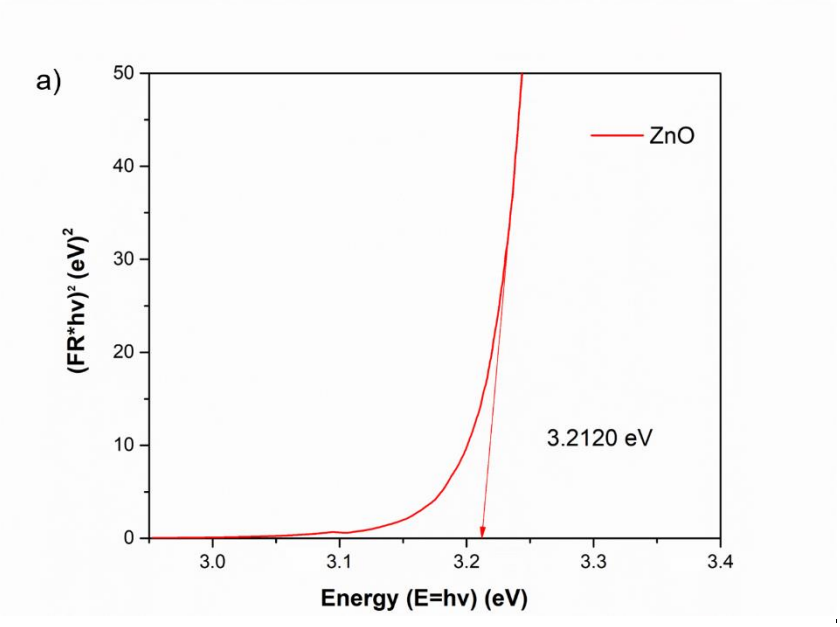
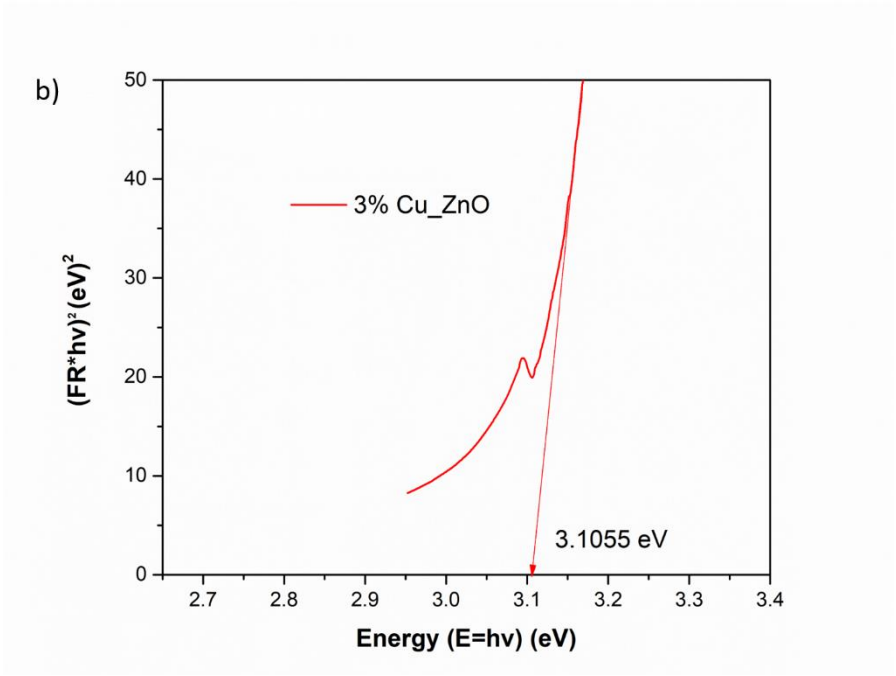
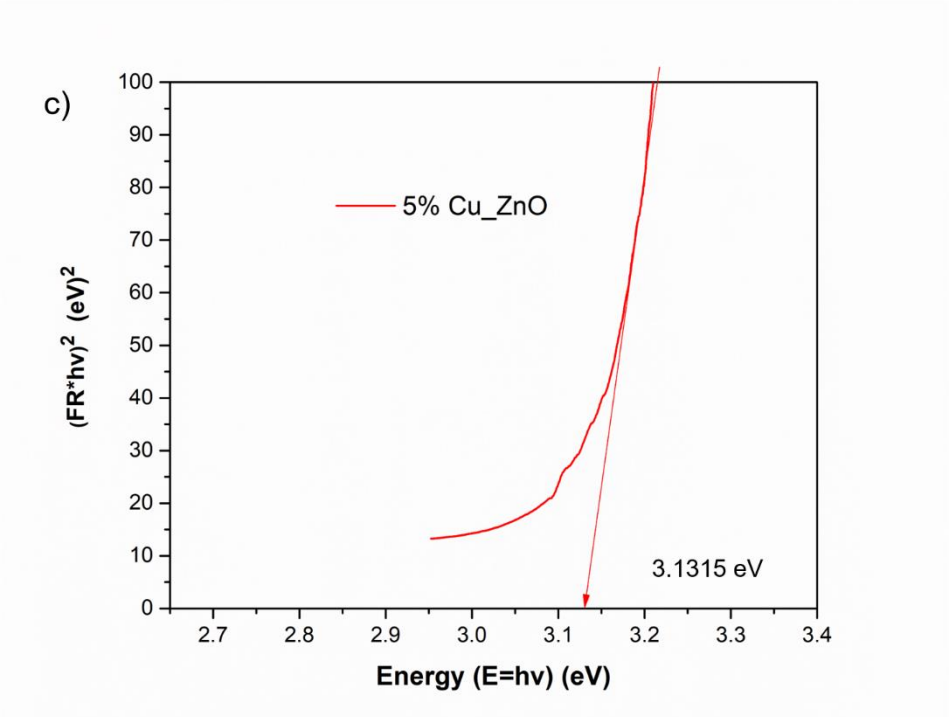
Fabrication and characterization of Cu–ZnO–cellulose acetate electrospun nanocomposite membranes for dual-function photocatalytic degradation and microbial inhibition

