Cape Peninsula University of Technology

Datasets: Synthesis of the photocatalyst evaluation of the photocatalytic performance of composites by the determination of the effect of some reaction parameters such as the catalyst loading, pH, and initial concentration of dye, and characterisation of the photocatalyst using XRD, SEM-EDS and BET.

Thesis title: Photocatalytic degradation of orange II sodium dye in textile wastewater using TiO_2-supported with activated carbon

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Dataset A: This section present the datasets created for the synthesis of the TiO_2-supported photocatalyst composite.

Table 1: Result of yields of the biochar after varying pyrolysis times.

Pyrolysis Time (hours)	Samples	Biomass (g)	Biochar (g)	Yield (%)
1	1	10.010	6.772	67.65
	2	10.002	6.971	69.17
	3	10.007	6.985	69.88
2	4	10.001	7.098	70.97
	5	10.005	7.081	70.78
	6	10.009	7.101	70.95
3	7	10.005	7.055	70.52
	8	10.007	7.063	70.58
	9	10.006	7.068	70.64

Table 2: Ash content of the samples after varying pyrolysis times

Sample	Pyrolysis time (hours)	Sample weight (g)	Weight after ashing (g)	Tare crucible weight (g)	Ash content (%)
Biomass	-	5.0094	74.366	73.961	8.085
	-	5.0087	74.359	73.955	8.065
	-	5.0096	74.369	73.963	8.093
Biochar	1	2.0036	58.637	58.425	10.55
	1	2.0037	58.635	58.426	10.43
	1	2.0034	58.640	58.425	10.74
Biochar	2	2.0023	47.487	47.272	10.76
	2	2.0027	47.483	47.276	10.34
	2	2.0020	47.492	47.265	11.33
Biochar	3	2.0019	72.746	72.521	11.23
	3	2.0070	72.735	72.524	10.76
	3	2.0013	72.746	72.521	12.09

Table 3: Energy band gap of TiO_2 synthesised

	Energy band gap (eV)		
Synthesis Time (h)	**Sample 1**	**Sample 2**	**Sample 3**
4	3.40	3.39	3.41
6	3.47	3.46	3.47
8	3.69	3.73	3.68
10	3.42	3.47	3.39

Table 4: Energy band gap of TiO_2-supported biochar composites

Samples	**Weight TiO_2 (mg)**	**Weight biochar (mg)**	**ratio**	**Energy band gap (eV)**
1	200	100	2 : 1	2.58
2	200	100	2 : 1	2.64
3	200	100	2 : 1	2.57
4	200	100	2 : 1	2.53
5	200	200	2 : 2	2.54
6	200	200	2 : 2	2.54
7	200	200	2 : 2	2.49
8	200	200	2 : 2	2.51
9	200	300	2 : 3	2.14
10	200	300	2 : 3	2.02
11	200	300	2 : 3	2.17
12	200	300	2 : 3	2.11
13	200	400	2 : 4	2.33
14	200	400	2 : 4	2.33
15	200	400	2 : 4	2.29
16	200	400	2 : 4	2.37
17	200	500	2 : 5	2.49
18	200	500	2 : 5	2.46
10	200	500	2 : 5	2.50
20	200	500	2 : 5	2.51

Dataset B: This section presents the datasets of the evaluation of the photocatalytic performance of composites by the determination of the effect of some reaction parameters such as the catalyst loading, pH, and initial concentration of dye.

1. Effect of catalyst loading

    - **Process parameters**

pH	6.8
Power	160 W
Time	60 min.
Dye concentration	20 ppm

Table 5: Effect of catalyst loading on the photodegradation efficiency.

	Yield (%)	
Catalyst (mg/L)	**TiO_2**	**TiO_2-supported biochar**
50	12.71	28.58
50	12.71	29.94
50	12.71	27.09
50	12.69	28.58
100	12.42	39.47
100	13.01	36.80
100	12.11	38.01
100	11.98	38.45
150	13.81	51.39
150	13.13	50.00
150	13.13	51.70
150	13.81	51.45
200	17.76	55.34
200	17.51	53.89
200	17.45	56.00
200	17.45	54.63
250	17.08	54.71
250	16.74	54.71
250	16.65	54.73
250	17.16	54.70

