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Synthesis of Cu-PTC (Perylene 3,4,9,10-tetracarboxylate) Metal-Organic Framework (MOF) for Methylene Blue Photodegradation

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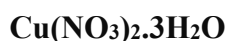
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1. Calculation

a. Precursor MOF Cu-PTC 1:0,5 mmol



$$\begin{aligned}\text{Massa} &= \text{mmol} \times \text{Mr} \\ &= 1 \text{ mmol} \times 241,63 \text{ mg/mmol} \\ &= 241,63 \text{ mg}\end{aligned}$$



$$\begin{aligned}\text{Massa} &= \text{mmol} \times \text{Mr} \\ &= 0,5 \text{ mmol} \times 516,28 \text{ mg/mmol}\end{aligned}$$

$$= 258,14 \text{ mg}$$

PTCDA

$$\text{Massa} = \text{mmol} \times \text{Mr}$$

$$= 1,27 \text{ mmol} \times 392,3 \text{ mg/mmol}$$

$$= 500 \text{ mg}$$

NaOH

$$\text{Massa} = \text{mmol} \times \text{Mr}$$

$$= 8,9 \text{ mmol} \times 40 \text{ mg/mmol}$$

$$= 356 \text{ mg}$$

b. NaOH 0,5N

$$M = \frac{m}{Mr} \times \frac{1000}{v}$$

$$m = \frac{M \times Mr \times v}{1000}$$

$$m = \frac{0,5 \times 40 \times 100}{1000}$$

$$m = 2 \text{ gram}$$

c. Concentration of methylene blue

- **25 ppm**

$$V_1 \times M_1 = V_2 \times M_2$$

$$V_1 \times 100 = 250 \times 25$$

$$V_1 = \frac{250 \times 25}{100}$$

$$V_1 = 62,5 \text{ mL}$$

- **50 ppm**

