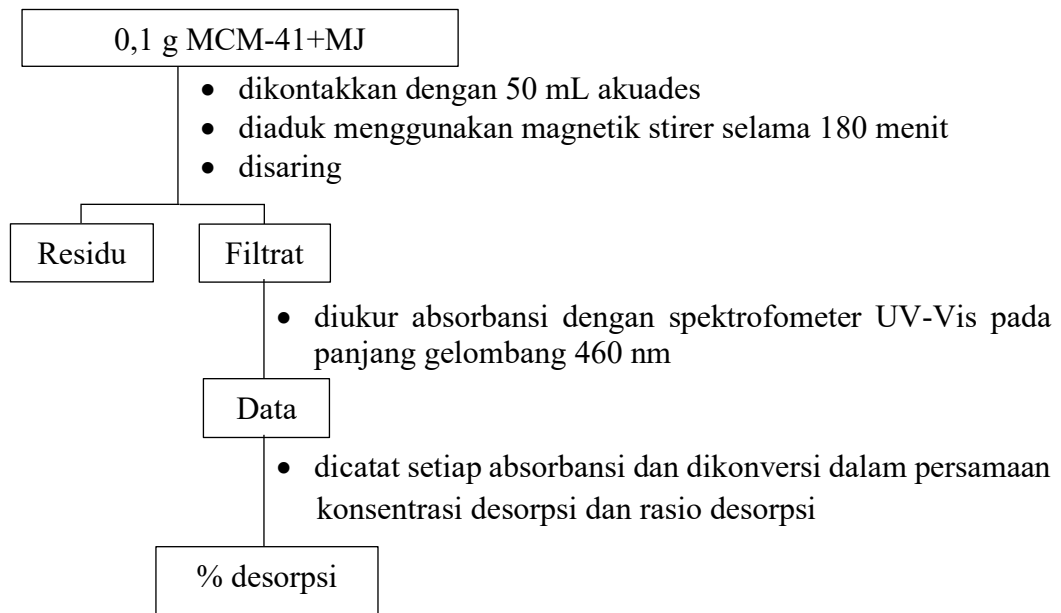
6. Penentuan Waktu Kontak Optimum



7. Penentuan Kapasitas Adsorpsi



8. Desorpsi Zat Warna MJ



Lampiran 2. Dokumentasi Penelitian

Sintesis silika mesopori MCM-41



Pembuatan natrium silika



Pemanasan pada suhu 80°C



Pencampuran larutan natrium silika dan surfaktan



Pemanasan pada suhu 97°C



Pengaturan pH 10



Penyaringan dengan akuades



MCM-41-TC

Penghilangan surfaktan dengan pencucian HCl-etanol satu kali



Pengadukan selama 30 menit



Penyaringan dengan akuades



MCM-41-C

Proses adsorpsi



Waktu kontak MCM-41-TC-MJ



Waktu kontak MCM-41-C-MJ



Variasi konsentrasi MCM-41-TC-MJ



Variasi konsentrasi MCM-41-C-MJ

Proses Desorpsi



Desorpsi zat warna MJ

Lampiran 3. Karakterisasi XRD

Match! Phase Analysis Report

Sample: MCM-41-TC (2-80)

Sample Data

File name MCM-41-TC.RAW
File path D:/xrd/MCM-41-TC
Data collected Nov 9, 2022 14:29:12
Data range 2.000° - 80.000°
Original data range 2.000° - 80.000°
Number of points 7801
Step size 0.010
Rietveld refinement converged No
Alpha2 subtracted No
Background subtr. No
Data smoothed Yes
Radiation X-rays
Wavelength 1.540600 Å

Peak List

No.	2theta [°]	d [Å]	I/I0 (peak height)	Counts (peak area)	FWHM
1	2.38	37.0909	1000.00	45.06	0.1597
2	3.82	23.1116	33.19	2.34	0.2499
3	4.41	20.0208	166.86	3.77	0.0800
4	4.93	17.9102	2.22	0.10	0.1600
5	22.12	4.0154	338.67	15.29	0.1600
6	33.77	2.6521	16.66	0.52	0.1097
7	64.51	1.4434	54.38	2.76	0.1800
8	77.65	1.2287	64.66	4.03	0.2210
9	77.89	1.2255	27.14	2.75	0.2210

Integrated Profile Areas

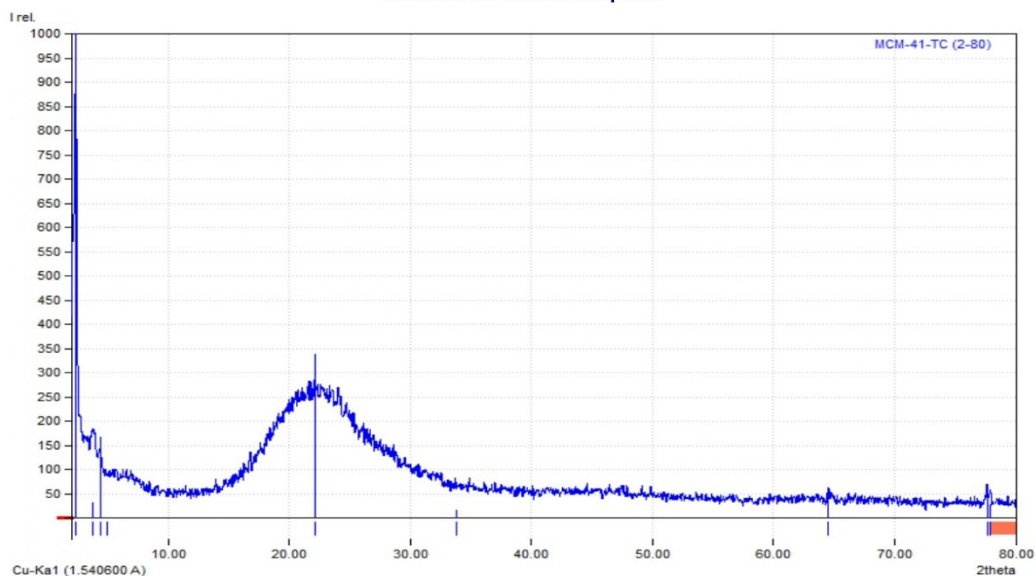
Based on calculated profile

Profile area	Counts	Amount
Overall diffraction profile	229463	100.00%
Background radiation	157838	68.79%
Diffraction peaks	71625	31.21%
Peak area belonging to selected phases	0	0.00%
Unidentified peak area	71625	31.21%

Peak Residuals

Peak data	Counts	Amount
Overall peak intensity	77	100.00%
Peak intensity belonging to selected phases	57	74.87%
Unidentified peak intensity	19	25.13%

Diffraction Pattern Graphics



Match! Phase Analysis Report

Sample: MCM-41-C1 (2-80)

