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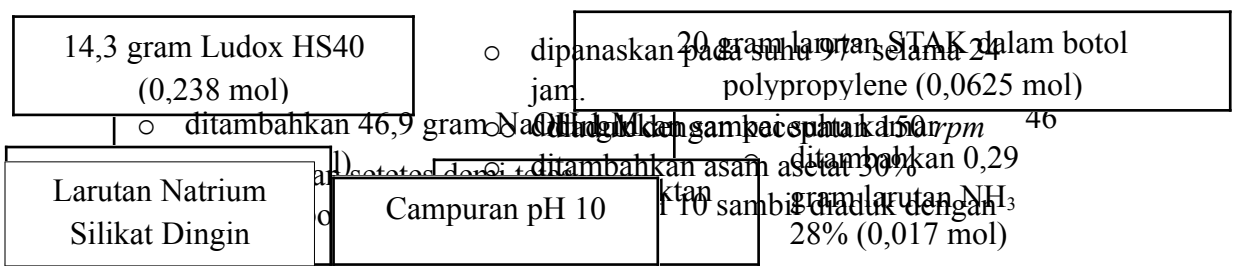
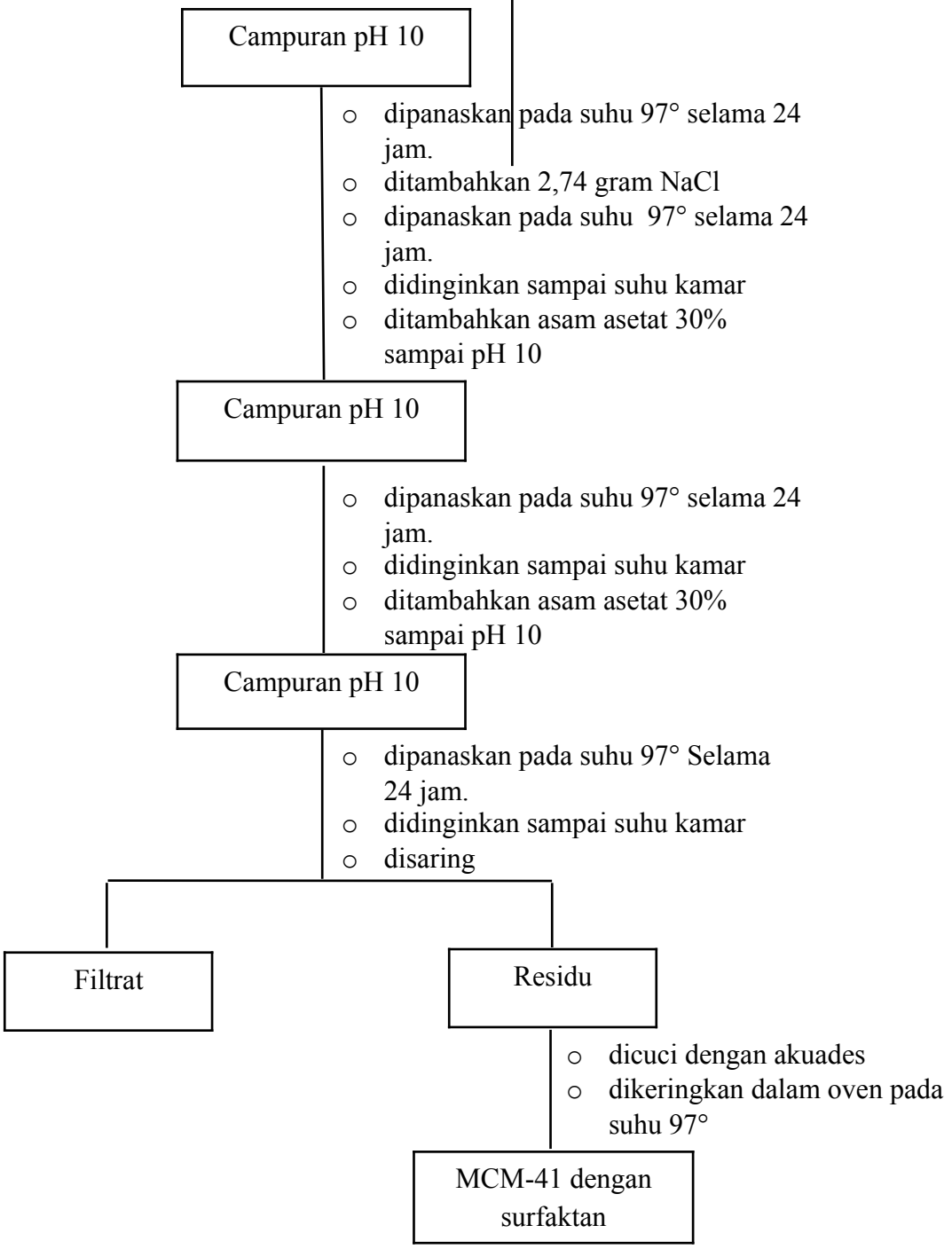
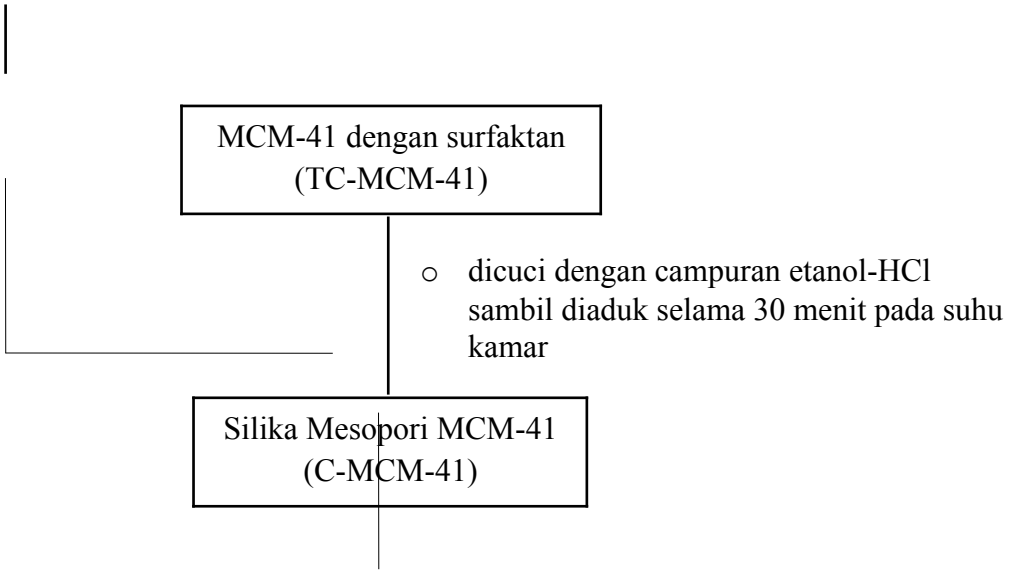
Lampiran 1. Diagram Alir Penelitian

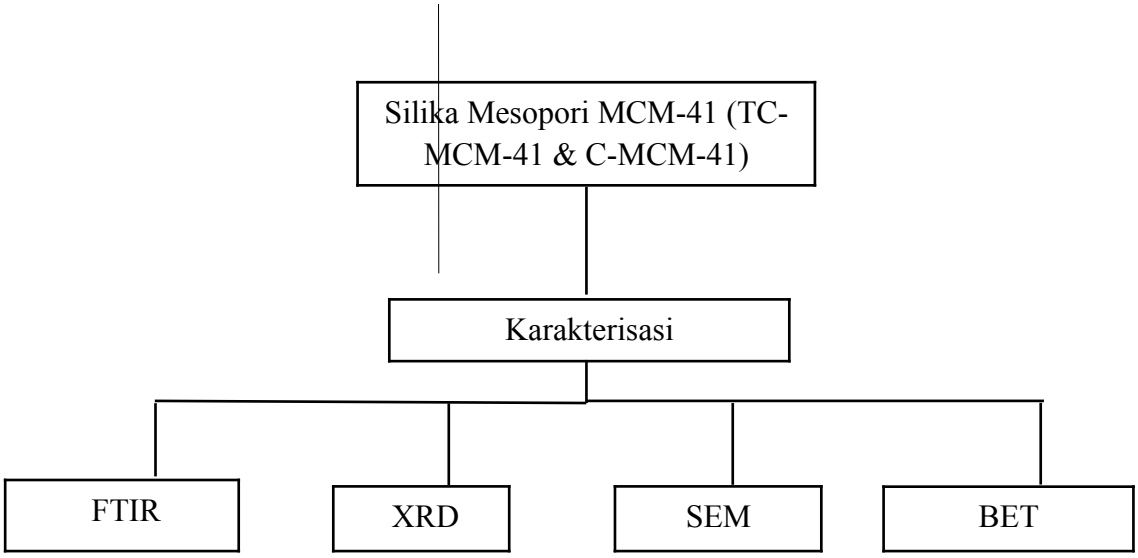
1. Sintesis Silika Mesopori MCM-41



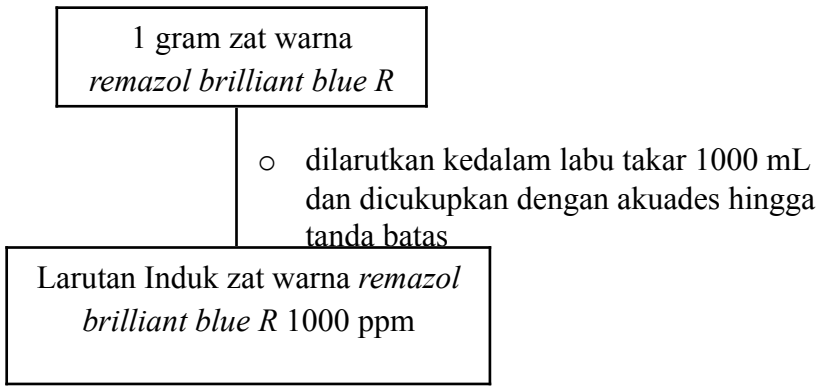

Campuran pH 10
dipanaskan pada suhu 97° selama 24 jam.
ditambahkan 2,74 gram NaCl
dipanaskan pada suhu 97° selama 24 jam.
didinginkan sampai suhu kamar
ditambahkan asam asetat 30% sampai pH 10
Campuran pH 10
dipanaskan pada suhu 97° selama 24 jam.
didinginkan sampai suhu kamar
ditambahkan asam asetat 30% sampai pH 10
Campuran pH 10
dipanaskan pada suhu 97° Selama 24 jam.
didinginkan sampai suhu kamar
disaring
Filtrat
Residu
dicuci dengan akuades
dikeringkan dalam oven pada suhu 97°
MCM-41 dengan surfaktan