2. Effect of pH

   - **Process parameters**

Power	160 W
Dye concentration	20 ppm
Catalyst concentration	200 mg/L

Table 6: Effect of pH on the photodegradation efficiency using TiO_2 composites

Time (min.)	Yield (%)			
	pH 4	pH 6.8	pH 8	pH 10
15	10.37	9.23	4.47	6.18
15	12.51	9.11	4.49	6.07
15	12.39	9.24	4.49	6.10
15	12.07	9.19	4.56	6.05
30	14.10	11.90	8.11	6.39
30	14.10	11.34	8.10	6.39
30	14.13	10.86	7.50	6.42
30	14.10	11.90	8.04	6.38
45	16.53	12.34	9.38	8.01
45	16.55	12.12	9.76	8.00
45	16.52	12.31	9.35	8.04
45	16.54	12.31	9.21	8.04
60	18.64	14.17	12.34	8.66
60	18.79	14.17	12.11	8.78
60	18.36	14.20	12.13	8.67
60	18.50	14.30	12.11	8.79
90	19.69	16.51	14.29	10.86
90	19.71	16.50	14.32	10.85
90	19.70	16.51	14.34	10.88
90	19.77	16.53	14.34	10.86
120	20.77	18.87	16.44	13.10
120	20.69	18.37	16.38	12.96
120	20.77	18.71	16.27	13.09
120	20.78	18.48	16.31	10.81
150	19.95	17.83	16.01	12.73
150	19.99	17.07	15.17	11.68
150	20.07	16.34	15.16	12.67
150	19.97	16.99	15.23	12.43

Table 7: Effect of pH on the photodegradation efficiency using TiO_2-biochar composites

Time (min.)	Yield (%)			
	pH 4	pH 6.8	pH 8	pH 10
15	17.30	25.14	20.41	20.21
15	17.15	28.63	20.44	20.21
15	17.08	27.87	20.39	20.02
15	17.07	27.99	20.39	20.19
30	32.24	30.58	28.02	24.34
30	33.33	30.61	27.99	24.01
30	32.18	30.69	27.92	24.76
30	32.89	30.00	28.13	24.43
45	38.52	33.41	32.21	26.77
45	38.52	33.96	32.24	26.77
45	38.94	33.99	32.21	26.03
45	38.52	33.46	32.21	26.53
60	48.12	51.87	51.43	48.31
60	48.09	51.20	51.55	48.29
60	48.07	51.90	50.11	48.24
60	48.11	52.03	51.43	48.76
90	65.02	64.74	68.08	60.43
90	65.09	64.38	68.06	60.54
90	65.11	64.65	68.00	60.59
90	64.73	64.74	68.06	60.79
120	81.37	82.90	77.69	73.01
120	81.16	83.11	77.21	73.07
120	81.16	83.82	78.90	73.09
120	80.23	83.09	77.80	72.91
150	79.12	82.90	76.24	69.71
150	79.23	82.84	75.35	70.92
150	79.00	82.91	75.98	70.11
150	79.43	82.90	75.98	69.38

3. Effect of initial dye concentration

- **Process parameters**

pH	6.8
Power	160 W
Catalyst concentration	200 mg/L

Table 8: Effect of initial dye concentration on the photodegradation efficiency using TiO_2-biochar composites

Time (min.)	Yield (%)			
	20 ppm	30 ppm	40 ppm	50 ppm
5	6.74	4.49	1.23	0.02
5	6.75	4.49	1.23	0.009
5	6.76	4.45	1.23	0.03
5	6.74	4.47	1.24	0.02
10	8.79	5.43	1.82	0.32
10	8.76	5.39	1.77	0.34
10	8.76	5.37	1.70	0.34
10	8.77	5.55	1.85	3.28
15	9.25	6.23	2.16	0.45
15	9.25	6.24	2.16	0.46
15	9.25	6.24	2.15	0.45
15	9.28	6.22	2.15	0.43
20	9.89	6.57	2.99	0.78
20	9.83	6.51	2.98	0.80
20	9.90	6.56	2.98	0.82
20	9.84	6.56	2.99	0.76
25	10.69	7.08	3.38	0.86
25	10.69	7.05	3.39	0.84
25	10.52	7.06	3.38	0.86
25	10.61	7.01	3.36	0.84
30	10.82	7.48	3.68	1.11
30	10.80	7.82	3.67	1.06
30	10.82	7.56	3.67	1.09
30	10.83	7.56	3.69	1.13
45	12.14	8.57	4.62	1.64
45	12.13	8.39	4.66	1.67
45	12.15	8.54	4.66	1.62
45	12.14	8.59	4.66	1.62
60	13.26	9.54	5.63	2.70
60	13.23	9.55	5.62	2,72
60	13.28	9.55	5.57	2.71
60	13.27	9.53	5.60	2.70
90	15.81	11.69	7.53	3.49
90	15.89	11.11	7.44	3.49
90	15.73	11.56	7.29	3.38
90	15.87	11.70	7.48	3.32
120	18.39	13.98	9.39	4.42
120	18.34	14.01	9.44	4.44
120	18.39	14.01	9.43	4.03
120	18.42	13.96	9.45	4.44