Sample Data

File name	MCM-41-C1.RAW
File path	D:\xrd\MCM-41-C1
Data collected	Nov 9, 2022 14:29:12
Data range	2.000° - 80.000°
Original data range	2.000° - 80.000°
Number of points	7801
Step size	0.010
Rietveld refinement converged	No
Alpha2 subtracted	No
Background subtr.	No
Data smoothed	Yes
Radiation	X-rays
Wavelength	1.540600 Å

Peak List

No.	2theta [°]	d [Å]	I/I0 (peak height)	Counts (peak area)	FWHM
1	6.57	13.4427	28.71	7.62	1.6400
2	21.88	4.0589	1000.00	271.69	2.2600
3	64.69	1.4398	44.29	10.49	1.9699
4	77.72	1.2277	31.62	11.90	3.1300
5	79.39	1.2060	33.18	12.49	3.1300
6	79.39	1.2060	0.13	0.10	6.2600

Integrated Profile Areas

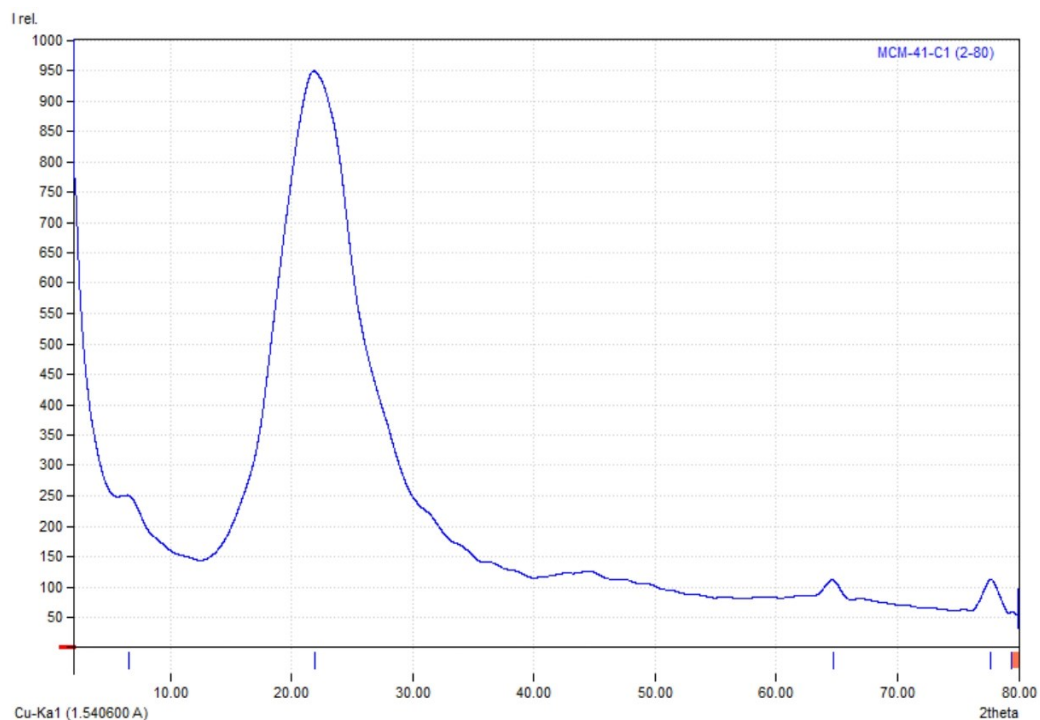
Based on calculated profile

Profile area	Counts	Amount
Overall diffraction profile	207876	100.00%
Background radiation	133690	64.31%
Diffraction peaks	74186	35.69%
Peak area belonging to selected phases	0	0.00%
Unidentified peak area	74186	35.69%

Peak Residuals

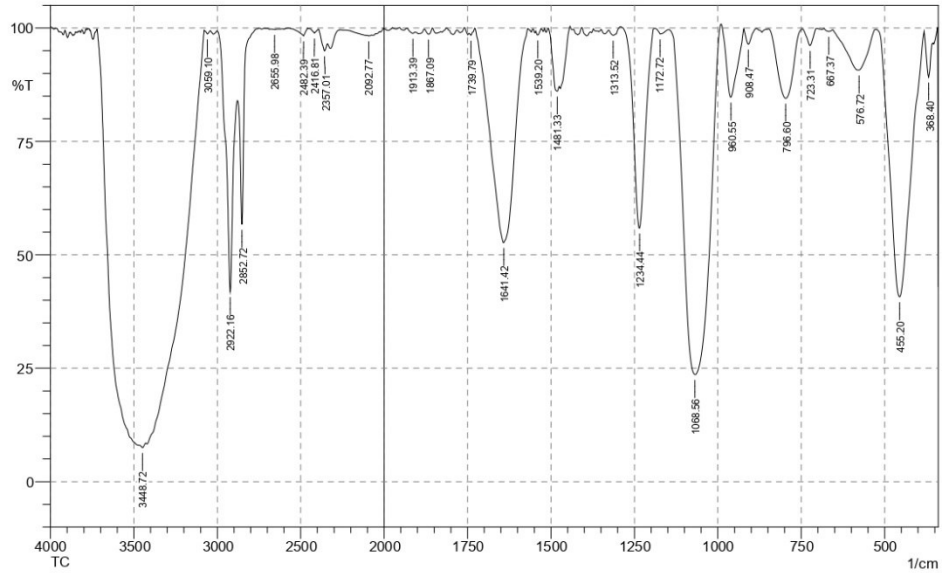
Peak data	Counts	Amount
Overall peak intensity	314	100.00%
Peak intensity belonging to selected phases	0	0.00%
Unidentified peak intensity	314	100.00%