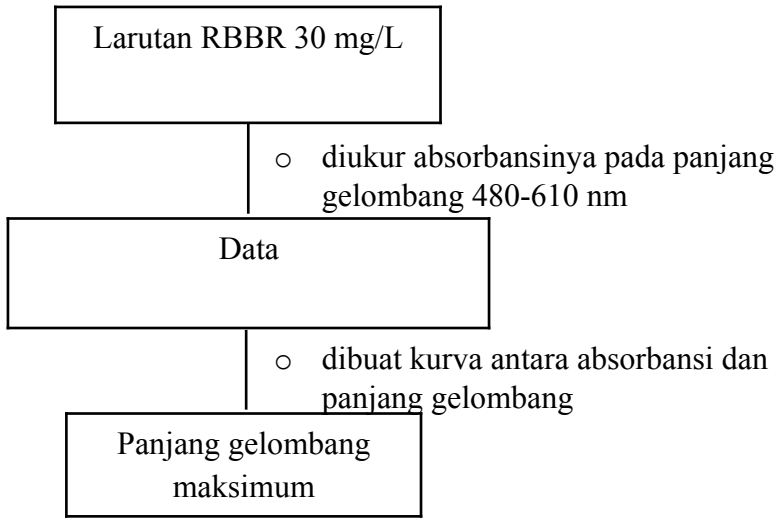
2. Karakterisasi Silika Mesopori MCM-41



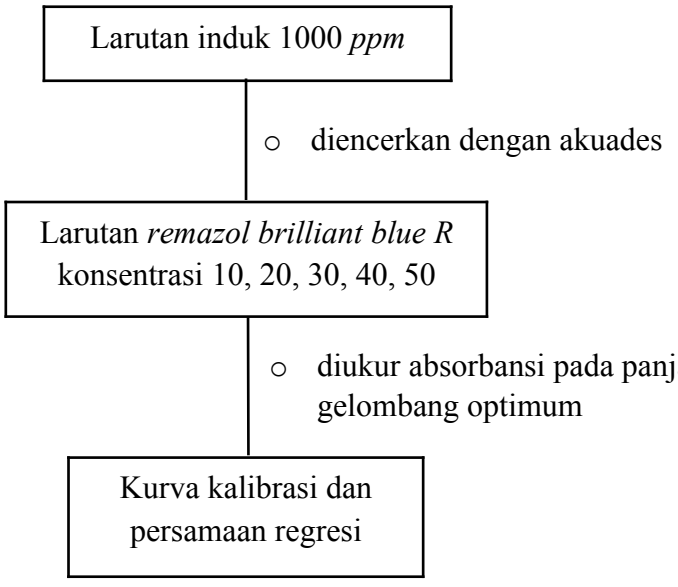
3. Pembuatan Larutan Induk *Remazol Brilliant Blue R*



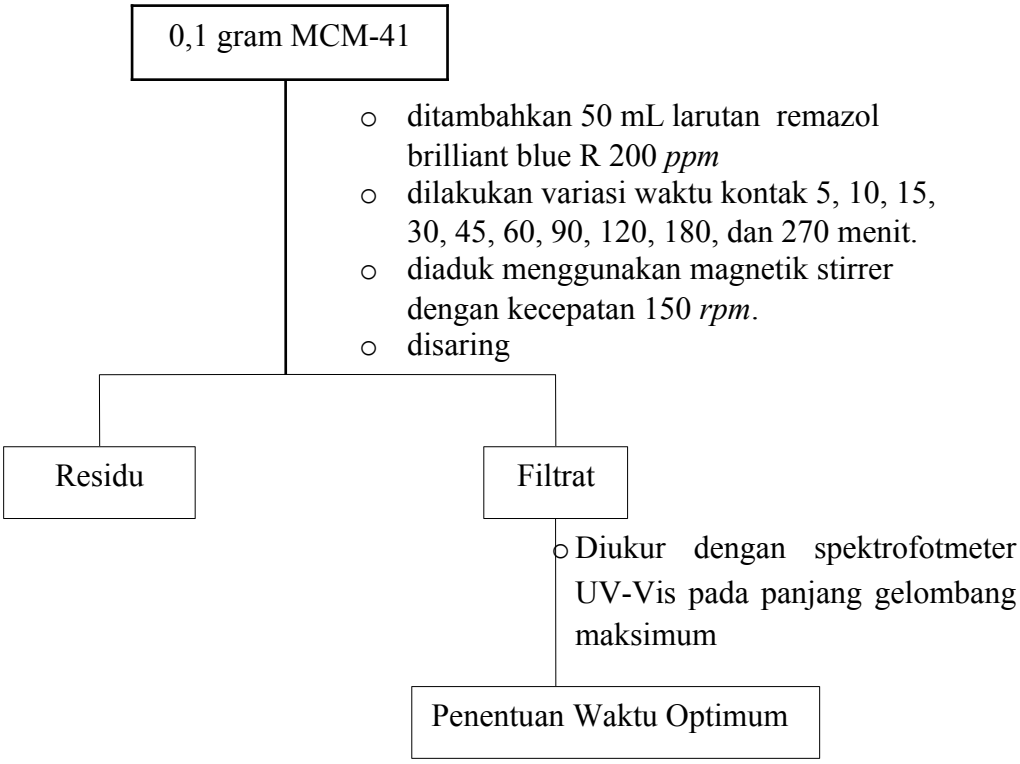
4. Penentuan Panjang Gelombang Maksimum



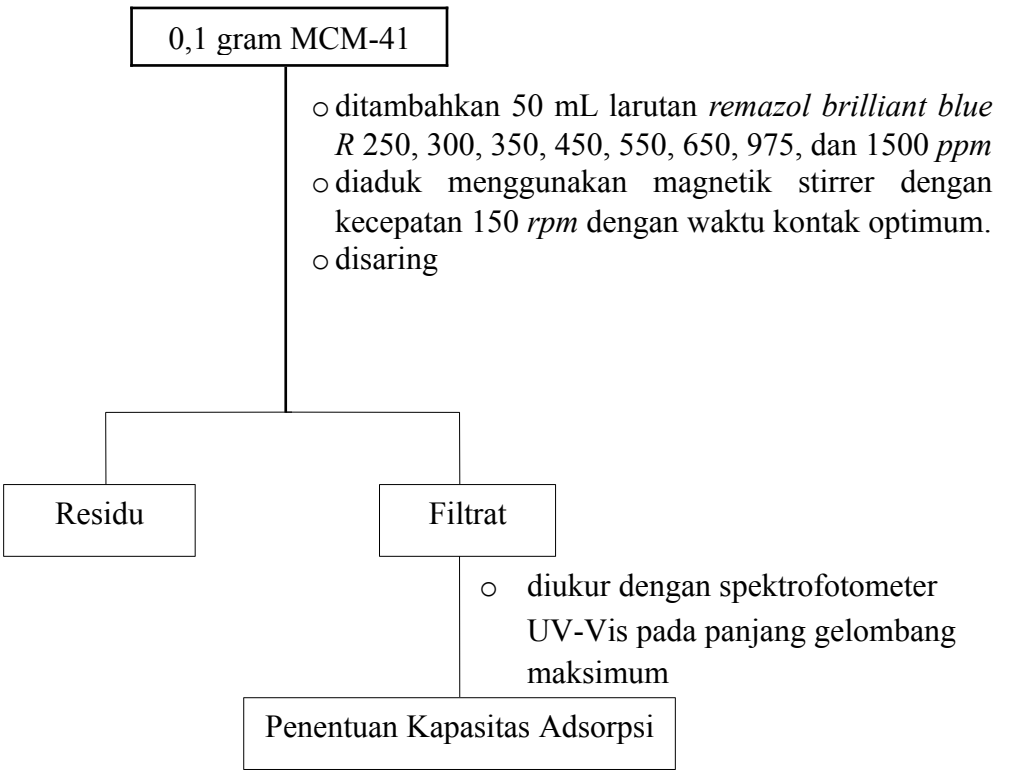
5. Pembuatan Kurva Kalibrasi Larutan Standar Zat Warna *Remazol Brilliant Blue R*