$$V_1 \times M_1 = V_2 \times M_2$$

$$V_1 \times 100 = 250 \times 50$$

$$V_1 = \frac{250 \times 50}{100}$$

$$V_1 = 125 \text{ mL}$$

- **75 ppm**

$$V_1 \times M_1 = V_2 \times M_2$$

$$V_1 \times 100 = 250 \times 75$$

$$V_1 = \frac{250 \times 75}{100}$$

$$V_1 = 187,5 \text{ mL}$$

- **100 ppm**

$$100 \text{ ppm} = 100 \text{ mg/L}$$

$$\text{Mass} = 100 \text{ mg/L} \times 0,5\text{L}$$

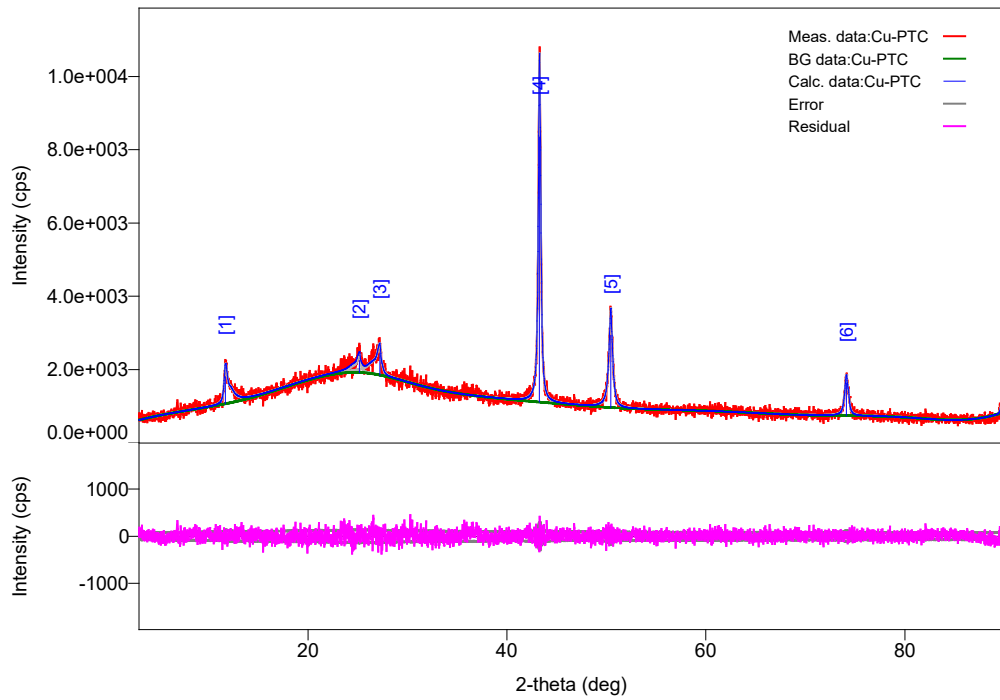
$$\text{Mass} = 50 \text{ mg}$$

2. Activity Documentation



Photocatalytic activity test

3. Diffraction Pattern of Cu-PTC MOF



Peak List

MOF Cu-PTC	
$2\theta(^{\circ})$	FWHM ($^{\circ}$)
11.705(8)	0.47(3)
25.17(2)	0.51(7)
27.22(2)	0.57(7)
43.266(7)	0.242(8)
50.443(11)	0.36(2)
74.12(2)	0.35(3)
89.933(18)	0.33(4)

$$\beta = \text{FWHM} \times \frac{\pi}{180} = 0,242 \times \frac{3,14}{180} = 0,0042215556$$

$$2\theta = 43.266 \rightarrow \theta = \frac{43.266}{2} = 21,633$$

$$D = \frac{K \times \lambda}{\beta \cos \theta} = \frac{0,9 \times 0,15406}{0,0042215556 \cos 21,633} = 35,33 \text{ nm}$$

$$\text{Degree of crystallinity} = \frac{\text{Main diffraction peak area}}{\text{The total area of the peak}}$$

$$= \frac{51664,05}{60527,92} \times 100$$

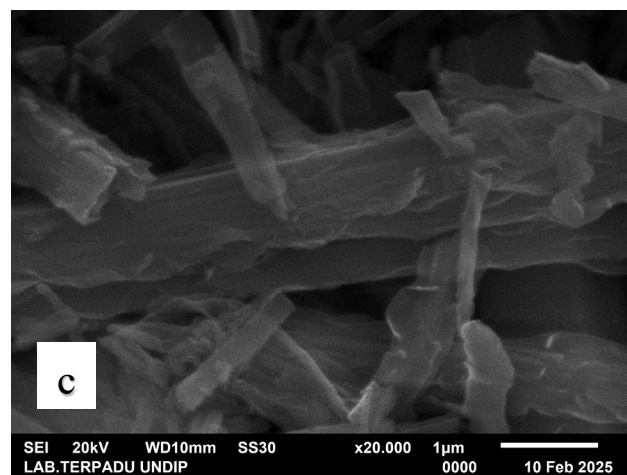
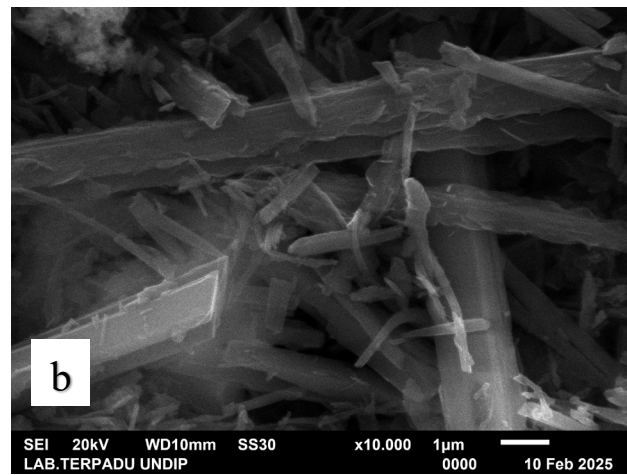
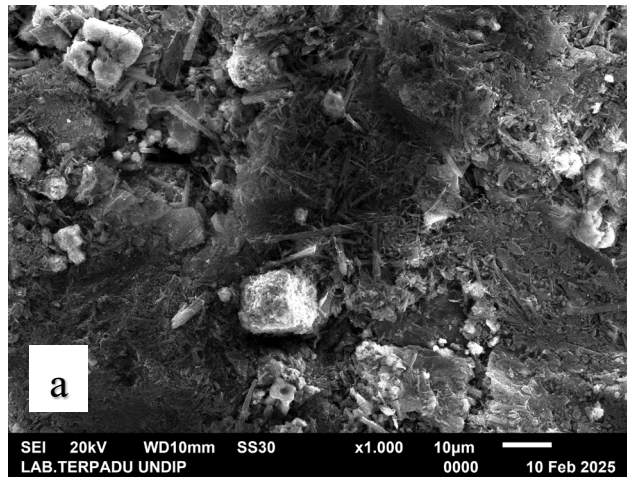
$$= 85,35\%$$