Diffraction Pattern Graphics



Lampiran 4. Data karakteristik FTIR

MCM-41-TC

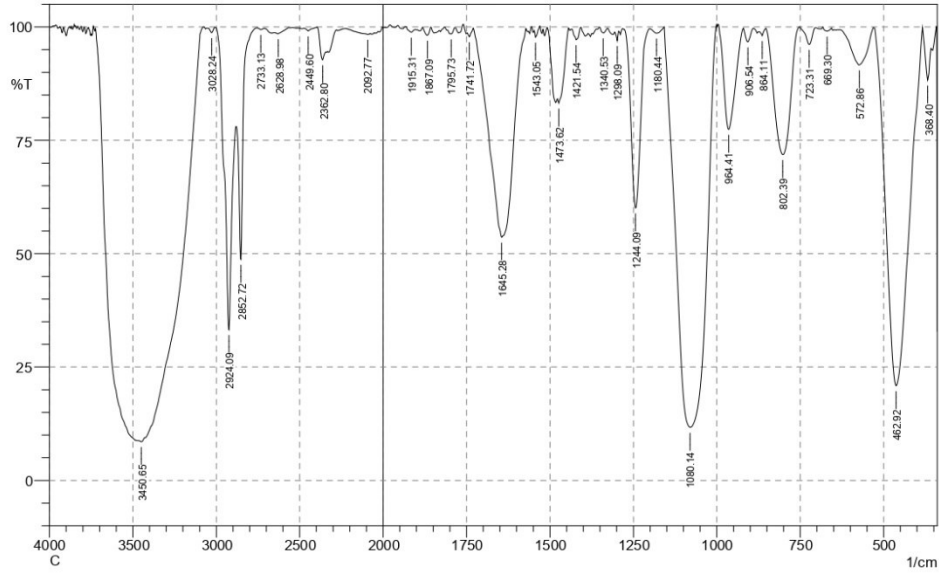


No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	368.4	89.187	8.818	381.91	354.9	0.772	0.534
2	455.2	40.727	58.359	526.57	383.83	23.688	23.112
3	576.72	90.738	8.887	653.87	528.5	2.95	2.736
4	667.37	99.236	0.491	682.8	655.8	0.065	0.035
5	723.31	96.16	3.712	746.45	704.02	0.359	0.334
6	796.6	84.512	15.271	848.68	748.38	3.697	3.603
7	908.47	96.433	3.423	921.97	885.33	0.287	0.265
8	960.55	84.776	15.639	989.48	921.97	2.488	2.583
9	1068.56	23.587	76.669	1145.72	991.41	45.543	45.719
10	1172.72	98.702	1.143	1188.15	1147.65	0.131	0.098
11	1234.44	55.904	44.21	1290.38	1188.15	9.024	9.081
12	1313.52	98.406	1.429	1327.03	1290.38	0.14	0.129
13	1481.33	86.078	3.298	1508.33	1475.54	1.309	0.325
14	1539.2	98.465	1.045	1544.98	1529.55	0.072	0.044
15	1641.42	52.699	47.091	1726.29	1570.06	19.906	19.76
16	1739.79	98.409	0.804	1745.58	1728.22	0.076	0.031
17	1867.09	98.628	1.284	1880.6	1855.52	0.091	0.08
18	1913.39	98.828	0.486	1930.74	1907.6	0.081	0.032
19	2092.77	98.289	0.127	2102.41	2075.41	0.196	0.01
20	2357.01	94.985	2.576	2393.66	2339.65	0.757	0.312
21	2416.81	98.9	0.9	2443.81	2393.66	0.136	0.094
22	2482.39	98.28	1.675	2573.04	2459.24	0.338	0.322
23	2655.98	99.7	0.01	2677.2	2654.05	0.026	0.001
24	2852.72	56.723	30.405	2877.79	2750.49	6.617	3.343
25	2922.16	41.862	47.507	3001.24	2879.72	16.455	11.65
26	3059.1	98.684	0.745	3078.39	3041.74	0.143	0.053
27	3448.72	7.501	0.776	3469.94	3429.43	44.625	0.786

Comment;
TC

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No. of Scans;
Resolution;
Apodization;

MCM-41-C



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	368.4	88.276	8.749	383.83	358.76	0.808	0.536
2	462.92	20.9	78.324	528.5	385.76	40.943	40.42
3	572.86	91.651	7.998	628.79	530.42	2.053	1.891
4	669.3	99.075	0.781	682.8	655.8	0.076	0.059
5	723.31	96.135	3.782	752.24	704.02	0.371	0.358
6	802.39	71.851	27.951	852.54	754.17	7.332	7.247
7	864.11	98.067	1.226	873.75	852.54	0.103	0.041
8	906.54	96.705	3.018	920.05	891.11	0.239	0.205
9	964.41	77.406	22.724	995.27	921.97	4.041	4.052
10	1080.14	11.722	88.201	1157.29	1002.98	72.157	72.105
11	1180.44	98.647	1.151	1201.65	1157.29	0.166	0.128
12	1244.09	60.083	39.547	1280.73	1201.65	6.53	6.403
13	1298.09	97.02	1.992	1305.81	1294.24	0.097	0.045
14	1340.53	98.71	1.111	1350.17	1327.03	0.088	0.068
15	1421.54	97.197	2.508	1435.04	1406.11	0.201	0.165
16	1473.62	83.225	2.741	1477.47	1444.68	1.568	0.394
17	1543.05	97.767	1.661	1546.91	1529.55	0.085	0.062
18	1645.28	53.624	45.917	1728.22	1571.99	19.68	19.365
19	1741.72	97.863	1.178	1747.51	1730.15	0.108	0.048
20	1795.73	98.456	1.415	1816.94	1786.08	0.121	0.107
21	1867.09	98.189	1.772	1882.52	1857.45	0.121	0.116
22	1915.31	98.837	0.875	1932.67	1903.74	0.09	0.062
23	2092.77	98.378	0.145	2104.34	2077.33	0.185	0.011
24	2362.8	92.762	3.673	2393.66	2345.44	1.035	0.411
25	2449.6	99.13	0.659	2472.74	2395.59	0.143	0.087
26	2628.98	98.481	0.582	2654.05	2565.33	0.376	0.103
27	2733.13	99.438	0.294	2754.35	2715.77	0.07	0.026
28	2852.72	48.75	34.045	2879.72	2756.28	9.165	4.36
29	2924.09	33.242	52.24	3007.02	2881.65	21.559	14.816
30	3028.24	98.745	1.092	3049.46	3007.02	0.121	0.091
31	3450.65	8.529	0.526	3466.08	3429.43	38.638	0.52

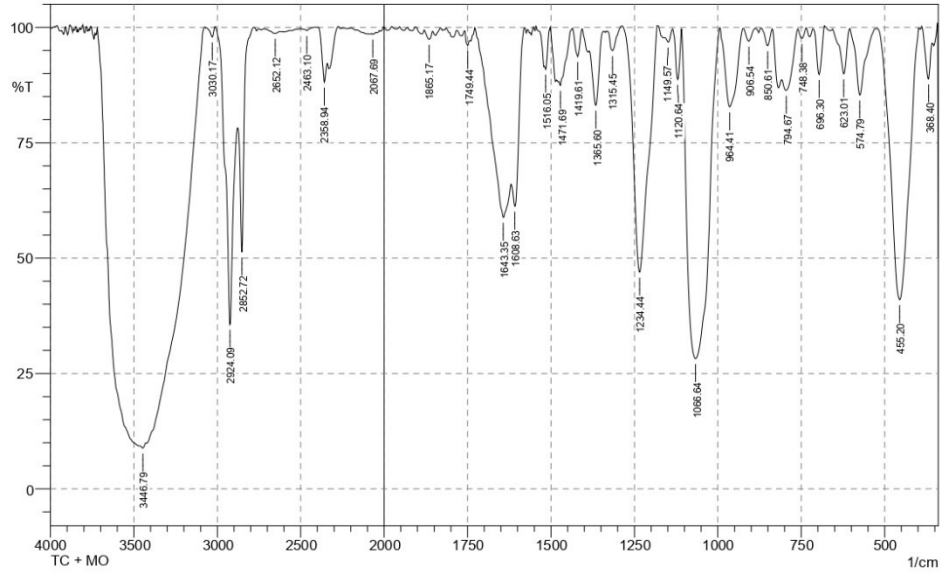
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No. of Scans;

Resolution;

Apodization;