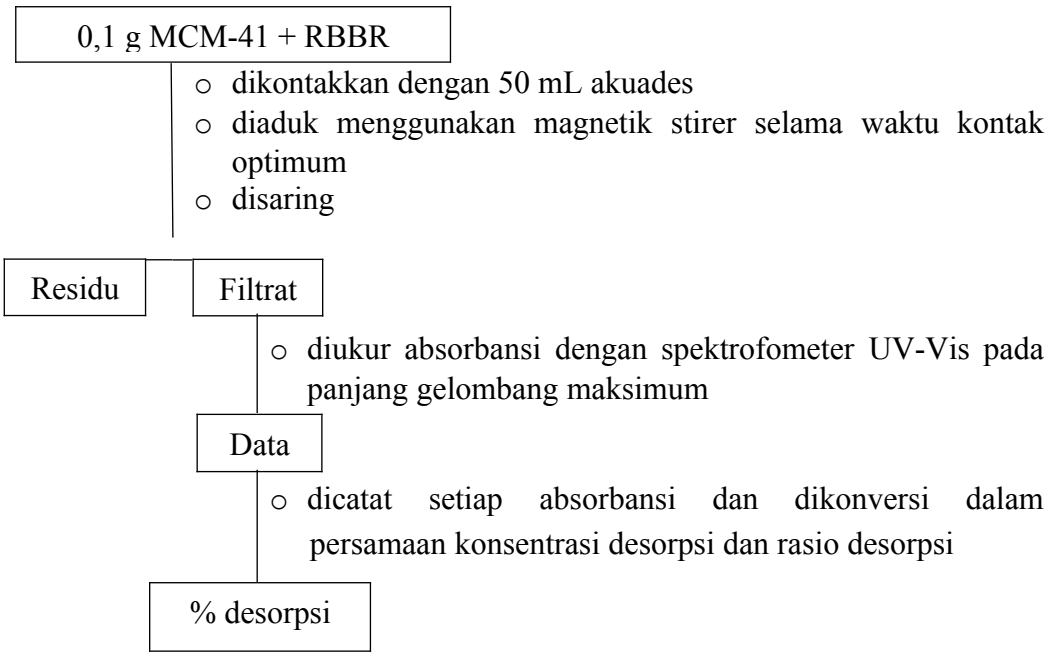
6. Penentuan Waktu Kontak Optimum



7. Penentuan Kapasitas Adsorpsi



8. Desorpsi Zat Warna *Remazol Brilliant Blue R*

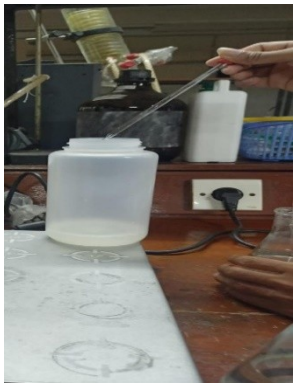


Lampiran 2. Dokumentasi Penelitian

Sintesis silika mesopori MCM-41

Pembuatan natrium silika

Pemanasan pada suhu 80^0C



Pencampuran larutan natrium silika dan surfaktan

Pemanasan pada suhu 97°C

Pengaturan pH 10

Penyaringan dengan akuades

MCM-41-TC

Pemanasan pada suhu 97°C

Pemanasan pada suhu 80^0C

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-RBBR

Waktu kontak MCM-41-C-RBBR

Variasi konsentrasi MCM-41-TC-RBBR

Variasi konsentrasi MCM-41-C-RBBR

Variasi konsentrasi -TC-MJ

Waktu kontak MCM-41-C-MJ

MCM-41-TC

Proses desorpsi

Desorpsi zat warna RBBR

Lampiran 3. Karakterisasi XRD

Match! Phase Analysis Report

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

Sample Data	
File name	MCM-41-TC-SHB.RAW
File path	C:/Users/MSI MODERN/Documents/xrd/MCM/MCM-41-TC-SHB
Data collected	Dec 5, 2022 12:05:45
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	2.25	39.2336	485.42	14.91	0.2400
2	21.62	4.1071	1000.00	409.46	3.2000
3	44.23	2.0461	34.14	23.86	5.4619
4	64.64	1.4408	26.48	11.35	3.3500
5	77.72	1.2277	25.80	7.36	2.2290

Integrated Profile Areas

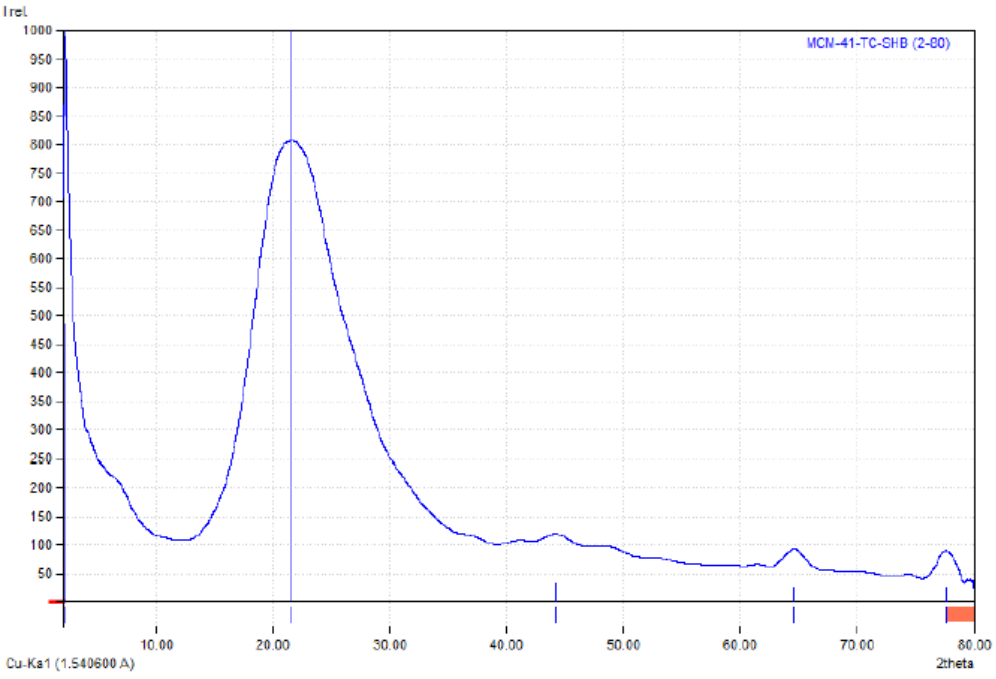
Based on calculated profile

Profile area	*Counts*	*Amount*
Overall diffraction profile	236343	100.00%
Background radiation	144132	60.98%
Diffraction peaks	92211	39.02%
Peak area belonging to selected phases	0	0.00%
Unidentified peak area	92211	39.02%

Peak Residuals

Peak data	*Counts*	*Amount*
Overall peak intensity	467	100.00%
Peak intensity belonging to selected phases	0	0.00%
Unidentified peak intensity	467	100.00%

Diffraction Pattern Graphics



Match! Phase Analysis Report

Sample: MCM-41-C-SHB (2-80)

Sample Data	
File name	MCM-41-C-SHB.RAW
File path	C:/Users/MSI MODERN/Documents/xrd/MCM/MCM-41-C-SHB
Data collected	Dec 5, 2022 12:05:45
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	2.42	36.4779	1000.00	31.24	0.1748
2	6.56	13.4631	111.32	3.48	0.1748
3	23.35	3.8066	432.47	45.60	0.5901
4	44.33	2.0417	65.08	6.87	0.5910
5	64.56	1.4424	124.59	8.86	0.3980
6	77.66	1.2285	146.77	10.75	0.4099

Integrated Profile Areas

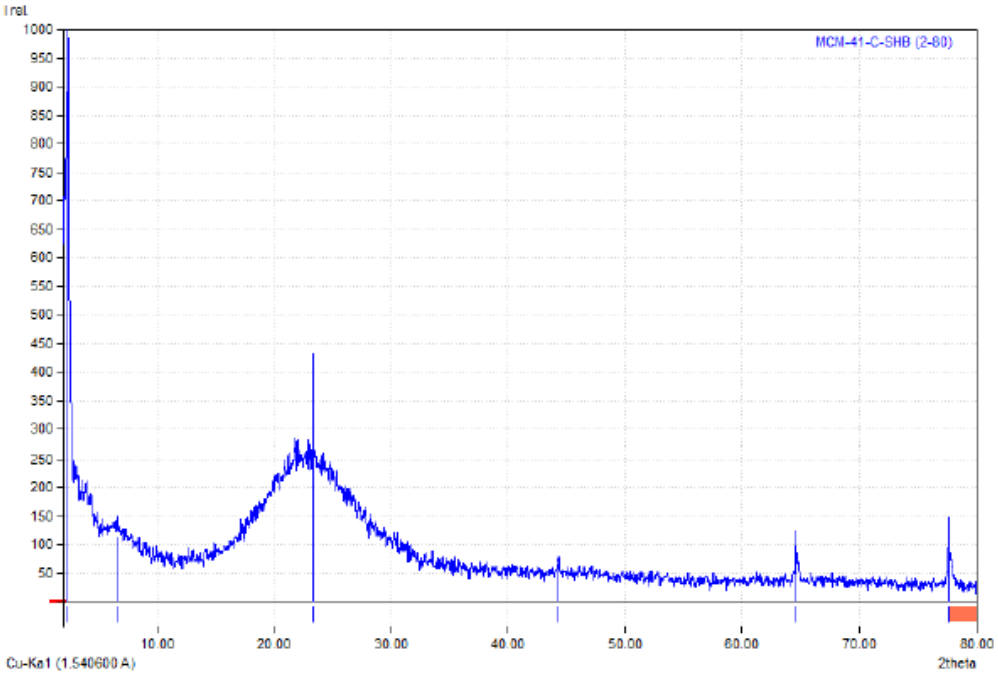
Based on calculated profile

Profile area	Counts	Amount
Overall diffraction profile	210469	100.00%
Background radiation	139453	66.26%
Diffraction peaks	71017	33.74%
Peak area belonging to selected phases	0	0.00%
Unidentified peak area	71017	33.74%