4. Determination of Band Gap Energy Value of Cu-PTC MOF

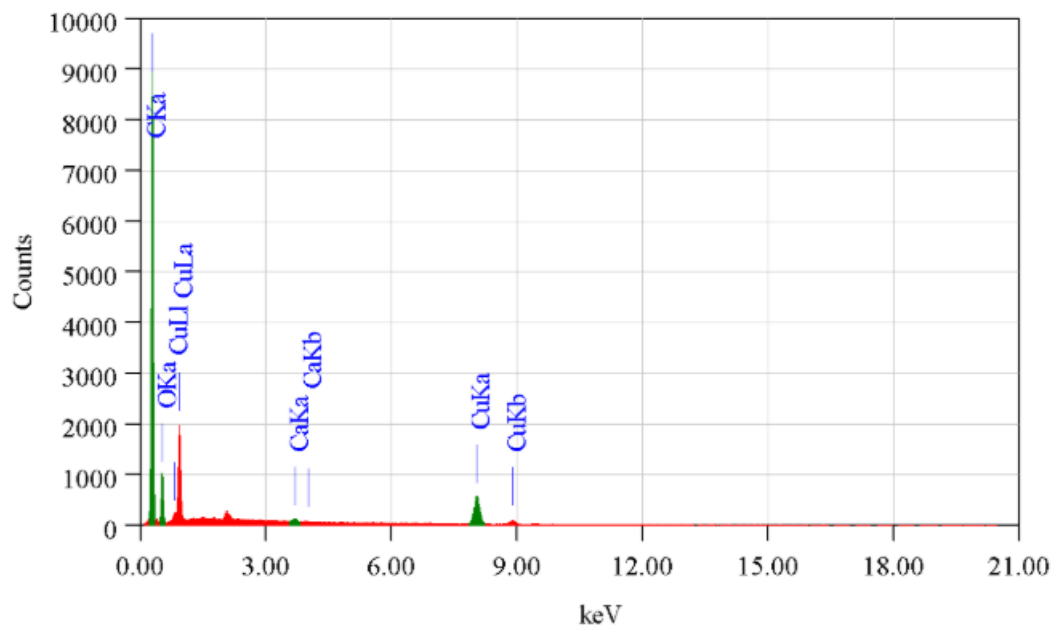
λ (nm)	Abs (%)	R	(1-R) ²	2R	F(R)	h ν	F(R)h ν	(F(R)h ν) ²
200	26,752	0,267523	0,536522	0,535047	1,002757	6,199919	6,217012	38,65124
200,99	24,448	0,244482	0,570807	0,488964	1,167381	6,169349	7,20198	51,86852
201,98	25,085	0,250854	0,56122	0,501708	1,118618	6,13908	6,867285	47,1596
203,02	27,381	0,27381	0,527352	0,54762	0,962989	6,107918	5,881856	34,59623
204,01	29,257	0,292569	0,500459	0,585137	0,855285	6,078253	5,198637	27,02583
205	25,627	0,256271	0,553133	0,512542	1,079197	6,048876	6,527928	42,61384
205,99	27,409	0,274093	0,526941	0,548186	0,961244	6,019785	5,786484	33,48339
207,02	26,757	0,267567	0,536457	0,535135	1,002471	5,989828	6,004631	36,0556
208,01	27,309	0,273087	0,528402	0,546174	0,967461	5,961305	5,767329	33,26209
209	25,66	0,256601	0,552642	0,513201	1,076853	5,933054	6,389026	40,81965
209,99	23,516	0,235164	0,584974	0,470329	1,243755	5,905073	7,344462	53,94111
211,02	24,024	0,240245	0,577228	0,48049	1,201332	5,876253	7,059328	49,83411
212,01	26,61	0,266095	0,538616	0,53219	1,012075	5,848808	5,919432	35,03968
213	23,936	0,239358	0,578576	0,478716	1,208599	5,82162	7,036005	49,50537
213,99	23,959	0,239591	0,578222	0,479182	1,206685	5,794686	6,992362	48,89312
215,02	26,426	0,264262	0,54131	0,528525	1,024191	5,76694	5,906445	34,8861
216,01	24,73	0,247297	0,566562	0,494593	1,145512	5,740513	6,575825	43,24148
217	23,667	0,236673	0,582668	0,473346	1,230957	5,714329	7,034093	49,47847
217,99	22,651	0,226515	0,598279	0,45303	1,320617	5,688385	7,512178	56,43282
219,02	24,956	0,249563	0,563155	0,499126	1,128283	5,661654	6,387945	40,80585
220,01	24,422	0,244223	0,571198	0,488447	1,169418	5,636189	6,591059	43,44206