MCM-41-TC-MJ



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	368.4	88.791	8.919	389.62	358.76	0.841	0.622
2	455.2	40.994	58.77	522.71	399.26	20.627	20.499
3	574.79	85.328	14.383	603.72	524.64	2.13	2.032
4	623.01	89.936	9.713	655.8	605.65	1.057	0.979
5	696.3	89.767	10.273	715.59	680.87	0.767	0.768
6	748.38	97.615	2.169	759.95	734.88	0.158	0.135
7	794.67	86.339	5.523	808.17	761.88	2.007	0.804
8	850.61	96.043	3.724	869.9	837.11	0.295	0.264
9	906.54	97.019	2.741	923.9	887.26	0.245	0.206
10	964.41	82.763	17.093	993.34	923.9	3.085	3.037
11	1066.64	28.237	70.325	1107.14	995.27	33.98	33.426
12	1120.64	88.739	10.976	1136.07	1109.07	0.719	0.685
13	1149.57	96.823	1.742	1159.22	1136.07	0.223	0.094
14	1234.44	46.946	53.373	1286.52	1182.36	14.344	14.489
15	1315.45	94.972	4.577	1330.88	1286.52	0.452	0.398
16	1365.6	83.099	13.727	1384.89	1342.46	1.804	1.262
17	1419.61	93.69	6.026	1435.04	1406.11	0.442	0.406
18	1471.69	87.432	1.924	1475.54	1436.97	1.178	0.178
19	1516.05	90.932	2.512	1519.91	1502.55	0.397	0.065
20	1608.63	61.245	13.521	1618.28	1581.63	4.461	1.35
21	1643.35	58.839	14.469	1726.29	1620.21	13.386	3.563
22	1749.44	96.025	2.067	1759.08	1741.72	0.223	0.087
23	1865.17	97.428	1.813	1880.6	1855.52	0.196	0.116
24	2067.69	98.543	0.192	2075.41	2050.33	0.148	0.015
25	2358.94	88.133	6.679	2393.66	2341.58	1.574	0.641
26	2463.1	99.313	0.57	2503.6	2412.95	0.119	0.08
27	2652.12	98.69	0.574	2717.7	2627.05	0.351	0.114
28	2852.72	51.311	32.559	2877.79	2781.35	8.116	3.989
29	2924.09	35.669	49.796	3012.81	2879.72	20.965	13.875
30	3030.17	97.944	2.121	3064.89	3012.81	0.204	0.209
31	3446.79	8.831	0.771	3462.22	3429.43	33.941	0.62

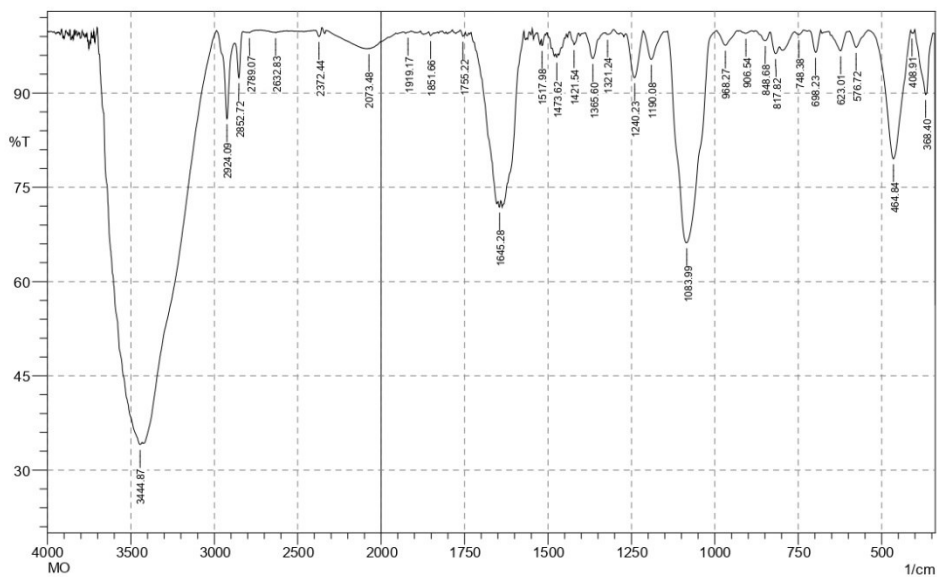
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No. of Scans;

Resolution;

Apodization;

MCM-41-C-MJ



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	368.4	89.733	9.994	401.19	347.19	1.261	1.21
2	408.91	99.547	0.163	412.77	406.98	0.008	0.003
3	464.84	79.52	20.458	538.14	412.77	5.153	5.14
4	576.72	97.254	2.651	596	540.07	0.319	0.303
5	623.01	96.706	2.831	650.01	603.72	0.388	0.284
6	698.23	96.473	3.502	717.52	682.8	0.267	0.263
7	748.38	99.287	0.559	759.95	732.95	0.051	0.035
8	817.82	96.264	2.049	835.18	806.25	0.326	0.141
9	848.68	98.334	1.446	877.61	835.18	0.177	0.143
10	906.54	99.502	0.41	925.83	889.18	0.047	0.033
11	968.27	97.601	2.331	995.27	933.55	0.337	0.318
12	1083.99	66.166	33.711	1141.86	995.27	12.646	12.577
13	1190.08	95.347	4.492	1215.15	1151.5	0.625	0.576
14	1240.23	92.441	7.234	1267.23	1215.15	0.963	0.887
15	1321.24	99.339	0.397	1327.03	1303.88	0.045	0.031
16	1365.6	95.475	4.117	1388.75	1330.88	0.529	0.425
17	1421.54	97.716	1.938	1435.04	1408.04	0.161	0.12
18	1473.62	95.693	0.533	1477.47	1469.76	0.138	0.009
19	1517.98	97.556	1.063	1519.91	1508.33	0.081	0.026
20	1645.28	71.841	0.931	1649.14	1641.42	1.091	0.026
21	1755.22	99.027	0.823	1762.94	1747.51	0.039	0.029
22	1851.66	99.137	0.545	1857.45	1842.02	0.042	0.019
23	1919.17	99.658	0.036	1921.1	1909.53	0.013	0.001
24	2073.48	97.069	0.058	2077.33	2029.11	0.584	0.019
25	2372.44	98.979	1.232	2391.73	2355.08	0.075	0.106
26	2632.83	99.618	0.07	2640.55	2615.47	0.036	0.003
27	2789.07	99.597	0.135	2800.64	2748.56	0.043	0.004
28	2852.72	92.434	6.418	2877.79	2827.64	0.807	0.555
29	2924.09	85.904	12.864	2985.81	2877.79	2.565	2.039
30	3444.87	34.055	2.658	3687.9	3435.22	73.883	12.633