Table 9: Effect of initial dye concentration on the photodegradation efficiency using TiO_2 composites.

Time (min.)	Yield (%)			
	20 ppm	30 ppm	40 ppm	50 ppm
5	9.67	18.57	11.54	5.56
5	9.75	18.56	11.54	5.51
5	9.73	18.03	11.34	5.39
5	9.73	18.57	11.30	5.57
10	11.73	21.38	13.70	6.67
10	11.64	21.29	13.47	6.66
10	11.59	21.53	13.70	6.66
10	11.69	21.34	13.48	6.70
15	14.31	26.34	18.56	9.50
15	14.33	26.36	18.31	9.72
15	14.34	26.36	18.29	9.77
15	14.33	26.38	18.31	9.78
20	17.52	26.19	20.76	12.87
20	17.56	26.19	20.99	12.99
20	17.40	26.60	20.88	13.01
20	17.50	26.32	20.88	12.98
25	20.24	30.11	23.24	15.12
25	20.30	30.15	23.13	15.16
25	20.31	30.15	23.25	15.13
25	20.30	30.17	23.09	15.13
30	22.49	32.69	25.85	19.65
30	22.49	32.69	25.83	19.61
30	22.49	32.67	25.85	19.64
30	22.56	32.67	25.84	19.00
45	29.79	39.76	35.88	25.01
45	29.76	39.73	35.88	25.00
45	29.75	39.75	35.31	29.84
45	28.99	39.74	35.88	29.88
60	51.09	35.14	42.32	29.32
60	51.00	33.90	42.33	29.43
60	51,19	35.34	42.33	29.35
60	51,11	35.13	41.00	29.41
90	67.31	52.29	59.08	44.91
90	67.32	52.27	56.39	44.90
90	67.31	52.37	59.11	44.93
90	67.34	52.33	59.05	44.93
120	83.52	69.23	75.45	60.64
120	85.01	69.22	75.46	60.70
120	83.33	69.11	75.65	60.63
120	83.60	69.13	75.56	60.63

4. Effect of irradiation time on Ln(*Co*/*Ct*) in the phototdegradation

- **Process parameters**

pH	6.8
Power	160 W
Catalyst concentration	200 mg/L

Table 10: Effect of the irradiation time on the Ln(*Co*/*Ct*) in the in the degradation of orange II sodium dye using TiO_2 TiO_2-supported biochar composites.

Time (min.)	**Ln Co/Ct**			
	20 ppm	**30 ppm**	**40 ppm**	**50 ppm**
5	0.06982	0.04595	0.01242	5.0435E-4
5	0.06318	0.04039	0.01239	5.0901E-4
5	0.06257	0.04061	0.01228	5.1383E-4
5	0.06399	0.04076	0.01239	4.6911E-4
10	0.09182	0.05580	0.01836	0.00637
10	0.09974	0.05848	0.01886	0.00584
10	0.09538	0.05877	0.01890	0.00551
10	0.09127	0.05193	0.01862	0.00552
15	0.09699	0.06439	0.02179	0.00933
15	0.09649	0.06469	0.02987	0.01000
15	0.09612	0.06528	0.02438	0.01003
15	0.09610	0.06541	0.02587	0.00976
20	0.10417	0.06798	0.03037	0.01595
20	0.10890	0.65497	0.03585	0.01539
20	0.10269	0.64035	0.03176	0.01596
20	0.10263	0.67091	0.03900	0.01595
25	0.11315	0.07308	0.03443	0.01701
25	0.11267	0.07061	0.03551	0.01723
25	0.11267	0.07067	0.03390	0.01702
25	0.11267	0.07054	0.03548	0.01705
30	0.11457	0.07770	0.03749	0.02211
30	0.11242	0.07648	0.03859	0.02219
30	0.11690	0.07928	0.03684	0.02264
30	0.11564	0.07770	0.03872	0.02211

Table 11: Effect of the irradiation time on the Ln(Co/Ct) in the in the degradation of orange II sodium dye using TiO_2-supported biochar composites.