221	23,008	0,230083	0,592772	0,460166	1,288169	5,610955	7,227855	52,24189
221,99	23,429	0,234288	0,586315	0,468576	1,251269	5,585946	6,989523	48,85344
223,01	22,952	0,229522	0,593636	0,459044	1,2932	5,560177	7,19042	51,70214
224	23,858	0,238578	0,579763	0,477157	1,215036	5,535623	6,725979	45,23879
224,99	22,676	0,226764	0,597894	0,453527	1,318321	5,511288	7,265644	52,78958
225,98	23,859	0,238587	0,57975	0,477173	1,214969	5,487166	6,666737	44,44538
227,01	23,819	0,238189	0,580356	0,476378	1,218268	5,462306	6,654555	44,2831
228	23,394	0,233944	0,586842	0,467887	1,254238	5,438616	6,821321	46,53043
228,99	23,113	0,231131	0,59116	0,462261	1,278843	5,415131	6,925105	47,95708
230,02	24,023	0,240234	0,577244	0,480468	1,201421	5,390925	6,476769	41,94854
231	19,82	0,198203	0,642878	0,396406	1,621767	5,367854	8,705406	75,7841
231,99	20,499	0,204988	0,632045	0,409975	1,541666	5,344982	8,240179	67,90055
232,98	26,587	0,265866	0,538953	0,531731	1,013583	5,322306	5,394597	29,10167
234,01	22,908	0,229083	0,594312	0,458167	1,297153	5,298928	6,873519	47,24527
235	30,18	0,301795	0,48749	0,60359	0,807651	5,276644	4,261686	18,16197
235,99	19,169	0,191692	0,653362	0,383384	1,704199	5,25455	8,954798	80,18841
237,01	30,535	0,305347	0,482542	0,610695	0,790154	5,231768	4,1339	17,08913
238	24,224	0,242244	0,574194	0,484489	1,185154	5,21005	6,174712	38,12707
238,99	19,745	0,197447	0,644092	0,394894	1,63105	5,188514	8,462728	71,61777
240,02	24,227	0,242273	0,57415	0,484547	1,184922	5,166307	6,121669	37,47483
241	17,119	0,171191	0,686925	0,342381	2,006317	5,145134	10,32277	106,5595
241,99	19,888	0,198884	0,641786	0,397768	1,613467	5,124136	8,267627	68,35365
243,02	18,745	0,187449	0,660239	0,374898	1,761118	5,102482	8,986074	80,74953
244,01	18,495	0,184951	0,664306	0,369901	1,7959	5,081833	9,126466	83,29239