Peak Residuals

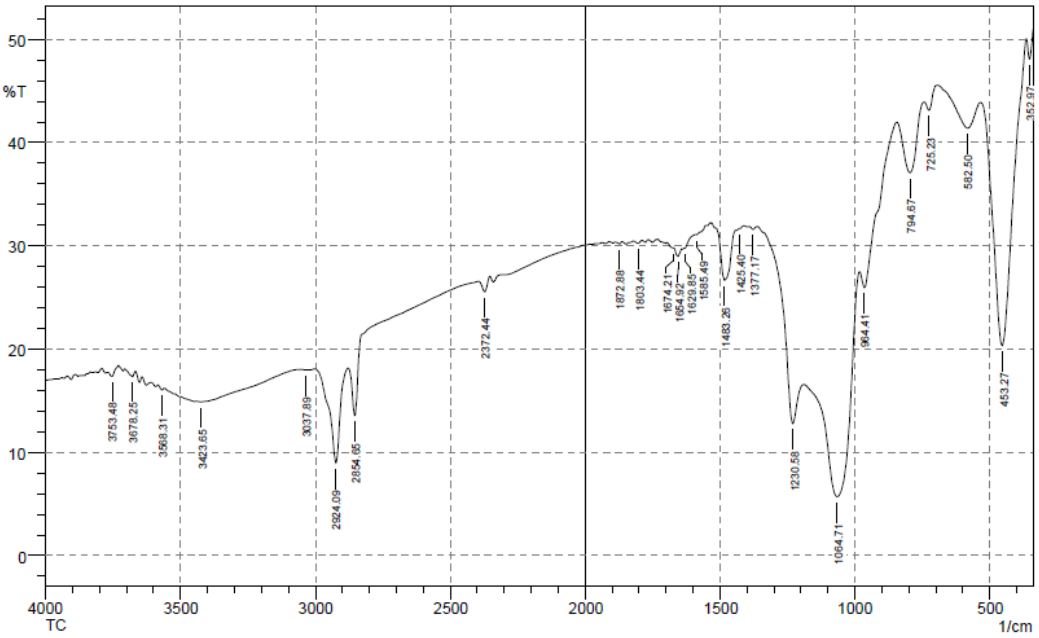
Peak data	Counts	Amount
Overall peak intensity	107	100.00%
Peak intensity belonging to selected phases	69	65.01%
Unidentified peak intensity	37	34.99%

Diffraction Pattern Graphics



Lampiran 4. Karakterisasi FTIR

MCM-41-TC



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	352.97	48.091	2.353	364.55	339.47	7.733	0.288
2	453.27	20.347	26.479	534.28	364.55	81.087	25.219
3	582.5	41.406	2.99	692.44	534.28	57.441	2.149
4	725.23	43.132	1.423	742.59	698.23	15.788	0.285
5	794.67	37.091	5.843	844.82	742.59	40.684	3.153
6	964.41	25.957	3.361	981.77	844.82	65.225	0.998
7	1064.71	5.699	17.452	1188.15	983.7	188.293	51.328
8	1230.58	12.776	7.45	1359.82	1190.08	110.42	5.914
9	1377.17	31.603	0.29	1392.61	1359.82	16.334	0.061
10	1425.4	31.691	0.039	1427.32	1409.96	8.634	0.001
11	1483.26	26.667	4.965	1514.12	1442.75	38.419	2.73
12	1585.49	31.087	0.081	1589.34	1573.91	7.807	0.008
13	1629.85	29.762	0.066	1631.78	1589.34	21.825	-0.099
14	1654.92	28.987	0.757	1672.28	1641.42	16.425	0.176
15	1674.21	29.789	0.051	1695.43	1672.28	12.107	0.022
16	1803.44	30.241	0.247	1816.94	1789.94	13.982	0.052
17	1872.88	30.192	0.197	1888.31	1863.24	13.006	0.034
18	2372.44	25.546	1.286	2395.59	2353.16	24.689	0.428
19	2854.65	13.553	5	2877.79	2397.52	303.239	2.42
20	2924.09	8.982	9.149	3001.24	2879.72	101.718	11.58
21	3037.89	17.989	0.019	3053.32	3028.24	18.672	0.006
22	3423.65	14.879	0.185	3439.08	3062.96	296.358	1.42
23	3568.31	16.033	0.294	3583.74	3558.67	19.811	0.097
24	3678.25	17.316	0.601	3705.26	3666.68	29.056	0.291
25	3753.48	17.362	0.652	3768.91	3730.33	28.943	0.285

Comment;
TC

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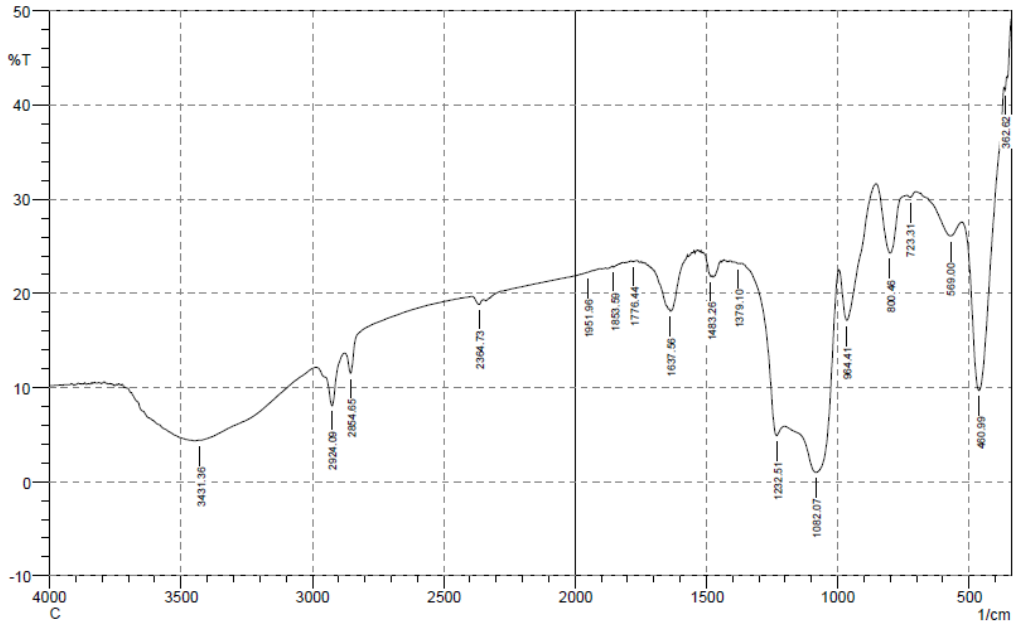
No. of Scans;
Resolution;
Apodization;

MCM-41-C



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	362.62	41.604	0.668	366.48	354.9	4.342	0.037
2	460.99	9.675	23.767	526.57	366.48	109.561	34.708
3	569	26.108	2.304	682.8	526.57	86.184	2.366
4	723.31	30.225	0.33	734.88	702.09	16.932	0.074
5	800.46	24.298	6.792	854.47	734.88	66.058	5.273
6	964.41	17.141	7.386	995.27	854.47	89.477	8.727
7	1082.07	0.989	14.535	1201.65	995.27	284.039	90.791
8	1232.51	4.893	4.075	1365.6	1203.58	142.079	4.754
9	1379.1	23.145	0.09	1392.61	1375.25	11.002	0.011
10	1483.26	21.769	0.543	1512.19	1477.47	22.19	0.097
11	1637.56	18.123	0.563	1641.42	1571.99	47.133	0.117
12	1776.44	23.367	0.053	1780.3	1770.65	6.083	0.005
13	1853.59	22.799	0.133	1857.45	1842.02	9.882	0.021
14	1951.96	22.223	0.045	1955.82	1930.74	16.329	0.008
15	2364.73	18.828	0.639	2391.73	2349.3	30.401	0.289
16	2854.65	11.514	2.417	2877.79	2391.73	367.17	-14.577
17	2924.09	8.042	4.941	2983.88	2877.79	101.329	6.903
18	3431.36	4.393	0.034	3433.29	2985.81	506.318	1.678

Comment;
C

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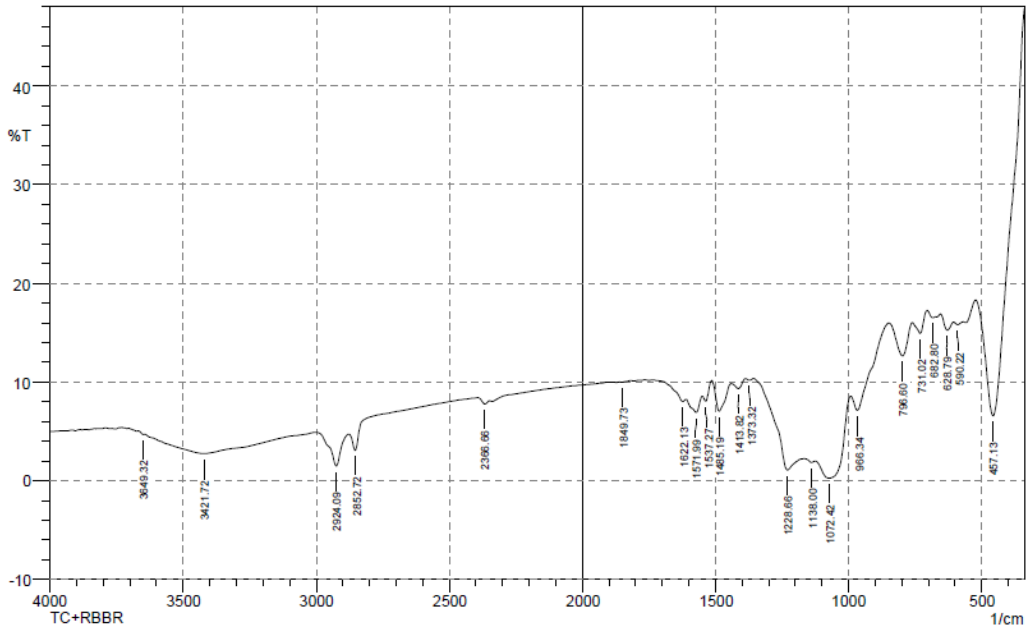
No. of Scans;
Resolution;
Apodization;