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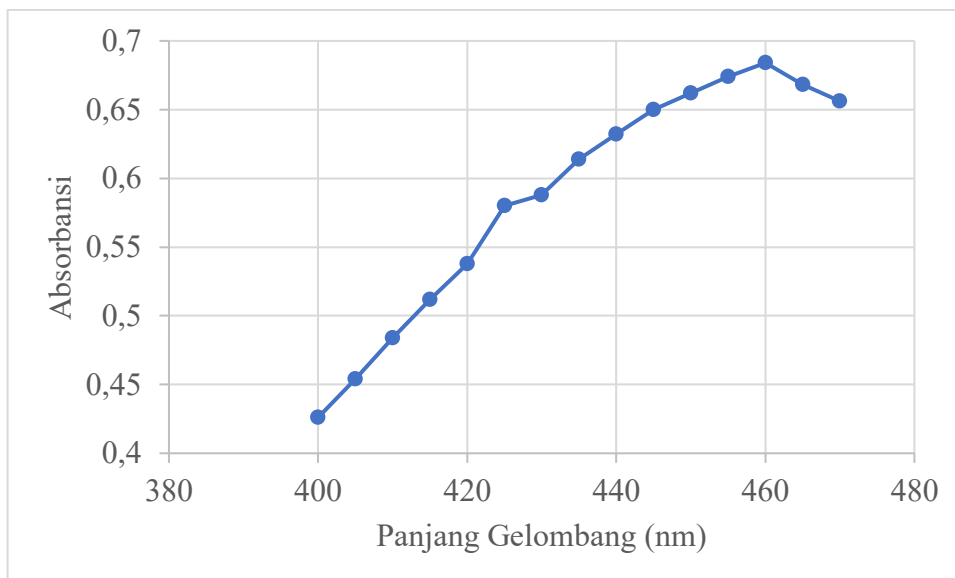
Lampiran 5. Data karakteristik BET

POLITEKNIK NEGERI UJUNG PANDANG		JURUSAN TEKNIK KIMIA		Quantachrome TouchWin v1.2.2	
Report date:	Wed Mar 1 2023	Operator:	Rifai		
Filename:	TC_Alif.qcuPhysIso	Analysis Data			
Sample ID	TC_Alif	Weight	0.1635g		
Analysis	Data ID {0c902fbd-f5bf-4ec3-bf31-5e0431636737} Operator Rifai Date 2023.02.28 Instrument St 1 on NOVA touch 2LX [s/n:1050025524] Comments Ambient Temp. 30.09 °C Void Volume Mode NOVA mode Cell Type 9mm with rod Thermal Delay 600 sec Cell ID 6_B Po Mode Measure				Duration 92.3min Firmware 1.07
Adsorbate	Name Nitrogen Non-ideality 6.580000e-05 1/barr	Molecular Weight 28.013g/mol Bath Temperature 77.35k	Cross Section Area 16.2 Å ² /mol		
Degas information	Type Vacuum Degassing Operator RIFAI Description Heating Heat to 125.0 °C at 10.0 °C/min then hold for 60 min Heat to 300.0 °C at 10.0 °C/min then hold for 30 min				
Data Reduction Parameters					
Data Reduction Parameters	Thermal Transpiration no Temp. Comp no Thickness Method deBoer P-tags below 0.35 included Adsorbate Model Nitrogen Molecular Weight 28.0134g Cross Section Area 16.2 Å ² /molec Bath Temperature 77.35k Moving Pt. Average off				
Multipoint BET Summary/Results					
Isotherm Branch	Adsorption	Slope 13.0084 C constant 14.3013	Intercept 0.977982 Surface area 248.993 m ² /g		
BET-Multi-point BET					
Relative Pressure	Volume Adsorbed @STP		1 / [W((P/Po) - 1)]		
	cc/g				
0.0973518	41.7832		2.0653		
0.146769	47.3615		2.9060		
0.196747	52.6454		3.7226		
0.246361	58.4062		4.4782		
0.295166	74.5031		4.4973		
Average Pore Size Summary/Results					
Average Pore radius	7.2747e-01 nm				
Total Pore Volume Summary/Results					
Total Pore Volume	9.0568e-02 cc/g for pores smaller than 1.15 nm (radius)		at relative pressure 0.24636		

POLITEKNIK NEGERI UJUNG PANDANG		JURUSAN TEKNIK KIMIA		Quantachrome TouchWin v1.2.2	
Report date:	Wed Mar 1 2023	Operator:	Rifai		
Filename:	C_Alif 2.qcuPhysIso	Analysis Data			
Sample ID	C_Alif2	Weight	0.1812g		
Analysis	Data ID {2bc53a74-bfcf-45d9-a5ba-d08e04ffa2ad} Operator Rifai Date 2023.02.26 Instrument St 1 on NOVA touch 2LX [s/n:1050025524] Comments Ambient Temp. 29.17 °C Void Volume Mode NOVA mode Cell Type 9mm with rod Thermal Delay 600 sec Cell ID 6_B Po Mode Measure				Duration 180.1min Firmware 1.07
Adsorbate	Name Nitrogen Non-ideality 6.580000e-05 1/barr	Molecular Weight 28.013g/mol Bath Temperature 77.35k	Cross Section Area 16.2 Å ² /mol		
Degas information	Type Vacuum Degassing Operator RIFAI Description Heating Heat to 125.0 °C at 10.0 °C/min then hold for 60 min Heat to 300.0 °C at 10.0 °C/min then hold for 30 min				
Data Reduction Parameters					
Data Reduction Parameters	Thermal Transpiration no Temp. Comp no Thickness Method deBoer P-tags below 0.35 included Adsorbate Model Nitrogen Molecular Weight 28.0134g Cross Section Area 16.2 Å ² /molec Bath Temperature 77.35k Moving Pt. Average off				
Multipoint BET Summary/Results					
Isotherm Branch	Adsorption	Slope 7.13044 C constant 20.0401	Intercept 0.374497 Surface area 464.030 m ² /g		
BET-Multi-point BET					
Relative Pressure	Volume Adsorbed @STP		1 / [W((P/Po) - 1)]		
	cc/g				
0.0953696	84.9821		0.9926		
0.145802	95.6436		1.4279		
0.195964	105.744		1.8441		
0.246689	119.236		2.1974		
0.295673	140.263		2.3947		
Average Pore Size Summary/Results					
Average Pore radius	7.9690e-01 nm				
Total Pore Volume Summary/Results					
Total Pore Volume	1.8489e-01 cc/g for pores smaller than 1.15 nm (radius)		at relative pressure 0.24669		