5. Surface Morphology of Cu-PTC MOF

Surface morphology of Cu-PTC MOF magnification (a) 1000x; (b) 10,000x; (c) 20,000x



6. Composition of Elements of Cu-PTC MOF



Elements	% Mass	% Atom
C	74,26	83,47
O	17,51	14,78
Cu	8,14	1,73
Impurities	0,08	0,03

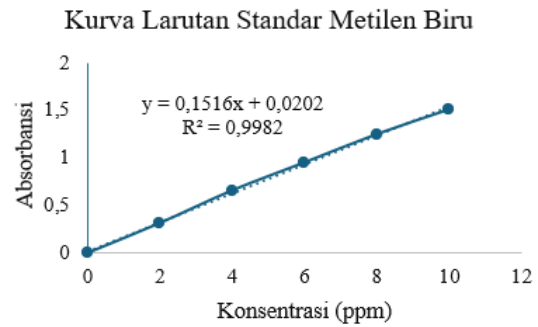
7. Degradation Efficiency and Degradation Capacity of Cu-PTC MOF

$$\text{Degradation Efficiency (\%)} = \frac{C_0 - C_t}{C_0} \times 100\%$$

$$\text{Degradation Capacity (Q)} \left(\frac{\text{mg}}{\text{g}}\right) = \frac{C_0 - C_t \left(\frac{\text{mg}}{\text{L}}\right)}{\text{mg}} \times V \text{ (L)}$$

a. Calibration curve of methylene blue dye

Concentration (ppm)	Absorbance
0	0
2	0,314
4	0,656
6	0,949
8	1,246
10	1,505



b. Preliminary test of photocatalytic activity of Cu-PTC MOF

- Light test of Cu-PTC MOF with mass 25 mg, pH 7, MB volume 50 mL, concentration 50 ppm

t (minutes)	Abs	C _t (ppm)	%DE	Q (mg/g)
0	1,575	51,2797	0,0000	0,0000
15	0,881	28,3905	44,6360	45,7784
30	0,587	18,6939	63,5452	65,1715
45	0,546	17,3417	66,1821	67,876
60	0,464	14,6372	71,4561	73,285

$$\text{DE (\%)} = \frac{C_0 - C_t}{C_0} \times 100\%$$

$$= \frac{51,2797 - 14,6372}{51,2797} \times 100\% = 71,4561\%$$

$$Q \left(\frac{\text{mg}}{\text{g}}\right) = \frac{C_0 - C_t \left(\frac{\text{mg}}{\text{L}}\right)}{\text{mg}} \times V \text{ (L)}$$

$$= \frac{(51,2797 - 14,6372)}{0,025} \times 0,05 = 73,285 \left(\frac{\text{mg}}{\text{g}}\right)$$

- Dark test of Cu-PTC MOF with mass 25 mg, pH 7, MB volume 50 mL, concentration 50 ppm

t (minutes)	Abs	C _t (ppm)	%DE	Q (mg/g)
0	1,638	53,3575	0,0000	0,0000
15	1,228	39,8351	25,3431	27,0449
30	1,144	37,0646	30,5353	32,5858
45	0,842	27,1042	49,2026	52,5066
60	0,928	29,9406	43,8868	46,8338

$$DE (\%) = \frac{C_0 - C_t}{C_0} \times 100\%$$

$$= \frac{53,3575 - 29,9406}{53,3575} \times 100\% = 43,8868\%$$

$$Q \left(\frac{mg}{g}\right) = \frac{C_0 - C_t \left(\frac{mg}{L}\right)}{mg} \times V (L)$$

$$= \frac{(53,3575 - 29,9406)}{0,025} \times 0,05 = 46,8338 \left(\frac{mg}{g}\right)$$

c. Concentration variation with Cu-PTC MOF photocatalyst mass 25 mg, pH 7, MB volume 50 mL