Time (min.)	Ln Co/Ct			
	20 ppm	30 ppm	40 ppm	50 ppm
5	0.20212	0.11766	0.08692	0.07150
5	0.20394	0.11004	0.08859	0.07124
5	0.20368	0.11101	0.08649	0.07812
5	0.20251	0.11360	0.08552	0.07810
10	0.25748	0.14618	0.10759	0.09761
10	0.25674	0.14111	0.10602	0.09758
10	0.25730	0.14885	0.10206	0.09758
10	0.25736	0.14618	0.10435	0.09758
15	0.28768	0.21443	0.15636	0.10203
15	0.28394	0.21637	0.15122	0,10540
15	0.27368	0.20427	0.15280	0.10701
15	0.27612	0.20427	0.15701	0.10723
20	0.32989	0.23319	0.16960	0.14966
20	0.32099	0.23435	0.16755	0.14968
20	0.32921	0.23964	0.16228	0.14966
20	0.32731	0.23391	0.16718	0.14939
25	0.36817	0.26266	0.19025	0.16960
25	0.36316	0.26257	0.17690	0.01702
25	0.36435	0.26309	0.18274	0.16943
25	0.36725	0.26941	0.18540	0.16321
30	0.39601	0.28104	0.20303	0.21816
30	0.39210	0.28898	0.20124	0.21761
30	0.39526	0.28182	0.20058	0.21843
30	0.39162	0.28070	0.20169	0.21782

5. Effect of the initial concentration of dye on the Kinetics parameters of orange II Sodium using using TiO_2 and TiO_2-supported biochar composites.

   - **Process parameters**

pH	6,8
Power	160 W
Time	2 h
Catalyst concentration	200 mg/L

Table 12: Kinetic parameters of orange II Sodium dye using TiO_2 and TiO_2-supported biochar composites.

Photocatalyst	Dye concentration (ppm)	k x 10^{-3} (min^{-1})	r^2	$1/K$ (min)
TiO_2	**20**	10.2	0.9041	98.04
	20	10.2	0.9020	98.04
	20	10.1	0.9036	97.96
	20	10.2	0.9021	98.03
	30	7.5	0.9651	133.33
	30	7.7	0.9667	133.32
	30	7.7	0.9668	135.62
	30	7.6	0.9668	135.28
	40	4.9	0.9823	204.08
	40	4.1	0.9895	203.22
	40	4.8	0.9863	203.77
	40	4.9	0.9869	203.65
	50	2.2	0.9776	454.54
	50	2.2	0.9774	482.31
	50	2.6	0.9790	453.90
	50	2.5	0.9771	454.76
TiO_2-supported biochar	**20**	15.0	0.9914	66.66
	20	14.9	0.9918	66.66
	20	15.0	0.9909	66.67
	20	14.9	0.9996	66.67
	30	13.2	0.9566	75.75
	30	13.0	0.9546	75.56
	30	13.0	0.9568	75.00
	30	13.1	0.9532	75.76
	40	9.8	0.9700	102.04
	40	9.2	0.9702	102.00
	40	9.5	0.9700	102.16
	40	9.5	0.9734	101.87
	50	7.8	0.9504	128.20
	50	7.6	0.9535	127.18
	50	7.2	0.9551	128.71
	50	7.8	0.9582	128.43

6. Effect of pH on the Electrical Energy Efficiency per order (EEo) and Kinetic parameters of orange II sodium using the TiO_2 and TiO_2-supported biochar composites.

   - **Process parameters**

Time	6.8
Power	160 W
Dye concentration	2 h

Catalyst concentration	200 mg/L

Table 13: Electrical Energy Efficiency per order (EE_o) and Kinetic parameters of orange II sodium using the TiO_2 and TiO_2-supported biochar composites at pH 4, 6.8, 8, and 10.