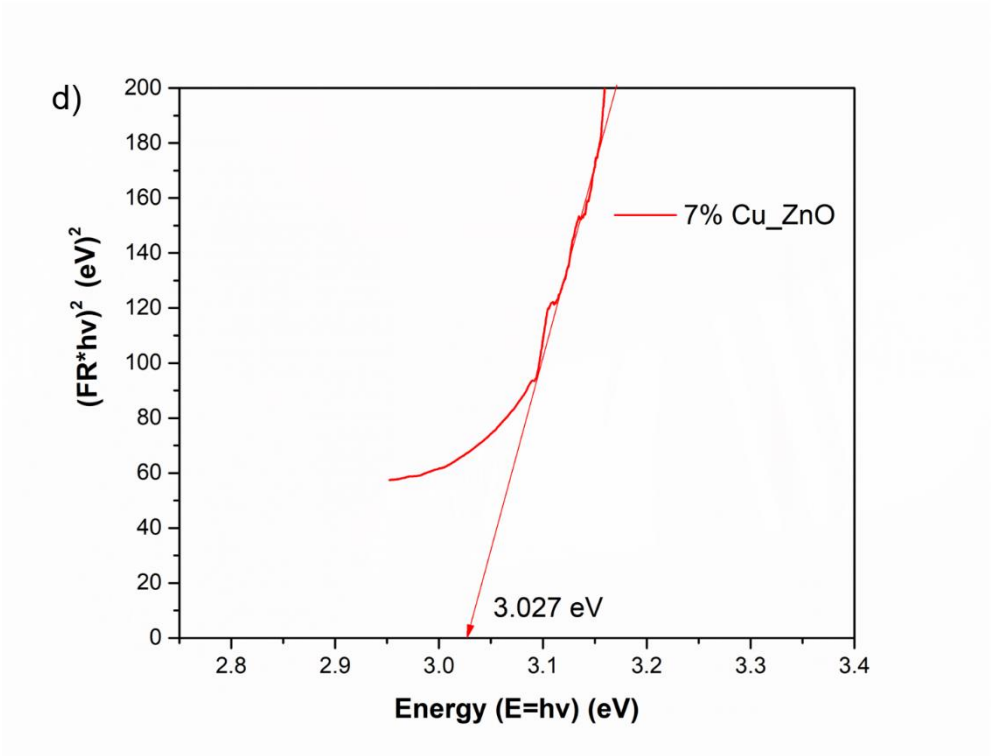
Supplementary Data

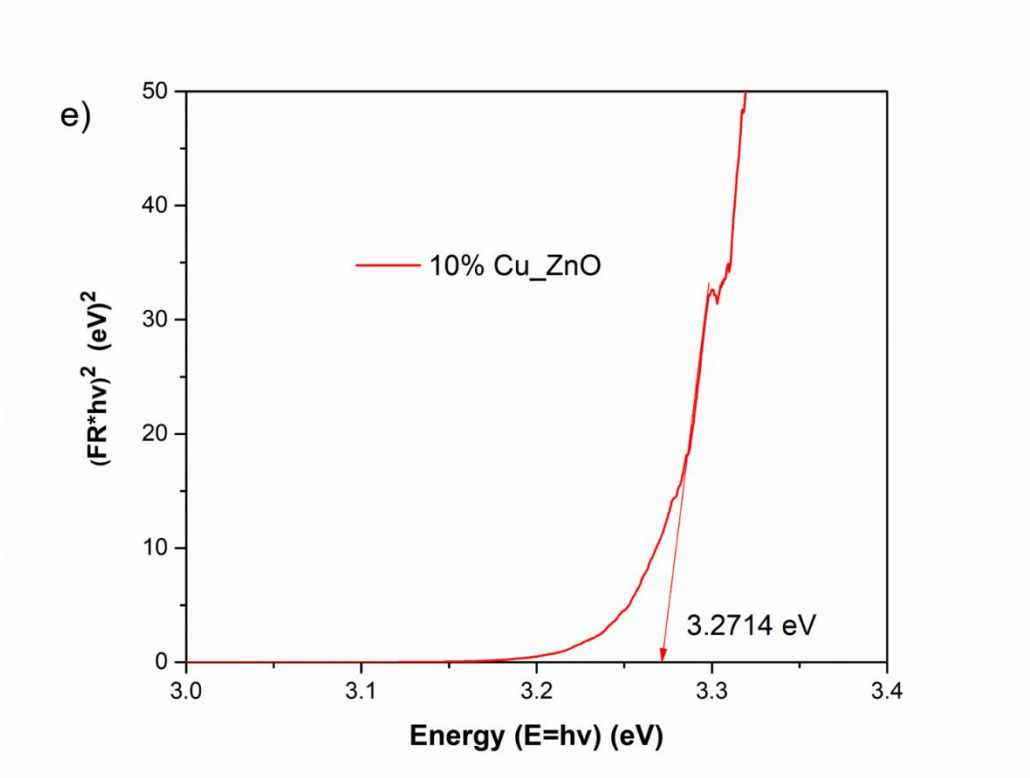
Figure S1: Tauc plots for 450°C Samples a) ZnO b) 3% Cu-ZnO c) 5% Cu-ZnO d) 7% Cu-ZnO e) 10% Cu-ZnO




b)
3% Cu_ZnO
3.1055 eV
(FR*hv)²(eV)²
Energy (E=hv) (eV)
0
10
20
30
40
50
2.7
2.8
2.9
3.0
3.1
3.2
3.3
3.4


c)
5% Cu_ZnO
3.1315 eV
(FR*hv)² (eV)²
Energy (E=hv) (eV)
0
10
20
30
40
50
60
70
80
90
100
2.7
2.8
2.9
3.0
3.1
3.2
3.3
3.4


d)
(FR*hv)² (eV)²
Energy (E=hv) (eV)
7% Cu_ZnO
3.027 eV
0
20
40
60
80
100
120
140
160
180
200
2.8
2.9
3.0
3.1
3.2
3.3
3.4


e)
(FR*hv)² (eV)²
Energy (E=hv) (eV)
10% Cu_ZnO
3.2714 eV
0
10
20
30
40
50
3.0
3.1
3.2
3.3
3.4