MCM-41-TC+RBBR



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	457.13	6.587	22.271	522.71	339.47	140.365	43.423
2	590.22	15.814	0.265	603.72	569	27.681	0.125
3	628.79	15.258	1.228	653.87	603.72	40.124	0.856
4	682.8	16.517	0.29	704.02	673.16	23.948	0.139
5	731.02	14.932	1.722	759.95	704.02	44.828	1.235
6	796.6	12.654	3.344	848.68	759.95	74.971	4.344
7	966.34	7.131	2.736	991.41	848.68	138.139	5.127
8	1072.42	0.265	4.3	1124.5	991.41	253.549	70.137
9	1138	1.858	0.204	1166.93	1126.43	68.632	0.754
10	1228.66	1.084	3.752	1355.96	1168.86	263.189	21.033
11	1373.32	10.184	0.17	1386.82	1355.96	30.512	0.119
12	1413.82	9.343	0.75	1440.83	1386.82	54.668	0.872
13	1485.19	7.057	2.973	1514.12	1440.83	78.764	5.454
14	1537.27	8.056	1.044	1548.84	1514.12	36.629	0.865
15	1571.99	6.923	1.526	1610.56	1548.84	69.145	2.767
16	1622.13	8.03	0.439	1705.07	1610.56	98.282	0.016
17	1849.73	9.99	0.049	1861.31	1820.8	40.429	0.04
18	2366.66	7.779	0.443	2393.66	2349.3	48.535	0.476
19	2852.72	3.086	1.827	2877.79	2395.59	557.029	3.546
20	2924.09	1.5	3.283	3001.24	2879.72	178.423	18.25
21	3421.72	2.759	2.006	3641.6	3003.17	916.536	74.435
22	3649.32	4.668	0.108	3668.61	3643.53	33.043	0.11

Comment;
TC+RBBR

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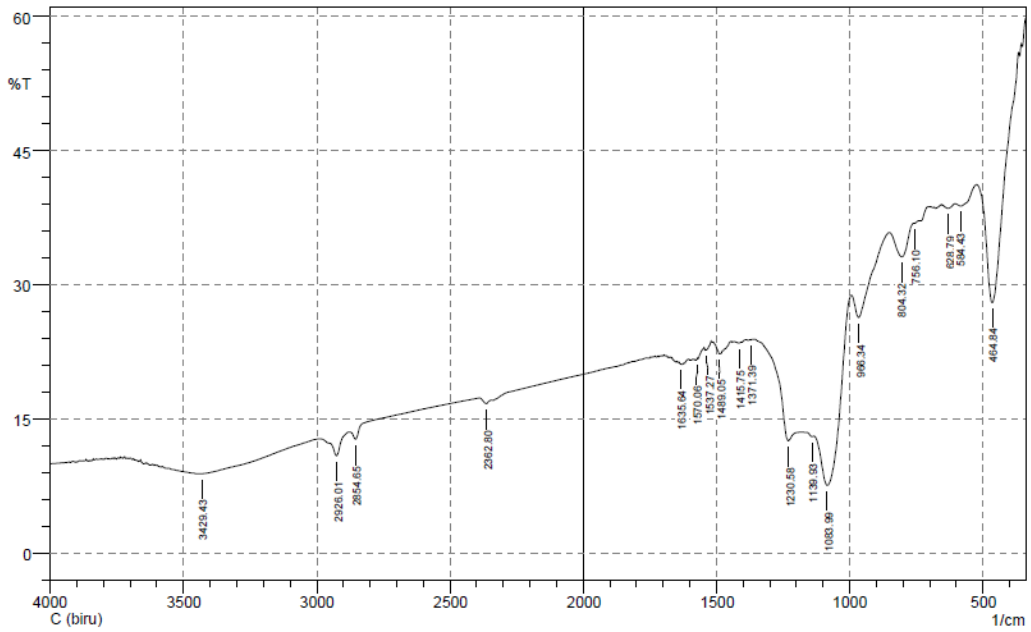
Resolution;
Apodization;

MCM-41-C+RBBR



No.	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	464.84	28.037	18.663	522.71	366.48	64.206	14.472
2	584.43	38.84	0.806	605.65	522.71	33.37	0.505
3	628.79	38.587	0.422	650.01	605.65	18.257	0.122
4	756.1	36.897	0.057	759.95	736.81	9.979	0
5	804.32	33.159	3.241	850.61	759.95	41.665	1.861
6	966.34	26.401	3.805	993.34	850.61	73.053	2.787
7	1083.99	7.638	11.028	1132.21	995.27	120.31	23.39
8	1139.93	13.09	0.092	1184.29	1134.14	43.775	0.032
9	1230.58	12.62	3.705	1354.03	1186.22	124.998	3.349
10	1371.39	23.877	0.042	1375.25	1361.74	8.39	0.004
11	1415.75	23.531	0.036	1417.68	1406.11	7.264	0.005
12	1489.05	22.337	0.874	1514.12	1469.76	28.44	0.339
13	1537.27	22.776	0.102	1539.2	1519.91	12.264	0.047
14	1570.06	21.787	0.162	1571.99	1546.91	16.299	0.025
15	1635.64	21.196	0.06	1641.42	1633.71	5.184	0.004
16	2362.8	16.754	0.51	2389.8	2343.51	35.563	0.273
17	2854.65	12.787	0.974	2875.86	2391.73	388.156	0.526
18	2926.01	10.939	2.322	2987.74	2877.79	99.596	2.965
19	3429.43	8.949	0.025	3431.36	2989.66	428.876	1.384

Comment;
C (biru)

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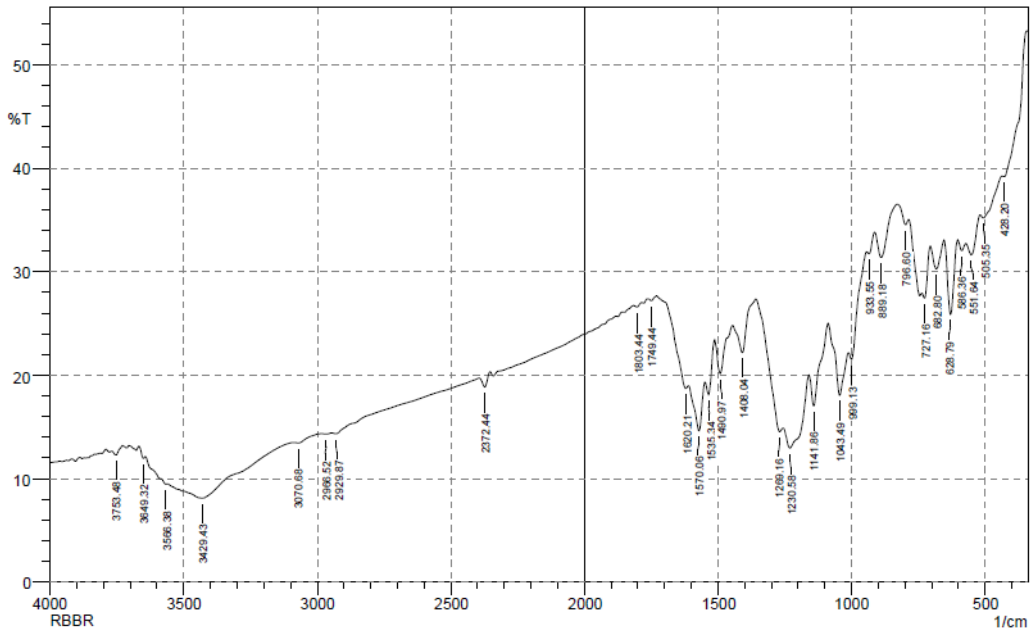
No. of Scans;
Resolution;
Apodization;

RBBR



	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	428.2	39.187	1.217	435.91	343.33	33.25	1.775
2	505.35	35.191	0.82	516.92	435.91	35.202	0.513
3	551.64	31.637	2.064	570.93	516.92	25.997	0.74
4	586.36	32.037	0.863	601.79	570.93	15.081	0.181
5	628.79	25.892	7.185	653.87	601.79	27.6	2.578
6	682.8	30.265	2.463	704.02	653.87	25.244	0.947
7	727.16	27.442	1.816	736.81	704.02	17.521	0.429
8	796.6	34.546	0.903	827.46	785.03	19.124	0.182
9	889.18	31.374	3.185	912.33	827.46	39.927	1.387
10	933.55	31.712	0.807	943.19	912.33	15.064	0.148
11	999.13	21.527	2.309	1010.7	943.19	39.23	0.405
12	1043.49	18.069	5.308	1087.85	1010.7	52.089	3.634
13	1141.86	17.044	4.196	1159.22	1087.85	49.205	2.812
14	1230.58	12.955	3.27	1255.66	1159.22	80.145	6.583
15	1269.16	14.534	2.002	1357.89	1255.66	71.356	0.301
16	1408.04	22.185	3.704	1444.68	1357.89	52.67	1.971
17	1490.97	20.149	3.716	1512.19	1444.68	43.722	2.02
18	1535.34	18.116	2.715	1548.84	1512.19	25.657	1.024
19	1570.06	14.635	4.561	1610.56	1548.84	47.691	3.371
20	1620.21	18.721	1.023	1714.72	1610.56	66.24	-0.673
21	1749.44	27.198	0.318	1764.87	1730.15	19.529	0.081
22	1803.44	26.59	0.26	1815.02	1786.08	16.571	0.062
23	2372.44	18.868	1.178	2393.66	2353.16	28.796	0.509
24	2929.87	14.33	0.247	2945.3	2393.66	422.35	-4.034
25	2966.52	14.308	0.068	2983.88	2945.3	32.53	0.04
26	3070.68	13.446	0.196	3088.03	2983.88	89.262	0.04
27	3429.43	8.129	2.467	3558.67	3088.03	464.407	19.505
28	3566.38	9.456	0.164	3583.74	3560.59	23.528	0.099
29	3649.32	11.941	0.436	3666.68	3643.53	21.017	0.208
30	3753.48	12.288	0.561	3766.98	3730.33	32.938	0.366