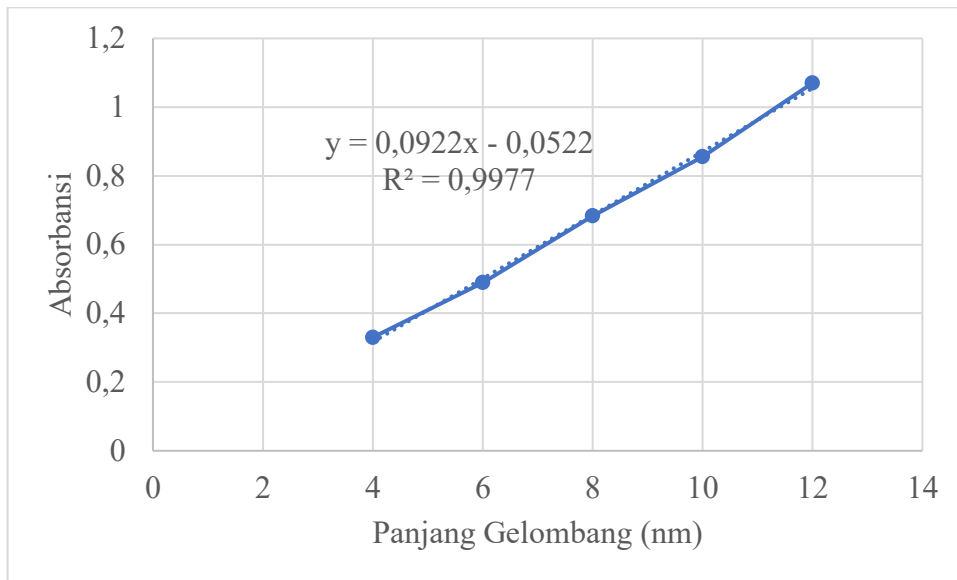
Lampiran 6. Data penentuan panjang gelombang maksimum MJ dengan konsentrasi 8 mg/L.

Panjang gelombang (nm)	Absorbansi
400	0,426
405	0,454
410	0,484
415	0,512
420	0,538
425	0,58
430	0,588
435	0,614
440	0,632
445	0,65
450	0,662
455	0,674
460	0,684
465	0,668
470	0,656



Lampiran 7. Data absorbansi kurva standar larutan MJ

Konsentrasi (ppm)	Absorbansi
4	0,33
6	0,49
8	0,684
10	0,855
12	1,07



41-TC

Waktu kontak (menit)	C ₀ (mg/L)	C _e (mg/L)	Jumlah adsorben (g)	Jumlah MJ yang diadsorpsi, q _e (mg/g)
5	150,2747	29,73969631	0,1	60,26750184
10	150,2747	24,20824295	0,1	63,03322852
15	150,2747	21,71366594	0,1	64,28051703
30	150,2747	10,38177874	0,1	69,94646063
45	150,2747	9,459869848	0,1	70,40741508
60	150,2747	8,321041215	0,1	70,97682939
90	150,2747	7,442516269	0,1	71,41609187
120	150,2747	6,835140998	0,1	71,7197795
180	150,2747	2,496746204	0,1	73,8889769
270	150,2747	1,607375271	0,1	74,33366236
405	150,2747	1,130151844	0,1	74,57227408

Contoh perhitungan MJ yang teradsorpsi pada t = 180 menit

$$q_e = \frac{(C_0 - C_e)V}{m}$$

$$q_e = \frac{(150,2747 \text{ mg/L} - 2,496746204 \text{ mg/L})0,05 \text{ L}}{0,1 \text{ g}}$$

$$q_e = 73,8889769 \text{ mg/g}$$

Lampiran 9. Data studi kinetika adsorpsi MJ oleh MCM-41-TC

Waktu kontak (menit)	q_e (mg/g)	q_t (mg/g)	$q_t - q_e$ (mg/g)	$\ln(q_t - q_e)$	t/q_e
5	60,26750184	73,8889769	13,62147505	2,611647595	0,082963452
10	63,03322852	73,8889769	10,85574837	2,384694744	0,158646483
15	64,28051703	73,8889769	9,60845987	2,262643947	0,233352199
30	69,94646063	73,8889769	3,942516269	1,371819166	0,428899472
45	70,40741508	73,8889769	3,481561822	1,247480993	0,639137227
60	70,97682939	73,8889769	2,912147505	1,068890783	0,845346298
90	71,41609187	73,8889769	2,472885033	0,905385498	1,260220178
120	71,71977957	73,8889769	2,169197397	0,774357236	1,673178596
180	73,8889769	73,8889769	0	0	2,436087324

Dari grafik kinetika orde satu semu diperoleh persamaan garis :

$$y = -0,0135x + 2,2356$$

dari persamaan garis diperoleh nilai *slope* (a) = -0,0135 dan nilai *intercept*

(b) = 2,2356

nilai k_1 dapat dihitung sebagai berikut :

$K = -\text{Slope}$

$k_1 = 0,0135 \text{ menit}^{-1}$;

$$\log q_e = \textit{intercept}$$

$$\log q_e = 2,2356$$

$$q_e = 172,0283 \text{ mg/g}$$

$$R^2 = 0,8496$$

Dari grafik kinetika orde dua semu diperoleh persamaan garis :

$$y = 0,0135x + 0,029$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,0135 dan nilai *intercept*

$$(b) = 0,029$$

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

$$q_e = \frac{1}{\textit{slop}} = \frac{1}{0,0135} = 74,074 \text{ mg/g}$$

nilai k_2 dapat dihitung sebagai berikut :

$$k_2 = \textit{Slope}^2 / \textit{intercept}$$

$$k_2 = (0,0135)^2 / 0,029$$

$$= 0,0063 \text{ g/mg min}^{-1}$$

$$R^2 = 0,9997$$

Lampiran 10. Penentuan waktu optimum adsorpsi MJ oleh MCM-41-C

Waktu kontak (menit)	C ₀ (mg/L)	C _e (mg/L)	Jumlah adsorben (g)	Jumlah MJ yang diadsorpsi, q _e (mg/g)
5	500,1084	192,6247289	0,1	153,7418356
10	500,1084	130,2603037	0,1	184,9240482
15	500,1084	124,8373102	0,1	187,6355449
30	500,1084	117,7874187	0,1	191,1604907
45	500,1084	112,3644252	0,1	193,8719874
60	500,1084	109,6529284	0,1	195,2277358
90	500,1084	107,483731	0,1	196,3123345
120	500,1084	100,9761388	0,1	199,5661306
180	500,1084	96,09544469	0,1	202,0064777
270	500,1084	93,38394794	0,1	203,362226
405	500,1084	91,75704989	0,1	204,1756751

Contoh perhitungan MJ yang teradsorpsi pada t = 180 menit

$$q_e = \frac{(C_0 - C_e)V}{m}$$

$$q_e = \frac{(500,1084 \text{ mg/L} - 96,09544469 \text{ mg/L})0,05 \text{ L}}{0,1 \text{ g}}$$

$$q_e = 202,0064777 \text{ mg/g}$$

Lampiran 11. Data studi kinetika adsorpsi MJ oleh MCM-41-C

Waktu kontak (menit)	q _e (mg/g)	q _t (mg/g)	q _t -q _e (mg/g)	ln (q _t -q _e)	t/q _e
5	153,7418356	202,0064777	48,26464208	3,876699245	0,032522052
10	184,9240482	202,0064777	17,0824295	2,838050421	0,054076255
15	187,6355449	202,0064777	14,37093275	2,665207608	0,079942209
30	191,1604907	202,0064777	10,84598698	2,383795148	0,156936195
45	193,8719874	202,0064777	8,134490239	2,096113076	0,232111924
60	195,2277358	202,0064777	6,778741866	1,913791519	0,30733338
90	196,3123345	202,0064777	5,694143167	1,739438132	0,458453109
120	199,5661306	202,0064777	2,440347072	0,892140272	0,601304438
180	202,0064777	202,0064777	0	0	0,891060535