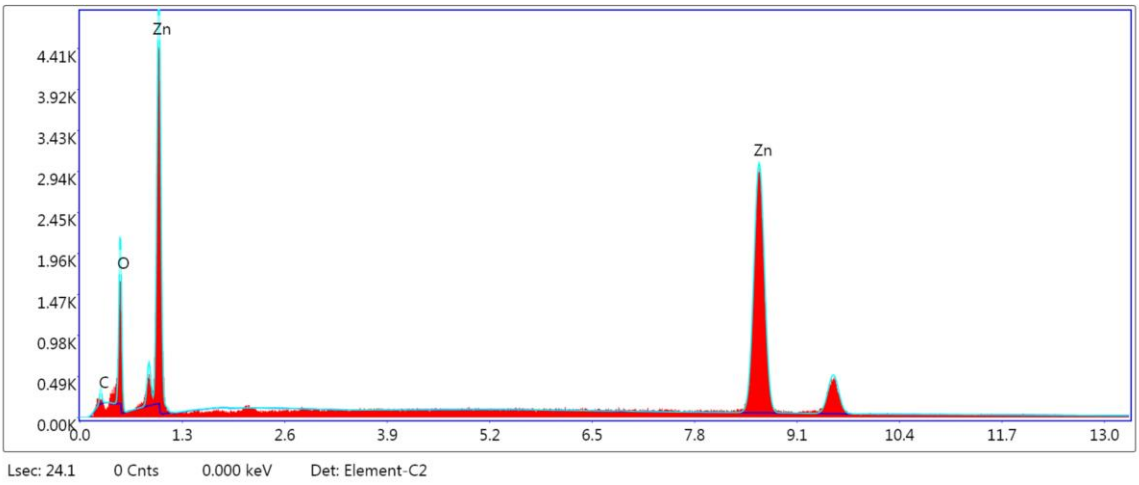


Figure S1: EDX for ZnO nanoparticles calcined at 450 ºC

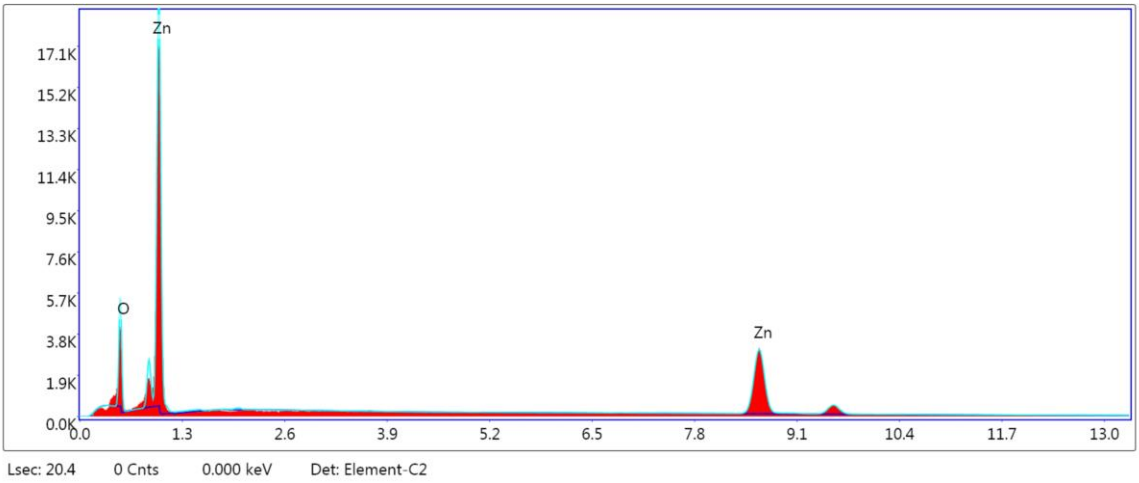


Figure S2: EDX for ZnO nanoparticles calcined at °C

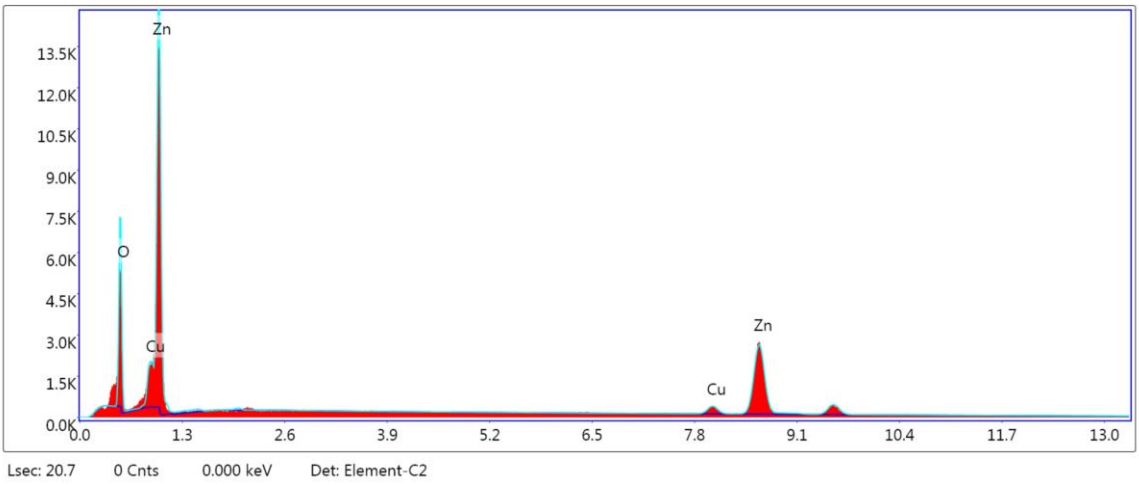


Figure S3: EDX for 7% Cu-ZnO nanoparticles calcined at 450 °C

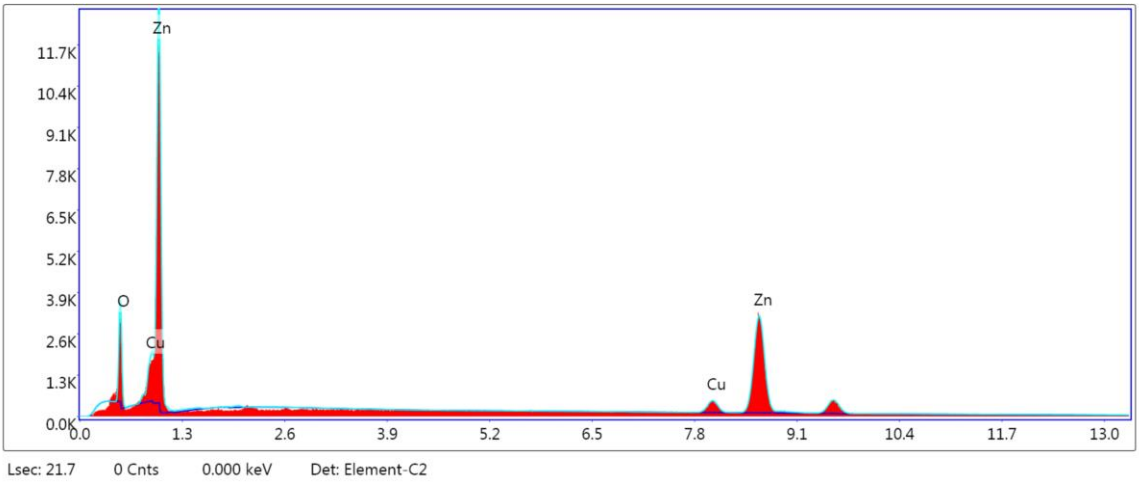


Figure S4: EDX for 7% Cu-ZnO nanoparticles calcined at 650 °C

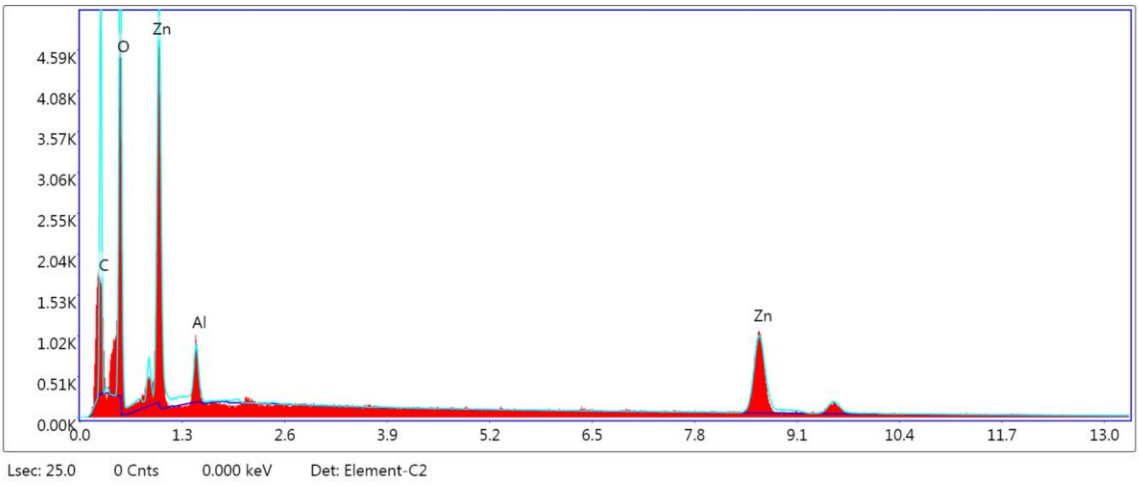


Figure S5 EDX for ZnO CA membrane

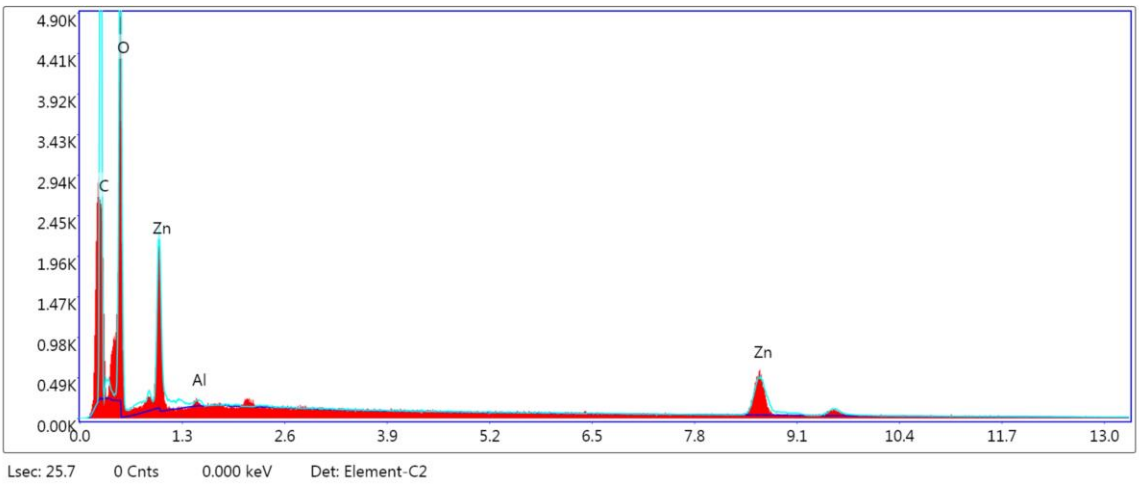


Figure S6 EDX for 7% Cu-ZnO CA membrane

ANOVAOneWay (6/6/2025 13:45:54)

Notes

Input Data

Descriptive Statistics

	N Analysis	N Missing	Mean	Standard Deviation	SE of Mean
A	3	0	0.22667	0.04041	0.02333
B	3	0	0.26	0.02646	0.01528
C	3	0	0.25667	0.01528	0.00882
D	3	0	0.22667	0.04163	0.02404
E	3	0	0.20667	0.02082	0.01202

One Way ANOVA

Overall ANOVA

	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	4	0.00611	0.00153	1.61268	0.24573
Error	10	0.00947	9.46667E-4		
Total	14	0.01557			

Null Hypothesis: The means of all levels are equal.
Alternative Hypothesis: The means of one or more levels are different.
At the 0.05 level, the population means are not significantly different.