Photocatalyst	**pH**	**Removal (%)**	***K*x10^{-3} (min^{-1})**	***r*²**	***EE*$_o$ (kWh/m^3)**
TiO_2	4	20.77	1.96	0.7123	1064.38
	4	20.69	1.86	0.7221	1056.75
	4	20.77	1.93	0.7170	1075.19
	4	20.78	1.99	0.7018	988.34
	6.8	18.87	1.83	0.7719	1170.20
	6.8	16.34	1.49	0.7997	1175.03
	6.8	18.71	1.81	0.7730	1198.57
	6.8	18.48	1.75	0.7768	1182.19
	8	16.44	1.61	0.8780	1379.36
	8	16.38	1.61	0.8766	1388.17
	8	16.27	1.54	0.8700	1390.86
	8	16.08	1.30	0.9930	1401.96
	10	13.10	1.27	0.8273	1750.58
	10	12.96	1.16	0.8268	1776.90
	10	13.09	1.19	0.8277	1769.81
	10	10.81	1.12	0.8313	1778.85
TiO_2-supported biochar	4	81.37	14.32	0.9427	142.72
	4	81.16	14.07	0.9607	147.44
	4	81.16	14.07	0.9613	144.31
	4	80.23	14.13	0.9549	143.81
	6.8	82.90	15.01	0.9525	134.82
	6.8	83.11	14.99	0.9997	139.94
	6.8	83.82	15.06	0.9532	135.17
	6.8	83.09	15.09	0.9517	136.03
	8	77.69	12.80	0.9541	165.03
	8	77.21	11.73	0.9901	162.01
	8	78.90	12.92	0.9673	170.98
	8	77.44	12.67	0.9541	165.84
	10	73.01	10.94	0.9435	185.22
	10	73.07	10.96	0.9420	187.17
	10	73.09	9.98	0.9437	193.01
	10	72.91	10.93	0.9471	187.65

Datasets C: this section presents the results on the characterisation of the photocatalyst using XRD, SEM-EDS and BET.

1. X-ray diffraction (XRD) analysis

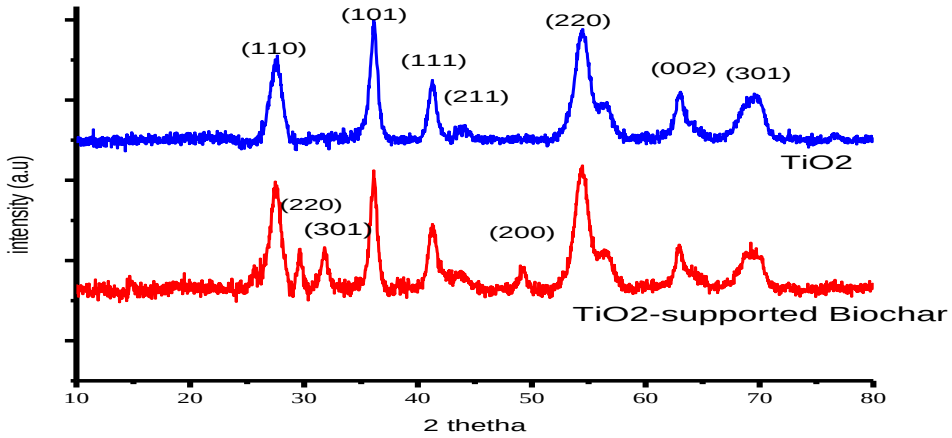


Figure 1: XRD patterns of TiO_2 and TiO_2-supported biochar composites.

Table 14: Particles sizes

samples	2θ	FWHM	Size (nm)
1	27,3297553	1,616398122	5,057980188
	36,0955167	0,928299648	9,000741981
	41,2223674	1,020049101	8,320747799
	54,3951725	2,316613656	3,855554984
	62,9982105	0,74110575	12,57201556
	69,4592537	2,300230049	4,202342382
	d spacing		7,168230482
2	27,31649654	1,62074	5,044303
	36,1177465	0,96142	8,691245
	41,20700662	1,10619	7,672426
	54,40688942	2,35031	3,800482
	63,01419644	0,66298	14,05462
	69,46709657	2,41914	3,995976
	d spacing		7,209843
3	27,31365	1,932648	4,230169
	36,09167	1,013939	8,240432
	41,15195	1,21356	6,992328
	54,36822	2,384667	3,745072
	62,95761	0,635626	14,6551
	69,45395	2,277703	4,243769
	d spacing		7,017812