Comment;
RBBR

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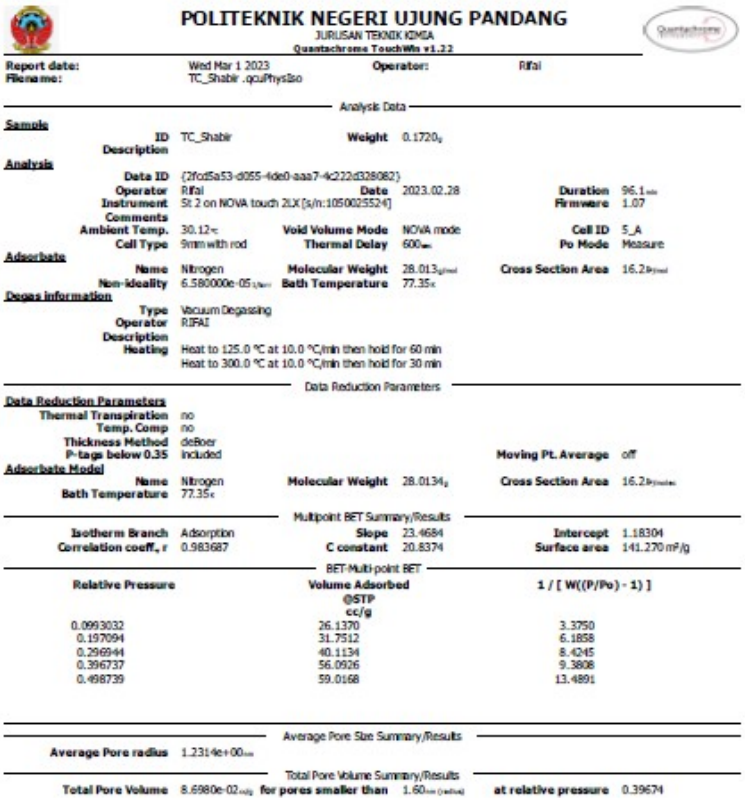
Resolution;
Apodization;

Lampiran 5. Karakterisasi BET



POLITEKNIK NEGERI UJUNG PANDANG
JURUSAN TEKNIK KIMIA
Quantachrome TouchWin v1.22

Report date: Wed Mar 1 2023 **Operator:** Rifai
Filename: TC_Shabir .qcuPhys1so

Analysis Data

Sample
ID TC_Shabir Weight 0.1720g
Description
Analysis
Data ID {2fcd5a53-d055-4de0-aaa7-4c222d328082}
Operator Rifai Date 2023.02.28 Duration 96.1min
Instrument St 2 on NOVA touch 2LX [s/n:1050025524] Firmware 1.07
Comments
Ambient Temp. 30.12°c Void Volume Mode NOVA mode Cell ID 5_A
Cell Type 9mm with rod Thermal Delay 600sec Po Mode Measure
Adsorbate
Name Nitrogen Molecular Weight 28.013g/mol Cross Section Area 16.2Å²/mol
Non-ideality 6.580000e-05 1/torr Bath Temperature 77.35K
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 Moving Pt. Average off
Adsorbate Model
Name Nitrogen Molecular Weight 28.0134g Cross Section Area 16.2Å²/molec
Bath Temperature 77.35K

Multipoint BET Summary/Results

Isotherm Branch Adsorption Slope 23.4684 Intercept 1.18304
Correlation coeff., r 0.983687 C constant 20.8374 Surface area 141.270 m²/g

BET Multi-point BET

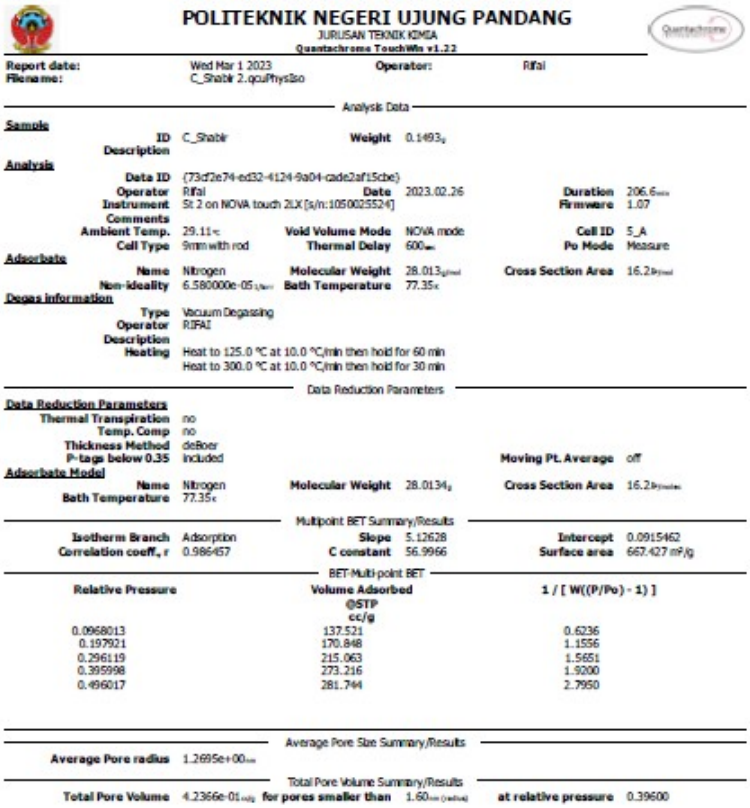
Relative Pressure	Volume Adsorbed @STP cc/g	1 / [W((P/Po) - 1)]
0.0993032	26.1370	3.3750
0.197094	31.7512	6.1858
0.296944	40.1134	8.4245
0.396737	56.0926	9.3808
0.498739	59.0168	13.4891

Average Pore Size Summary/Results

Average Pore radius 1.2314e+00nm

Total Pore Volume Summary/Results

Total Pore Volume 8.6980e-02cc/g for pores smaller than 1.60nm (radius) at relative pressure 0.39674



POLITEKNIK NEGERI UJUNG PANDANG
JURUSAN TEKNIK KIMIA
Quantachrome TouchWin v1.22

Report date: Wed Mar 1 2023 **Operator:** Rifai
Filename: C_Shabir 2.qcuPhys1so

Analysis Data

Sample
ID C_Shabir Weight 0.1493g
Description
Analysis
Data ID {73cf2e74-ed32-4124-9a04-cade2af15cbe}
Operator Rifai Date 2023.02.26 Duration 206.6min
Instrument St 2 on NOVA touch 2LX [s/n:1050025524] Firmware 1.07
Comments
Ambient Temp. 29.11°c Void Volume Mode NOVA mode Cell ID 5_A
Cell Type 9mm with rod Thermal Delay 600sec Po Mode Measure
Adsorbate
Name Nitrogen Molecular Weight 28.013g/mol Cross Section Area 16.2Å²/mol
Non-ideality 6.580000e-05 1/torr Bath Temperature 77.35K
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 Moving Pt. Average off
Adsorbate Model
Name Nitrogen Molecular Weight 28.0134g Cross Section Area 16.2Å²/molec
Bath Temperature 77.35K

Multipoint BET Summary/Results

Isotherm Branch Adsorption Slope 5.12628 Intercept 0.0915462
Correlation coeff., r 0.986457 C constant 56.9966 Surface area 667.427 m²/g

BET Multi-point BET

Relative Pressure	Volume Adsorbed @STP cc/g	1 / [W((P/Po) - 1)]
0.0968013	137.521	0.6236
0.197921	170.848	1.1556
0.296119	215.063	1.5651
0.395998	273.216	1.9200
0.496017	281.744	2.7950