Fit Statistics

R-Square	Coeff Var	Root MSE	Data Mean
0.39212	0.13074	0.03077	0.23533

Figure S8: ANOVA results for Zn in ZnO mat

ANOVAOneWay (6/6/2025 13:49:57)

Notes

Input Data

Descriptive Statistics

	N Analysis	N Missing	Mean	Standard Deviation	SE of Mean
A	3	0	0.16333	0.02309	0.01333
B	3	0	0.19667	0.00577	0.00333
C	3	0	0.16333	0.02309	0.01333
D	3	0	0.18333	0.01528	0.00882
E	3	0	0.15333	0.01528	0.00882

One Way ANOVA

Overall ANOVA

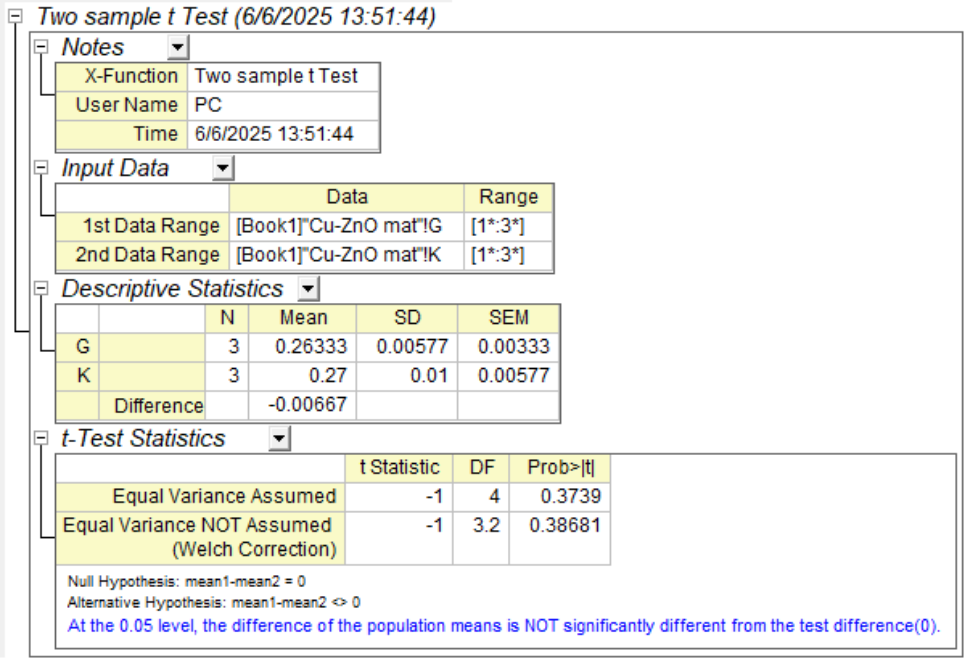
	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	4	0.00371	9.26667E-4	2.95745	0.07483
Error	10	0.00313	3.13333E-4		
Total	14	0.00684			

Null Hypothesis: The means of all levels are equal.
Alternative Hypothesis: The means of one or more levels are different.
At the 0.05 level, the population means are not significantly different.

Fit Statistics

R-Square	Coeff Var	Root MSE	Data Mean
0.54191	0.10291	0.0177	0.172

Figure S9: ANOVA results for Zn in 7% Cu_ ZnO mat



Two sample t Test (6/6/2025 13:51:44)

Notes

X-Function	Two sample t Test
User Name	PC
Time	6/6/2025 13:51:44

Input Data

	Data	Range
1st Data Range	[Book1]"Cu-ZnO mat"!G	[1*:3*]
2nd Data Range	[Book1]"Cu-ZnO mat"!K	[1*:3*]

Descriptive Statistics

		N	Mean	SD	SEM
G		3	0.26333	0.00577	0.00333
K		3	0.27	0.01	0.00577
	Difference		-0.00667		

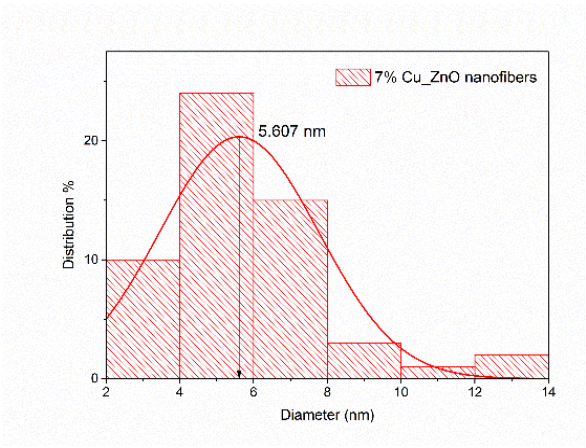
t-Test Statistics

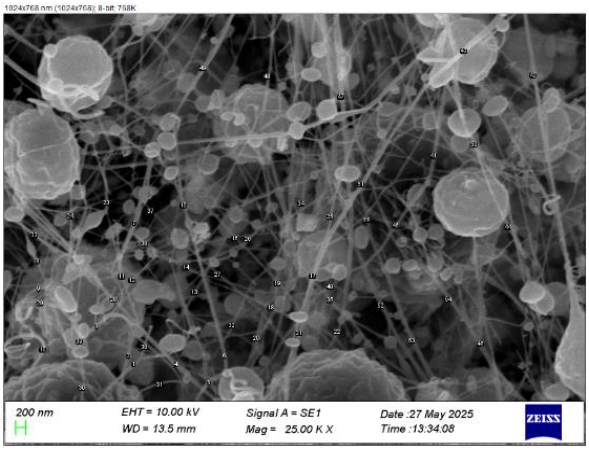
	t Statistic	DF	Prob>|t|
Equal Variance Assumed	-1	4	0.3739
Equal Variance NOT Assumed (Welch Correction)	-1	3.2	0.38681