Dari grafik kinetika orde satu semu diperoleh persamaan garis :

$$y = -0,0183x + 3,1709$$

dari persamaan garis diperoleh nilai *slope* (a) = -0,0183 dan nilai *intercept*

$$(b) = 3,1709$$

nilai k₁ dapat dihitung sebagai berikut :

$$k_1 = -\text{slope}$$

$$k_1 = 0,0183 \text{ menit}^{-1};$$

$$\log q_e = \text{intercept}$$

$$\log q_e = 3,1709$$

$$q_e = 1482,1767 \text{ mg/g}$$

$$R^2 = 0,9085$$

Dari grafik kinetika orde dua semu diperoleh persamaan garis :

$$y = 0,0049x + 0,0087$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,0049 dan nilai *intercept* (b) = 0,0087

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

$$q_e = \frac{1}{\text{slop}} = \frac{1}{0,0049} = 204,082 \text{ mg/g}$$

nilai k_2 dapat dihitung sebagai berikut :

$$k_2 = \text{Slope}^2 / \text{intercept}$$

$$\begin{aligned} k_2 &= (0,0049)^2 / 0,0087 \\ &= 0,00276 \text{ g/mg min}^{-1} \end{aligned}$$

$$R^2 = 0,9999$$

Lampiran 12. Penentuan kapasitas adsorpsi MJ oleh MCM-41-TC

C₀ (mg/L)	C_e (mg/L)	m (g)	q_e (mg/g)	C_e/q_e	log C_e	log q_e
351,5184	105,856833	0,1	122,8307835	0,86181	2,024719	2,089307
401,4099	147,6138829	0,1	126,8980086	1,163248	2,169127	2,103455
449,1323	193,7093275	0,1	127,7114862	1,516773	2,287151	2,10623
551,6269	266,9197397	0,1	142,3535802	1,875048	2,426381	2,153368
657,3753	360,1952278	0,1	148,5900361	2,424087	2,556538	2,17199
749,5662	451,8438178	0,1	148,8611911	3,035337	2,654988	2,172781
1130,3688	830,9110629	0,1	149,7288685	5,549438	2,919555	2,175306
1878,7419	1585,900217	0,1	146,4208415	10,83111	3,200276	2,165603

Contoh perhitungan MJ yang teradsorpsi (q_e) pada konsentrasi

(C₀) 351,5184 mg/L :

$$q_e = \frac{(C_0 - C_e)V}{m}$$

$$q_e = \frac{(351,5184 \text{ mg/L} - 105,856833 \text{ mg/L})0,05 \text{ L}}{0,1 \text{ g}}$$

$$q_e = 122,8307835 \text{ mg/g}$$

Lampiran 13. Isoterm adsorpsi MCM-41-TC

1. Isoterm adsorpsi langmuir bentuk linear

Berdasarkan model isotermal Langmuir diperoleh persamaan garis :

$$y = 0,0067x + 0,1013$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,0067 dan nilai *intercept* (b) = 0,1013

- Nilai kapasitas adsorpsi dapat dihitung sebagai berikut :

$$\frac{1}{Q_{\text{maks}}} = \text{kemiringan (slope)}$$

$$Q_{\text{maks}} = \frac{1}{\text{slope}} = \frac{1}{0,0067} = 149,2537 \text{ mg/g}$$

- Intensitas adsorpsi dapat dihitung sebagai berikut :

$$\frac{1}{Q_{\text{maks}} \cdot b} = \text{intercept}$$

$$b = \frac{1}{149,2537 \text{ mg/g} \cdot 0,1013}$$
$$= 0,0661 \text{ L mg}^{-1}$$

2. Isoterm adsorpsi Freundlich bentuk linear

Berdasarkan model isotermal Freundlich diperoleh persamaan garis :

$$y = 0,076x + 1,9501$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,076 dan nilai *intercept* (b) = 1,9501

- Nilai kapasitas adsorpsi dapat dihitung sebagai berikut :

$$\text{Log } k = \textit{intercept}$$

$$k = \textit{invers log intercept}$$

$$k = \textit{invers log } 1,9501$$

$$k = 89,1456 \text{ mg/g}$$

- Intensitas adsorpsi dapat dihitung sebagai berikut :

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

$$\frac{1}{n} = 0,076$$

3. Isoterm adsorpsi Sips bentuk linear

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

Parameter	Nilai
Persamaan	$y = 0,03785 x - 0,7197$
K_s	0,4
N	0,29
q_{\max}	172,21
R^2	0,6676

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeL (mg/g)	Res ²
350	105,856833	122,8307835	121,1704643	2,756660056
400	147,6138829	126,8980086	129,0704787	4,719626312
450	193,7093275	127,7114862	134,3546942	44,13221161
550	266,9197397	142,3535802	139,3662499	8,924141866
650	360,1952278	148,5900361	143,0215969	31,00751568
750	451,8438178	148,8611911	145,2325811	13,16681039
1125	830,9110629	149,7288685	149,3728601	0,126741985
1800	1585,900217	146,4208415	151,8290238	29,24843482

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

Parameter	Nilai
K	0,03
Qmax	154,62
RSS	134,17

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeF (mg/g)	Res ²
350	105,856833	122,8307835	127,9534521	26,24173344
400	147,6138829	126,8980086	131,0009806	16,83437964
450	193,7093275	127,7114862	133,5455177	34,03592344
550	266,9197397	142,3535802	136,6108831	32,9785698
650	360,1952278	148,5900361	139,5400964	81,9014086
750	451,8438178	148,8611911	141,7973899	49,89728763
1125	830,9110629	149,7288685	148,0459902	2,832079553
1800	1585,900217	146,4208415	154,9775063	73,21651144