4	27,28247	1,920895	4,255772
	36,06506	0,970818	8,605794
	41,12828	1,075916	7,886261
	54,33889	2,321005	3,847289
	62,93256	0,635626	14,65314
	69,40378	2,277703	4,242481
	d spacing		7,248457

Table 15**:** XRD data of TiO_2 and TiO_2-supported biochar composites

Photocatalyst	**2θ (The strongest peak)**	**β (rad)**	**Crystallite size (nm)**
TiO_2	36.08°	0.01937	7.158
TiO_2-supported biochar	54.39°	0.01749	7.927

2. Brunauer Emmet Teller Surface Area Analysis

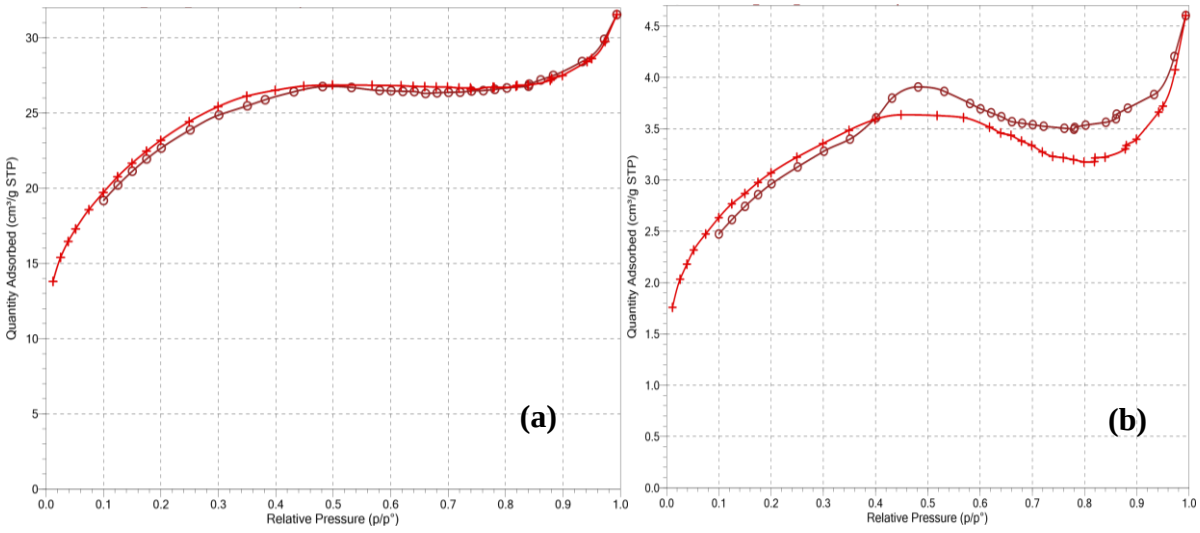


Figure 2: N_2 adsorption-desorption isotherm of (a) TiO_2 and (b) TiO_2-supported biochar composites

Table 16: The specific surface area and pore structure parameters of TiO_2 and TiO_2-supported biochar composites.

Photocatalyst	**Surface Area (m^2/g)**	**Pore size (Å)**	**Pore volume (cm^3/g)**
TiO_2	84.25	10.133	0.0488
TiO_2-supported biochar	11.11	9.793	0.0071

3. Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS)