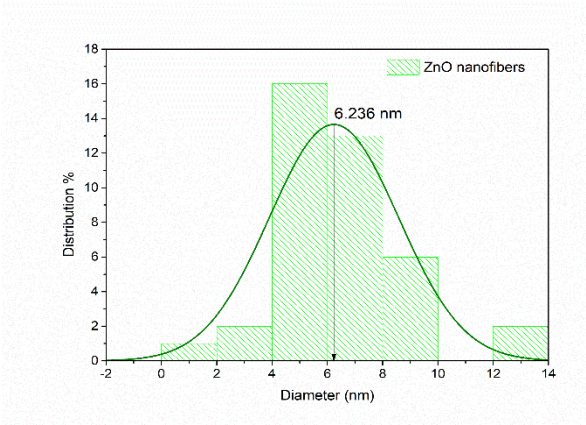
Null Hypothesis: mean1-mean2 = 0
Alternative Hypothesis: mean1-mean2 <> 0
At the 0.05 level, the difference of the population means is NOT significantly different from the test difference(0).

Figure S10: 2 sample T results for Cu in 7% Cu_ZnO mat

Figure S11


7% Cu_ZnO nanofibers
5.607 nm
Distribution %
Diameter (nm)


1024x768 nm (1024x768); 8-bit; 768K
200 nm
EHT = 10.00 kV
WD = 13.5 mm
Signal A = SE1
Mag = 25.00 K X
Date :27 May 2025
Time :13:34:08
ZEISS


ZnO nanofibers
6.236 nm
Distribution %
Diameter (nm)

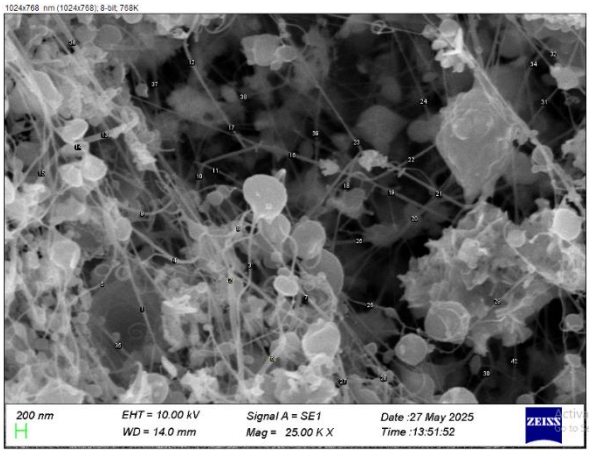
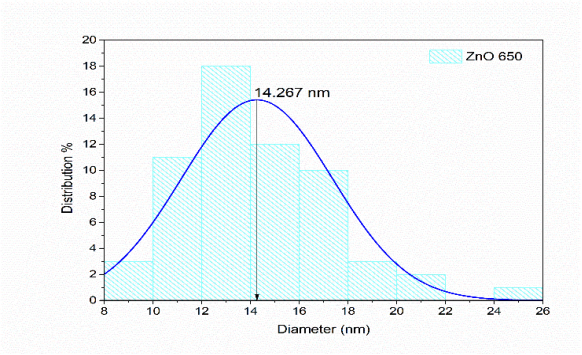
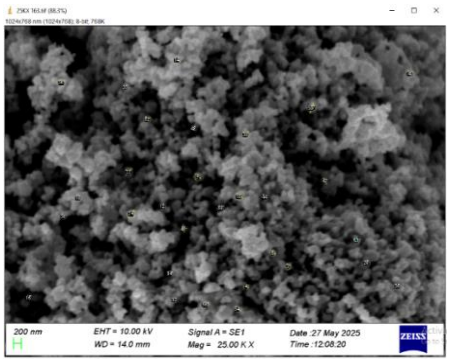
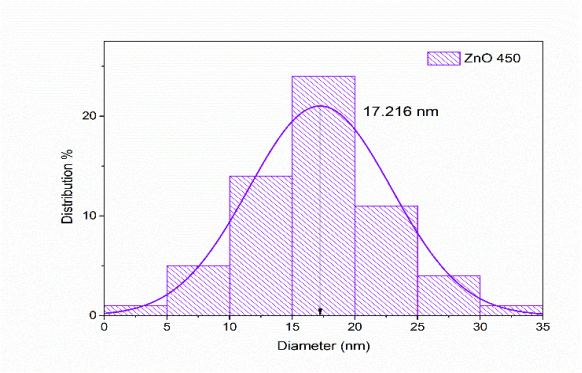
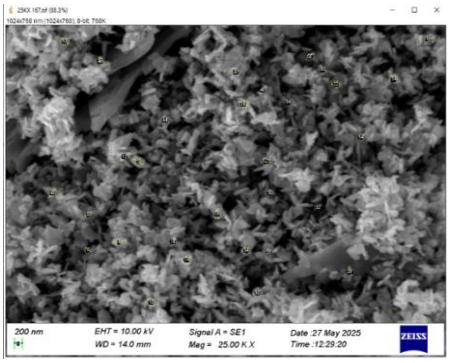

1024x768 nm (1024x768); 8-bit; 768K
200 nm
EHT = 10.00 kV
WD = 14.0 mm
Signal A = SE1
Mag = 25.00 K X
Date :27 May 2025
Time :13:51:52
ZEISS

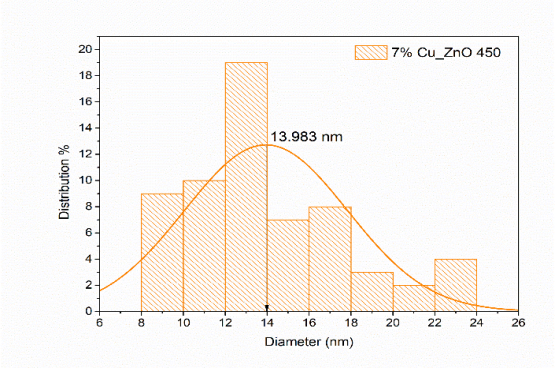
Figure S12

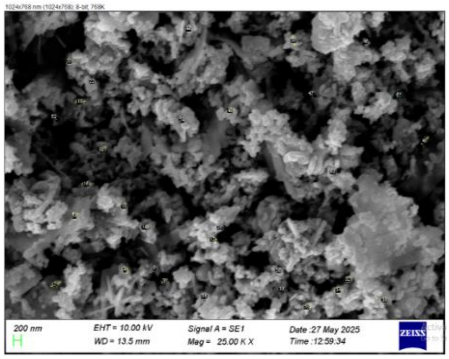

ZnO 650
14.267 nm
Distribution %
Diameter (nm)