C ₀ (ppm)	t (minutes)	Abs	C _t (ppm)	%DE	Q (mg/g)
25	0	0,776	24,9274	0,0000	0,0000
	15	0,372	11,6029	53,4533	26,6491
	30	0,249	7,5462	69,7274	34,7625
	45	0,211	6,2929	74,7552	37,2691
	60	0,19	5,6003	77,5337	38,6544
50	0	1,575	51,2797	0,0000	0,0000
	15	0,881	28,3905	44,6360	45,7784
	30	0,587	18,6939	63,5452	65,1715
	45	0,546	17,3417	66,1821	67,876
	60	0,464	14,6372	71,4561	73,285
75	0	2,287	74,7625	0,0000	0,0000
	15	1,739	56,6887	24,1750	36,1478
	30	1,587	51,6755	30,8805	46,1741
	45	1,365	44,3536	40,6741	60,8179
	60	1,277	41,4512	44,5562	66,6227
100	0	2,933	96,0686	0,0000	0,0000
	15	2,313	75,6201	21,2854	40,8971
	30	2,068	67,5396	29,6965	57,058
	45	2,006	65,4947	31,8250	61,1478

	60	1,95	63,6478	33,7476	64,8417
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d. Variation of Cu-PTC MOF photocatalyst mass with pH 7, MB volume 50 mL concentration 50 ppm

Mass (mg)	t (minutes)	Abs	C _t (ppm)	%DE	Q (mg/g)
15	0	1,549	50,4222	0,0000	0,0000
	15	1,128	36,5369	27,5379	46,2841
	30	0,947	30,5673	39,3773	66,1829
	45	0,935	30,1715	40,1622	67,5022
	60	0,901	29,0501	42,3862	71,2401
25	0	1,575	51,2797	0,0000	0,0000
	15	0,881	28,3905	44,6360	45,7784
	30	0,587	18,6939	63,5452	65,1715
	45	0,546	17,3417	66,1821	67,876
	60	0,464	14,6372	71,4561	73,285
35	0	1,535	49,9604	0,0000	0,0000
	15	0,866	27,8958	44,1642	31,5209
	30	0,608	19,3865	61,1962	43,677
	45	0,519	16,4512	67,0716	47,8703
	60	0,439	13,8127	72,3528	51,6397
45	0	1,498	48,7401	0,0000	0,0000
	15	0,517	16,3852	66,3825	35,9499
	30	0,277	8,4697	82,6228	44,7449
	45	0,205	6,0950	87,4949	47,3835
	60	0,197	5,8311	88,0363	47,6766

e. pH variation with Cu-PTC MOF photocatalyst mass 25 mg, MB volume 50 mL, concentration 50 ppm

pH	t (minutes)	Abs	C _t (ppm)	%DE	Q (mg/g)
5	0	1,645	53,5884	0,0000	0,0000
	15	1,296	42,0778	21,4796	23,0211
	30	1,432	46,5633	13,1093	14,0501
	45	1,487	48,3773	9,7243	10,4222
	60	1,486	48,3443	9,7858	10,4881
7	0	1,575	51,2797	0,0000	0,0000
	15	0,881	28,3905	44,6360	45,7784
	30	0,587	18,6939	63,5452	65,1715
	45	0,546	17,3417	66,1821	67,876
	60	0,464	14,6372	71,4561	73,285
9	0	1,516	49,3338	0,0000	0,0000
	15	0,948	30,6003	37,9730	37,467
	30	0,744	23,8720	51,6112	50,9235
	45	0,593	18,8918	61,7061	60,8839
	60	0,505	15,9894	67,5892	66,6887

f. Methylene blue photolysis test results with a volume of 50 mL MB at a concentration of 50 ppm

pH	t (minutes)	Abs	C_t (ppm)	%DE	Q (mg/g)
7	0	1,524	49,5976	0,0000	0,0000
	15	1,452	47,2230	4,7879	4,7493
	30	1,42	46,1675	6,9158	6,8602
	45	1,391	45,2111	8,8443	8,7731
	60	1,43	46,4974	6,2508	6,2005