Average Pore Size Summary/Results

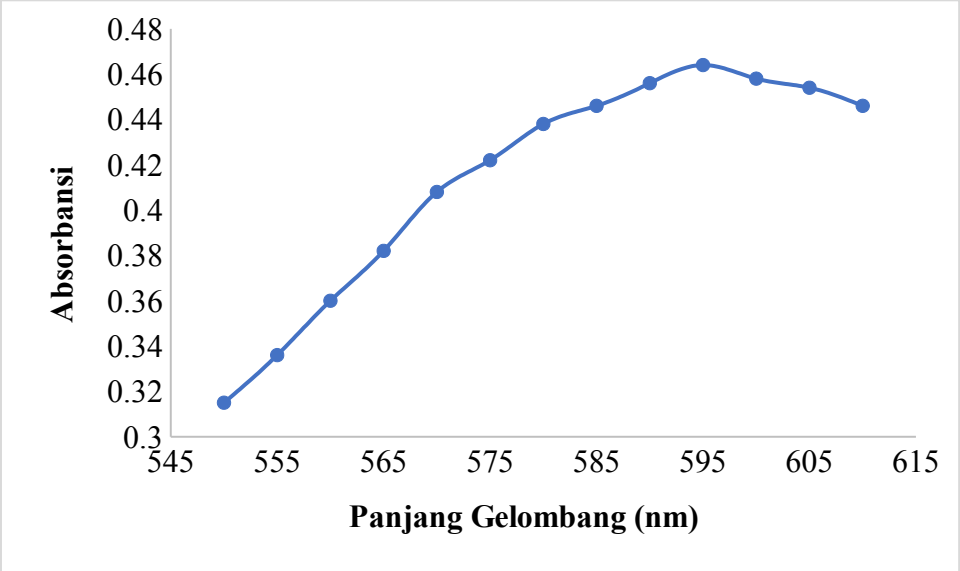
Average Pore radius 1.2695e+00nm

Total Pore Volume Summary/Results

Total Pore Volume 4.2366e-01cc/g for pores smaller than 1.60nm (radius) at relative pressure 0.39600

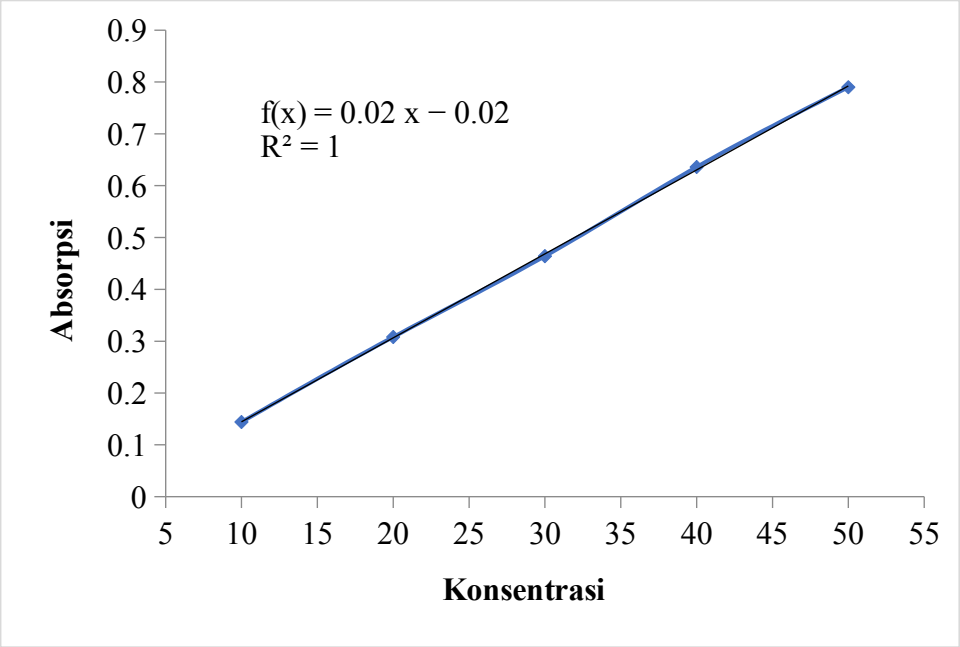
Lampiran 6. Data penentuan panjang gelombang maksimum RBBR dengan konsentrasi 30 mg/L.

Panjang gelombang (nm)	Absorbansi
550	0,315
555	0,336
560	0,360
565	0,382
570	0,408
575	0,422
580	0,438
585	0,446
590	0,456
595	**0,464**
600	0,458
605	0,454
610	0,446



Lampiran 7. Data absorbansi kurva standar larutan RBBR

Konsentrasi (ppm)	absorbansi
10	0.144
20	0.308
30	0.464
40	0.636
50	0.79



Lampiran 8. Penentuan waktu optimum adsorpsi zat warna RBBR oleh MCM-41-TC

Waktu kontak (menit)	C_o (mg/L)	C_e (mg/L)	Jumlah adsorben (g)	Jumlah RBBR yang diadsorpsi, q_e (mg/g)
5	200	29,25	0,1	85,375
10	200	18,75	0,1	90,625
15	200	11,125	0,1	94,4375
30	200	8,9375	0,1	95,53125
45	200	6,8125	0,1	96,59375
60	200	6,375	0,1	96,8125
90	200	5,625	0,1	97,1875
120	**200**	**4,3125**	**0,1**	**97,84375**
180	200	5,3125	0,1	97,34375
270	200	5,875	0,1	97,0625

Contoh perhitungan RBBR yang teradsorpsi pada t = 120 menit

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

$$q_e = \frac{(200\ \text{mg/L} - 4{,}3125\ \text{mg/L})\,0{,}05\ \text{L}}{0{,}1\ \text{g}}$$

$q_e = 97{,}84375$ mg/g

Lampiran 9. Data studi kinetika adsorpsi RBBR 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	85,375	97,84375	12,46875	2,523225514	0,058565154
10	90,625	97,84375	7,21875	1,976681808	0,110344828
15	94,4375	97,84375	3,40625	1,225611979	0,158835208
30	95,53125	97,84375	2,3125	0,83832919	0,314033366
45	96,59375	97,84375	1,25	0,223143551	0,465868651
60	96,8125	97,84375	1,03125	0,030771659	0,61975468
90	97,1875	97,84375	0,65625	-0,42121346	0,926045016
120	97,84375	97,84375	0	0	1,226445225

Dari grafik kinetika orde satu semu diperoleh persamaan garis :

$$y = -0,0212x + 1,7927$$

dari persamaan garis diperoleh nilai *slope* (a) = -0,0212 dan nilai *intercept* (b) = 1,7927

nilai k_1 dapat dihitung sebagai berikut :

K = -Slope

$k_1 = 0,0212$ menit^{-1};

log q_e = *intercept*

log $q_e = 1,7927$

$q_e = 62,0440$ mg/g

$R^2 = 0,6975$

Dari grafik kinetika orde dua semu diperoleh persamaan garis :

$$y = 0{,}0102x + 0{,}0082$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,0102 dan nilai *intercept* (b) = 0,0082

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

$$q_e = \frac{1}{\text{slop e}} = \frac{1}{0{,}0102} = 98{,}0392 \text{ mg/g}$$

nilai k_2 dapat dihitung sebagai berikut :

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

$k_2 = (0{,}0102)^2/0{,}0082$

$= 0{,}01268 \text{ g/mg min}^{-1}$

$R^2 = 1$

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

Waktu kontak (menit)	C_o (mg/L)	C_e (mg/L)	Jumlah adsorben (g)	Jumlah RBBR yang diadsorpsi, q_e (mg/g)
5	200	29,75	0,1	85,125
10	200	28,5625	0,1	85,71875
15	200	25,0625	0,1	87,46875
30	200	20,875	0,1	89,5625
45	200	15,3125	0,1	92,34375
60	200	12,125	0,1	93,9375
90	200	8,6875	0,1	95,65625
120	**200**	**7,375**	**0,1**	**96,3125**
180	200	9,25	0,1	95,375
270	200	10,5	0,1	94,75

Contoh perhitungan RBBR yang teradsorpsi pada t = 120 menit

$$q_e = \frac{(C0 - Ce)V}{m}$$

$$q_e = \frac{(200\ mg/L - 7,375\ mg/L)0,05\ L}{0,1\ g}$$

q_e= 96,3125 mg/g

Lampiran 11. Data studi kinetika adsorpsi RBBR 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	85,125	96,3125	11,1875	2,41479708	0,05873715
10	85,71875	96,3125	10,59375	2,36026420	0,11666059
15	87,46875	96,3125	8,84375	2,17971099	0,17148981
30	89,5625	96,3125	6,75	1,90954250	0,33496161
45	92,34375	96,3125	3,96875	1,37845118	0,487309645
60	93,9375	96,3125	2,375	0,86499743	0,63872255
90	95,65625	96,3125	0,65625	-0,42121346	0,94086899
120	96,3125	96,3125	0	0	1,24594419

Dari grafik kinetika orde satu semu diperoleh persamaan garis :

$$y = -0,0254x + 2,5249$$

dari persamaan garis diperoleh nilai *slope* (a) = -0,0254 dan nilai *intercept* (b) = 2,5249

nilai k_1 dapat dihitung sebagai berikut :

k_1 = -slope

$k_1 = 0,0254$ menit^{-1};

log q_e = *intercept*

log $q_e = 2,5249$

$q_e = 334,8883$ mg/g

$R^2 = 0,9091$

Dari grafik kinetika orde dua semu diperoleh persamaan garis :

$$y = 0{,}0103x + 0{,}0175$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,0103 dan nilai *intercept* (b) = 0,0175

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

$$q_e = \frac{1}{\text{slop e}} = \frac{1}{0{,}0103} = 97{,}0873 \text{ mg/g}$$

nilai k_2 dapat dihitung sebagai berikut :

$_2$ = Slope^2/ *intercept*

$k_2 = (0{,}0103)^2 / 0{,}0175$

$= 0{,}006062 \text{ g/mg min}^{-1}$

$R^2 = 0{,}9998$

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

C_O (mg/L)	C_e (mg/L)	m (g)	q_e (mg/g)	C_e/q_e	log C_e	log q_e
253,125	6,5625	0,1	123,28125	0,053231	-1,27382	2,090897
304,375	11,3125	0,1	146,53125	0,077201	-1,11237	2,165930
356,875	12,75	0,1	172,0625	0,074100	-1,13017	2,235686
444,375	35	0,1	204,6875	0,170992	-0,76702	2,311091
551,25	93,75	0,1	228,75	0,409836	-0,38738	2,359361
657,5	184,375	0,1	236,5625	0,779392	-0,10824	2,373945
987,5	**503,125**	**0,1**	**242,1875**	**2,077419**	**0,317524**	**2,384151**
1425	950	0,1	237,5	4	0,602059	2,375663