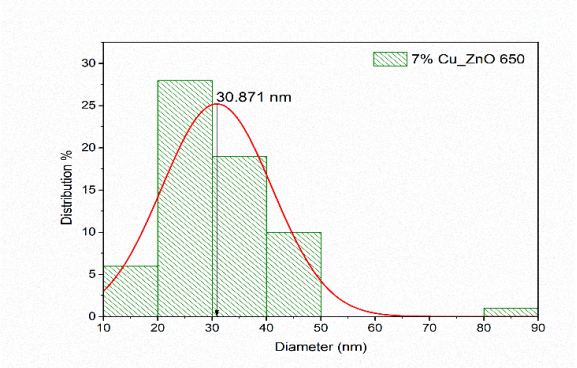

200 nm
EHT = 10.00 kV
WD = 14.0 mm
Signal A = SE1
Mag = 25.00 K X
Date :27 May 2025
Time :12:08:20
ZEISS

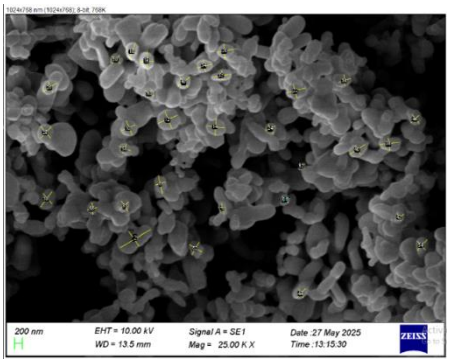

ZnO 450
17.216 nm
Distribution %
Diameter (nm)


200 nm
EHT = 10.00 kV
WD = 14.0 mm
Signal A = SE1
Mag = 25.00 K X
Date :27 May 2025
Time :12:29:20
ZEISS


7% Cu_ZnO 450
13.983 nm
Distribution %
Diameter (nm)


200 nm
EHT = 10.00 kV
WD = 13.5 mm
Signal A = SE1
Mag = 25.00 K X
Date :27 May 2025
Time :12:59:34
ZEISS


7% Cu_ZnO 650
30.871 nm
Distribution %
Diameter (nm)


200 nm
EHT = 10.00 kV
WD = 13.5 mm
Signal A = SE1
Mag = 25.00 K X
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Time :13:15:30
ZEISS

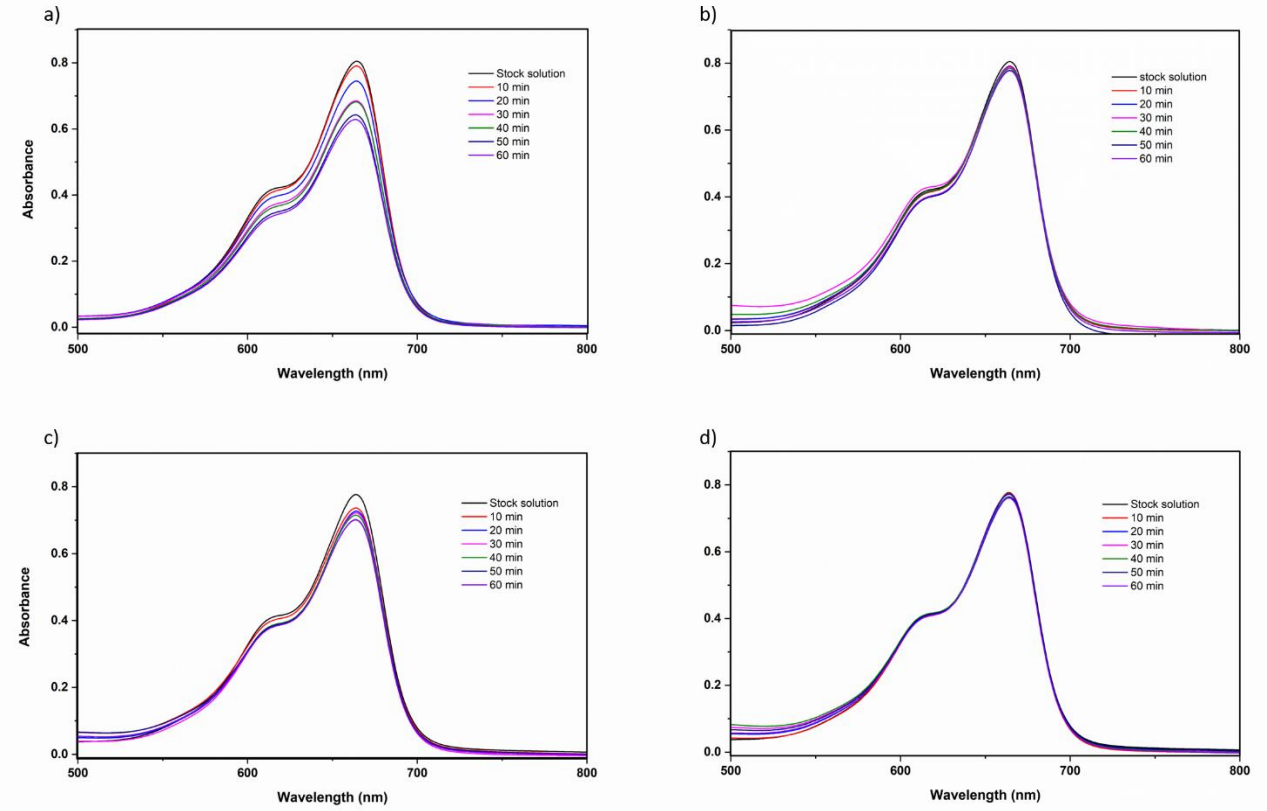

Figure S13*:* UV-Vis absorbance spectra for the degradation of MB dye; (a) ZnO (450°C) under visible light, (b) ZnO (450°C) under dark, (c) ZnO (650°C) under visible light, (d) ZnO (650°C) under dark.