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

Parameter	Nilai
K	91,98
N	0,07
RSS	317,93

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeS (mg/g)	Res ²
350	105,856833	122,8307835	129,7025215	47,22078245
400	147,6138829	126,8980086	132,7927559	34,74804665
450	193,7093275	127,7114862	135,198555	56,05619859
550	266,9197397	142,3535802	137,8972315	19,85904374
650	360,1952278	148,5900361	140,2839037	68,99183578
750	451,8438178	148,8611911	142,0025407	47,04108537
1125	830,9110629	149,7288685	146,2593224	12,03775024
1800	1585,900217	146,4208415	150,2235007	14,46021676

$$q_e = \frac{q_m \cdot K_s \cdot C_e^{1/n}}{1 + K_s \cdot C_e^n}$$

Parameter	Nilai
K	0,4
N	0,29
Qmax	172,21
RSS	300.41

Lampiran 14. Penentuan kapasitas adsorpsi MJ oleh MCM-41-C

C₀ (mg/L)	C_e (mg/L)	m (g)	q_e (mg/g)	C_e/q_e	log C_e	log q_e
348,2646	1,10845987	0,1	173,5780701	0,006386	0,04472	2,239495
398,6985	1,813449024	0,1	198,4425255	0,009138	0,258505	2,297635
451,3015	19,54446855	0,1	215,8785157	0,090535	1,291024	2,334209
554,3383	99,34924078	0,1	227,4945296	0,43671	1,997165	2,356971
654,6638	176,8980477	0,1	238,8828761	0,740522	2,247723	2,378185
752,2776	264,208243	0,1	244,0346785	1,082667	2,421946	2,387452
1133,6225	635,6832972	0,1	248,9696014	2,553257	2,803241	2,396146
1846,2039	1350,542299	0,1	247,8308003	5,449453	3,130508	2,394155

Contoh perhitungan MJ yang teradsorpsi (q_e) pada konsentrasi

(C₀) 348,2646 mg/L :

$$q_e = \frac{(C_0 - C_e)V}{m}$$

$$q_e = \frac{(348,2646 \text{ mg/L} - 1,10845987 \text{ mg/L})0,05 \text{ L}}{0,1 \text{ g}}$$

$$q_e = 173,5780701 \text{ mg/g}$$

Lampiran 15. Isoterm adsorpsi MCM-41-C

1. Isoterm adsorpsi langmuir bentuk linear

Berdasarkan model isotermal Langmuir diperoleh persamaan garis :

$$y = 0,004x + 0,0147$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,004 dan nilai *intercept* (b) = 0,0147

- Nilai kapasitas adsorpsi dapat dihitung sebagai berikut :

$$\frac{1}{Q_{\text{maks}}} = \text{kemiringan (slope)}$$

$$Q_{\text{maks}} = \frac{1}{\text{slope}} = \frac{1}{0,004} = 250 \text{ mg/g}$$

- Intensitas adsorpsi dapat dihitung sebagai berikut :

$$\frac{1}{Q_{\text{maks}} \cdot b} = \text{intercept}$$

$$b = \frac{1}{250 \text{ mg/g} \cdot 0,0147}$$
$$= 0,2721 \text{ L mg}^{-1}$$

2. Isoterm adsorpsi Freundlich bentuk linear

Berdasarkan model isoterma Freundlich diperoleh persamaan garis :

$$y = 0,0466x + 2,2654$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,0466 dan nilai *intercept* (b) = 2,2654

- Nilai kapasitas adsorpsi dapat dihitung sebagai berikut :

$$\text{Log } k = \textit{intercept}$$

$$k = \text{invers log } \textit{intercept}$$

$$k = \text{invers log } 2,2654$$

$$k = 184,2468 \text{ mg/g}$$

- Intensitas adsorpsi dapat dihitung sebagai berikut :

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

$$\frac{1}{n} = 0,0466$$

3. Isoterm adsorpsi Sips bentuk linear

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

Parameter	Nilai
Persamaan	$y = 0,1453 x + 0,2885$
K_s	7,42
N	0,12
q_{max}	319,62
R^2	0,9517

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeL (mg/g)	Res ²
350	1,10845987	173,5780701	172,1771732	1,962511918
400	1,813449024	198,4425255	194,7208961	13,8505255
450	19,54446855	215,8785157	239,4401337	555,14984
550	99,34924078	227,4945296	244,0446831	273,9075791
650	176,8980477	238,8828761	244,5495817	32,11155181
750	264,208243	244,0346785	244,7639647	0,531858319
1125	635,6832972	248,9696014	245,0182779	15,61295776
1800	1350,542299	247,8308003	245,1141558	7,380157482

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

Parameter	Nilai
K	2,12
Qmax	245,19
RSS	900,5

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeF (mg/g)	Res ²
350	1,10845987	173,5780701	182,3107331	76,25940425
400	1,813449024	198,4425255	186,0226668	154,2528888
450	19,54446855	215,8785157	205,0421924	117,4259029
550	99,34924078	227,4945296	219,1577247	69,5023158
650	176,8980477	238,8828761	224,3965206	209,8544963
750	264,208243	244,0346785	228,1128994	253,5030515
1125	635,6832972	248,9696014	236,4625005	156,4275742
1800	1350,542299	247,8308003	243,8723293	15,66949305

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

Parameter	Nilai
K	181,54
N	0,04
RSS	1052,89

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qeS (mg/g)	Res^2
350	1,10845987	173,5780701	180,2800726	44,91683771
400	1,813449024	198,4425255	184,9870891	181,0487687
450	19,54446855	215,8785157	206,9627179	79,49145151
550	99,34924078	227,4945296	220,9961112	42,2294417
650	176,8980477	238,8828761	225,7366541	172,8231546
750	264,208243	244,0346785	228,9532298	227,4500958
1125	635,6832972	248,9696014	235,7552664	174,6186497
1800	1350,542299	247,8308003	241,3245544	42,33123569

$$q_e = \frac{q_m \cdot K_s \cdot C_e^{1/n}}{1 + K_s \cdot C_e^n}$$

Parameter	Nilai
K	7,42
N	0,12
Qmax	319,62
RSS	964,90

Lampiran 16. Data desorpsi zat warna MJ oleh MCM-41-TC dan MCM-41-C

Desorpsi menggunakan agen pendesorpsi Akuades (H₂O)

Adsorben	Abs	C _{des} (mg/L)	V (L)	m (g)	q _e (mg/g)	% Desorpsi
MCM-41-TC	1,52	17,05206074	0,05	0,1	8,526030369	5,822962279
MCM-41-C	0,498	59,67462039	0,05	0,1	29,8373102	12,03938742

dimana:

$$q_{ads} \text{ MCM-41-TC} = 146,4208415 \text{ mg/g}$$

$$q_{ads} \text{ MCM-41-C} = 247,8308003 \text{ mg/g}$$

Contoh perhitungan jumlah MJ yang terdesorpsi oleh TC MCM-41:

$$q_{des} = \left[\frac{C_{des}}{w} \right] V$$

$$q_{des} = \frac{17,05206074 \text{ mg/L}}{0,1 \text{ g}} 0,05 \text{ L}$$

$$q_{des} = 8,526030369 \text{ mg/g}$$

Rasio desorpsi dapat dihitung menggunakan persamaan berikut:

$$\% \text{ Desorpsi} = \frac{\text{Jumlah zat warna terdesorpsi}}{\text{Jumlah zat warna teradsorpsi}} \times 100$$

Contoh perhitungan rasio desorpsi RB oleh TC MCM-41:

$$\% \text{ Desorpsi} = \frac{q_{des}}{q_{ads}} \times 100$$

$$\begin{aligned} \% \text{ Desorpsi} &= \frac{8,526030369 \text{ mg/g}}{146,4208415 \text{ mg/g}} \times 100 \\ &= 5,822962279\% \end{aligned}$$