Contoh perhitungan RBBR yang teradsorpsi (qe) pada konsentrasi

(C_o) 253,125 mg/L :

$$q_e = \frac{(C0 - Ce)V}{m}$$

$$q_e = \frac{(253{,}125\ \text{mg/L} - 6{,}5625\ \text{mg/L})\,0{,}05\ \text{L}}{0{,}1\ \text{g}}$$

q_e = 123,28125 mg/g

Lampiran 13. Isoterm adsorpsi MCM-41-TC

1. Isoterm adsorpsi langmuir bentuk linear

Berdasarkan model isotermal Langmuir diperoleh persamaan garis :

$$y = 0{,}0042x + 0{,}0192$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,0042 dan nilai *intercept* (b) = 0,0192

Nilai kapasitas adsorpsi dapat dihitung sebagai berikut :

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

$$Q_{maks} = \frac{1}{\text{slope}} = \frac{1}{0{,}0042} = 238{,}0952 \text{ mg/g}$$

Intensitas adsorpsi dapat dihitung sebagai berikut :

$\frac{1}{Q_{maks}.b}$ = *intercept*

$$b = \frac{1}{238{,}0952 \text{ mg/g}. \ 0{,}0192}$$

$= 0{,}2187 \text{ L mg}^{-1}$

2. Isoterm adsorpsi Freundlich bentuk linear

Berdasarkan model isotermal Freundlich diperoleh persamaan garis :

$$y = 0{,}135x + 2{,}3522$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,135 dan nilai *intercept* (b) = 2,3522

Nilai kapasitas adsorpsi dapat dihitung sebagai berikut :

Log k = *intercept*

k = invers log *intercept*

k = invers log 2,3522

k = 225,0090 mg/g

Intensitas adsorpsi dapat dihitung sebagai berikut :

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

$\frac{1}{n}$ = 0,135

3. Isoterm adsorpsi Sips bentuk linear

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

Parameter	**Nilai**
Persamaan	y = 0,825 x – 1,3507
K_s	0,1537
N	0,9906
q_{maks}	245,2298
R^2	0,9196

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qe L (mg/g)	Res^2
250	6,5625	123,28125	123,4677	0,0347
300	11,3125	146,53125	155,6431	83,0271
350	12,75	172,0625	162,2284	96,7094
450	35	204,6875	205,7866	1,2081
550	93,75	228,75	227,7455	1,0089
650	184,375	236,5625	235,0912	2,1644
975	503,125	242,1875	240,1682	4,0775
1500	950	237,5	241,5877	16,7097

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

Parameter	Nilai
K	0,1571
q_{maks}	243,2062
RSS	204,9402

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qe F (mg/g)	Res^2
250	6,5625	123,28125	153.1023	889.2984
300	11,3125	146,53125	162.5151	255.4848
350	12,75	172,0625	164.6592	54.8080
450	35	204,6875	183.9240	431.1192
550	93,75	228,75	204.8913	569.2342
650	184,375	236,5625	220.6518	253.1493
975	503,125	242,1875	246.3070	16.9708

1500	950	237,5	264.0725	706.0997

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

Parameter	Nilai
K	124,5822
N	0,1095
RSS	3176,1648

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qe S (mg/g)	Res^2
250	6,5625	123,28125	123.1478	0.01778
300	11,3125	146,53125	155.4025	78.7004
350	12,75	172,0625	162.0353	100.5440
450	35	204,6875	206.2810	2.5394
550	93,75	228,75	228.9419	0.0368
650	184,375	236,5625	236.6158	0.0028
975	503,125	242,1875	241.9712	0.0467
1500	950	237,5	243.4829	35.7952

$$q_e = \frac{qm \,.\, Ks \,.\, C_e^{1/n}}{1 + K_s \,.\, C_e^{n}}$$

Parameter	Nilai
K	0,1537
N	0,9906
q_{maks}	245,2298
RSS	217,683

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

C_O (mg/L)	**C_e (mg/L)**	**m (g)**	**q_e (mg/g)**	**C_e/q_e**	**log C_e**	**log q_e**
253.125	12.3125	0,1	120.40625	0.1022	-0.9903	2.0806
304.375	21.6875	0,1	141.34375	0.1534	-0.8140	2.1502
356.875	30.4375	0,1	163.21875	0.1864	-0.7293	2.2127
444.375	76.875	0,1	183.75	0.4183	-0.3784	2.2642
551.25	170.625	0,1	190.3125	0.8965	-0.0474	2.2794
657.5	262.5	0,1	197.5	1.3291	0.1235	2.2955
987.5	**568.75**	**0,1**	**209.375**	**2.7164**	**0.4339**	**2.3209**
1425	1021.875	0,1	201.5625	5.0697	0.7049	2.3044

Contoh perhitungan RBBR yang teradsorpsi (qe) pada konsentrasi

(C_o) 253,125 mg/L :

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

$$q_e = \frac{(253{,}125\ mg/L - 12{,}3125\ mg/L)\,0{,}05\ L}{0{,}1\ g}$$

q_e = 120,40625 mg/g

Lampiran 15. Isoterm adsorpsi MCM-41-C

1. Isoterm adsorpsi langmuir bentuk linear

Berdasarkan model isotermal Langmuir diperoleh persamaan garis :

$$y = 0{,}0049x + 0{,}0391$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,0049 dan nilai *intercept* (b) = 0,0391

Nilai kapasitas adsorpsi dapat dihitung sebagai berikut :

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

$$Q_{maks} = \frac{1}{\text{slope}} = \frac{1}{0{,}0049} = 204{,}0816 \text{ mg/g}$$

Intensitas adsorpsi dapat dihitung sebagai berikut :

$\frac{1}{Q_{maks}.b}$ = *intercept*

$$b = \frac{1}{204{,}0816 \text{ mg/g}. \ 0{,}0391}$$

$= 0{,}1253 \text{ L mg}^{-1}$

2. Isoterm adsorpsi Freundlich bentuk linear

Berdasarkan model isotermal Freundlich diperoleh persamaan garis :

$$y = 0{,}122x + 2{,}2644$$

dari persamaan garis diperoleh nilai *slope* (a) = 0,122 dan nilai *intercept* (b) = 2,2644

Nilai kapasitas adsorpsi dapat dihitung sebagai berikut :

Log k = *intercept*

k = invers log *intercept*

k = invers log 2,2644

k = 183,8230 mg/g

Intensitas adsorpsi dapat dihitung sebagai berikut :

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

$\frac{1}{n}$ = 0,122

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 = 0,7319 x – 1,4528
K_s	0,1119
N	0,8506
q_{maks}	212,7650
R^2	0,8642

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qe L (mg/g)	Res^2
250	12.3125	120.40625	119.1184	1.6584
300	21.6875	141.34375	145.5530	17.7182
350	30.4375	163.21875	158.8634	18.9684
450	76.875	183.75	184.0649	0.0992
550	170.625	190.3125	195.2179	24.0638
650	262.5	197.5	198.6729	1.3757
975	568.75	209.375	202.2523	50.7319
1500	1021.875	201.5625	203.6468	4.3446

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

Parameter	Nilai
K	0,1120
q_{maks}	205,4247
RSS	118,9605

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qe F (mg/g)	Res^2
250	12.3125	120.40625	140.4176	400.4573
300	21.6875	141.34375	148.5747	52.2868
350	30.4375	163.21875	153.6834	90.9225
450	76.875	183.75	168.5625	230.6576
550	170.625	190.3125	182.5147	60.8053
650	262.5	197.5	190.5278	48.6108
975	568.75	209.375	205.8028	12.7603
1500	1021.875	201.5625	218.1893	276.4522

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

Parameter	Nilai
K	109,3119
N	0,0997
RSS	1172,9532

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

Konsentrasi (mg/L)	Ce (mg/L)	qe (mg/g)	qe S (mg/g)	Res^2
250	12.3125	120.40625	120.8311	0.1805
300	21.6875	141.34375	144.7325	11.4837
350	30.4375	163.21875	157.3337	34.6337
450	76.875	183.75	183.3873	0.1314
550	170.625	190.3125	196.7675	41.6671
650	262.5	197.5	201.4138	15.3182
975	568.75	209.375	206.7296	6.9980
1500	1021.875	201.5625	209.0574	56.1738

$$q_e = \frac{qm \,.\, Ks \,.\, C_e^{1/n}}{1 + K_s \,.\, C_e^{n}}$$

Parameter	Nilai
K	0,1119
N	0,8506
q_{maks}	212,7650
RSS	166,5869

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

Desorpsi menggunakan agen pendesorpsi akuades (H_2O)

Adsorben	Abs	C_{des} (mg/L)	V (L)	m (g)	q_e (mg/g)	% Desorpsi
TC-MCM-41	0.364	23.8125	0.05	0.1	11.90625	4.916129032
C-MCM-41	0.853	54.375	0.05	0.1	27.1875	12.98507463

dimana:

q_{ads} MCM-41-TC = 242,1875 mg/g

q_{ads} MCM-41-C = 209,375 mg/g

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

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

$$q_{des} = \frac{23{,}8125 \ \text{mg/L}}{0{,}1 \ \text{g}} \ 0{,}05 \ \text{L}$$

q_{des} = 11,90625 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 RBBR oleh MCM-41-TC:

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

$$\%\ \text{Desorpsi} = \frac{11{,}90625 \ \text{mg/g}}{242{,}1875 \ \text{mg/g}} \times 100$$

= 4,916129032%