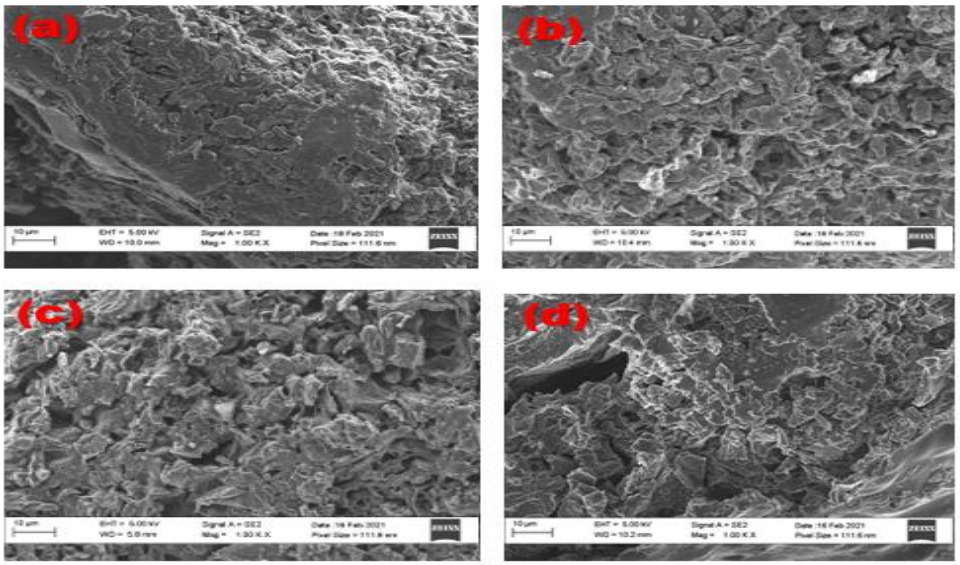


Figure 3: SEM images 10 µm: (a) biomass, (b) biochar at 1 h, (c) biochar at 2 h and (d) biochar at 3 h.

Table 17: chemical composition of the biomass at 1h.

Element	Wt%	Vt%sigma
C	71.88	0.46
O	25.52	0.45
Mg	0.155	0.04
Si	0.115	0.03
S	0.375	0.04
Cl	0.445	0.04
K	0.39	0.04
Ca	1.12	0.07
Total	100	

Table 18: chemical composition of the biochar at 1h.

Element	Wt%	Vt%sigma
C	74.705	0.44
O	20.95	0.43
Mg	0.2	0.03
Si	0.135	0.03
P	0.115	0.03
S	0.65	0.04
Cl	0.665	0.05
K	0.575	0.05
Ca	2.065	0.08
Total	100	

Table 19: chemical composition of the biochar at 2h.

element	Wt%	Vt%sigma
C	70.905	0.47
O	24.29	0.46
Mg	0.142	0.04
Al	0.07	0.03
Si	0.215	0.03
S	0.605	0.05
Cl	0.755	0.05
K	0.645	0.05
Ca	2.185	0.09
Total	100	

Table 20: chemical composition of the biochar at 3h.

element	Wt%	Vt%sigma
C	73.015	0.55
O	21	0.51
Mg	0.215	0.04
Al	0.34	0.04
Si	0.09	0.04
P	0.12	0.04
S	0.675	0.06
Cl	0.68	0.06
K	0.63	0.06
Ca	2.395	0.11
Cu	1	0.18
Total	100	

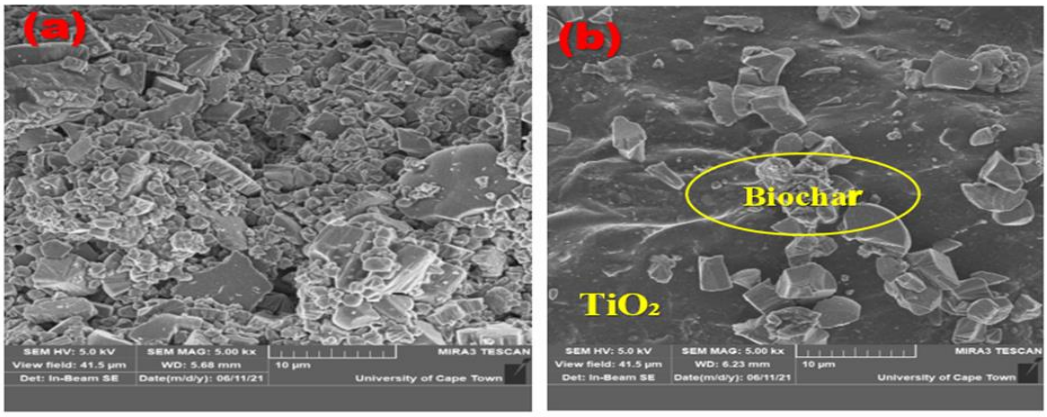


Figure 4.: SEM images of the (a) TiO_2 and (b) TiO_2-supported biochar composites.

Table 21: Chemical composition of the composites.

Elements	TiO_2 (Wt%)	TiO_2-supported biochar (Wt%)
C	15.14	34.59
O	41.40	39.71
Ti	43.45	24.29
K	-	0.69
Ca	-	0.72
Total	100	100