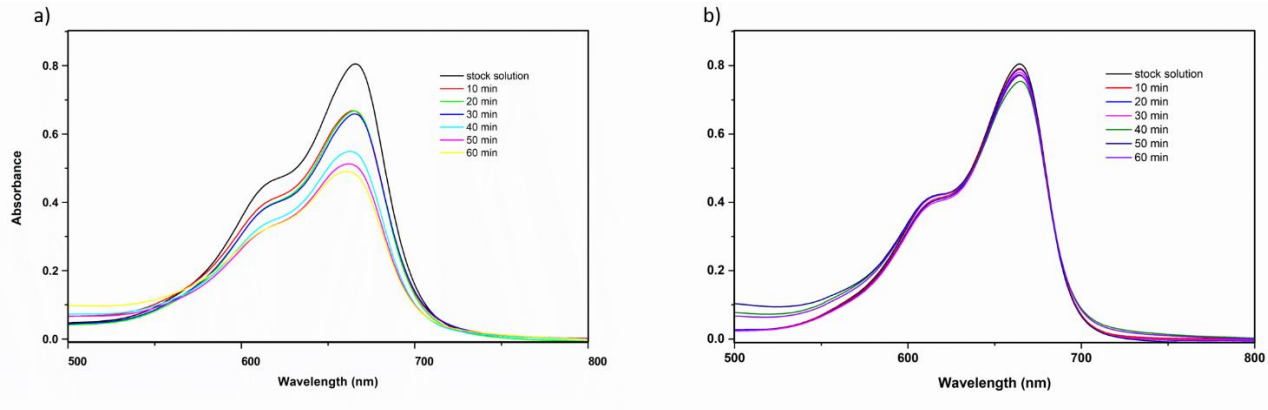

Figure S14*:* UV-Vis absorbance spectra for the degradation of MB dye; (a) 7% Cu-ZnO (450°C) under visible light, (b) 7% Cu-ZnO (450°C) under dark.

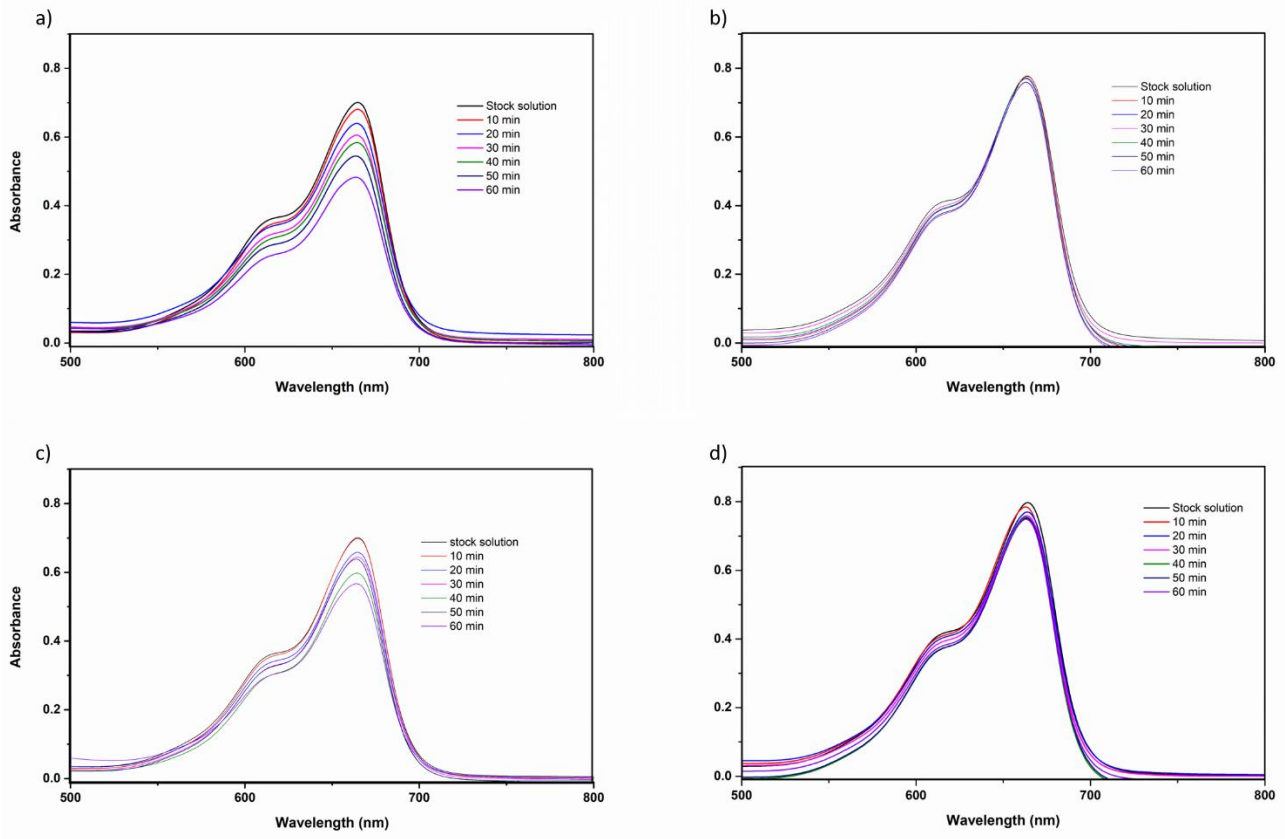

Figure S15*:* UV-Vis absorbance spectra for the degradation of MB dye; (a) 7% Cu-ZnO mat under visible light, (b) 7% Cu-ZnO mat under dark, (c) ZnO mat under visible light, (d) ZnO mat under dark.