Supporting Information

Organic Sorbents for Air Purification: A New Application for Recyclable Hyper-cross-linked Polystyrene

Yevgen Nazarenko[1], Chitra Narayanan[2], Hannah Szeptycki[3], Aflah Kayium[4], Parisa A. Ariya[1,3,*]

[1] Department of Atmospheric and Oceanic Sciences, McGill University, 805 Sherbrooke Street West, Montreal, QC H3A 0B9, Canada.

[2] Department of Chemistry, New Jersey City University, 2039 Kennedy Boulevard, Jersey City, NJ 07305, USA.

[3] Department of Chemistry, McGill University, 801 Sherbrooke Street West, Montreal, QC H3A 2K6, Canada.

[4] Department of Mechanical Engineering, McGill University, 817 Sherbrooke Street West, Montreal, QC H3A 0C3, Canada.

Aflah Kayium's current affiliation is the Department of Mechanical Engineering, University of Ottawa, 800 King Edward Ave. Ottawa ON K1N 6N5, Canada.

Hannah Szeptycki's current affiliation is the Department of Atmospheric and Oceanic Sciences, McGill University, 805 Sherbrooke Street West, Montreal, QC H3A 0B9, Canada.

***Address correspondence to** Parisa A. Ariya at (514) 398-6931 & (514) 398-3615, parisa.ariya@mcgill.ca.

Table of Contents

Supporting Information 1
Table of Contents 2
Supplementary Figures 3
Supplementary Tables 13
Details of Statistical Analysis 15
Supplementary Data 22
Script to automatically detect sorbent beads and calculate the bead radii 39

Supplementary Figures

Figure S1. Selected parts of the experimental setup. Activated-carbon-filled cylinder for preconditioning of the total experimental air stream (**a**), a 40-mL stainless-steel capsule filled with a sorbent subject to testing (**b**), the syringe pump with a syringe filled with a pollutant solution (**c**), the mass flow controller (**d**), and the WP6912 Indoor Air Quality Meter (**e**).

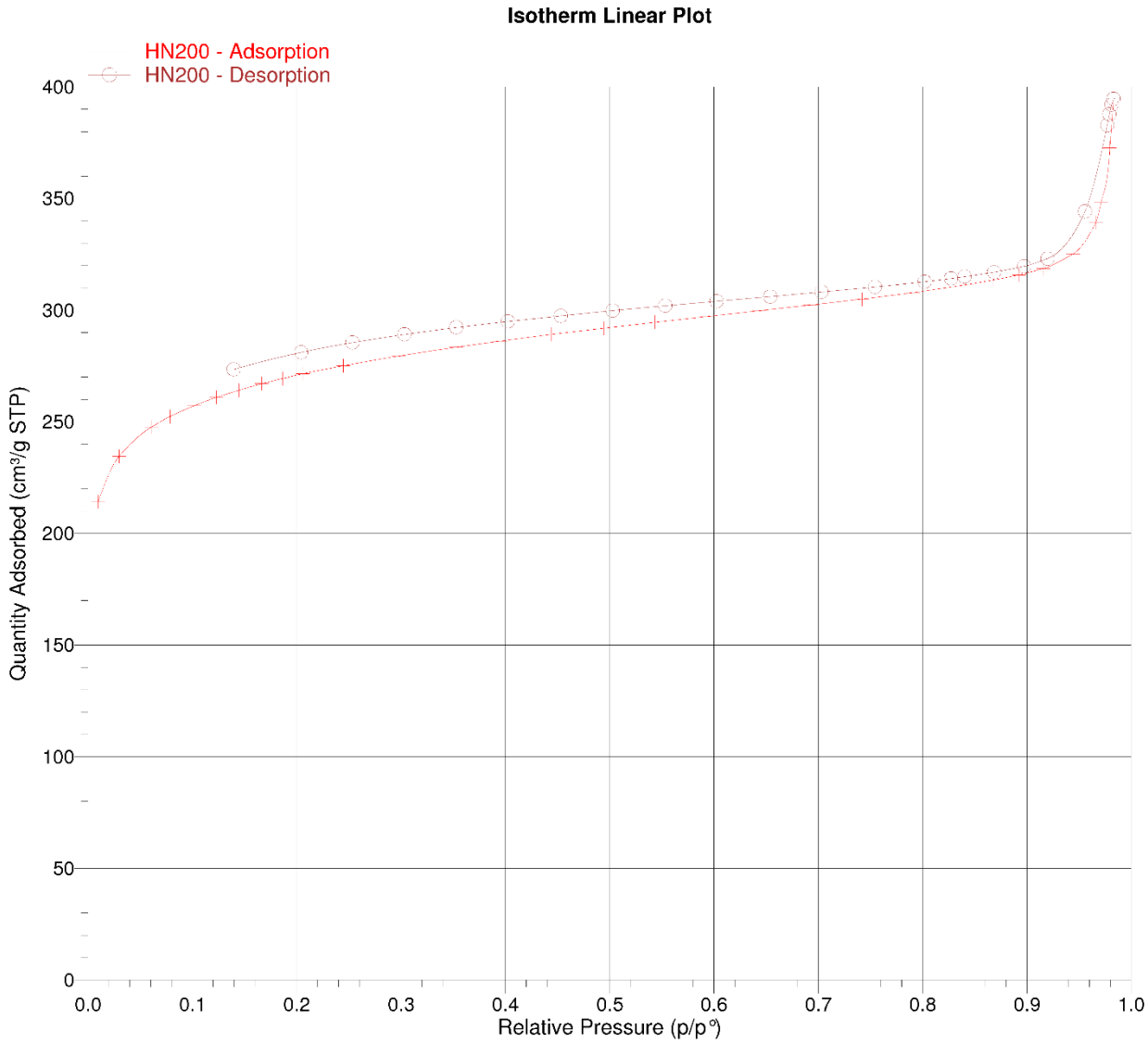


Figure S2. Isotherm linear plot for BET analysis of MN200.

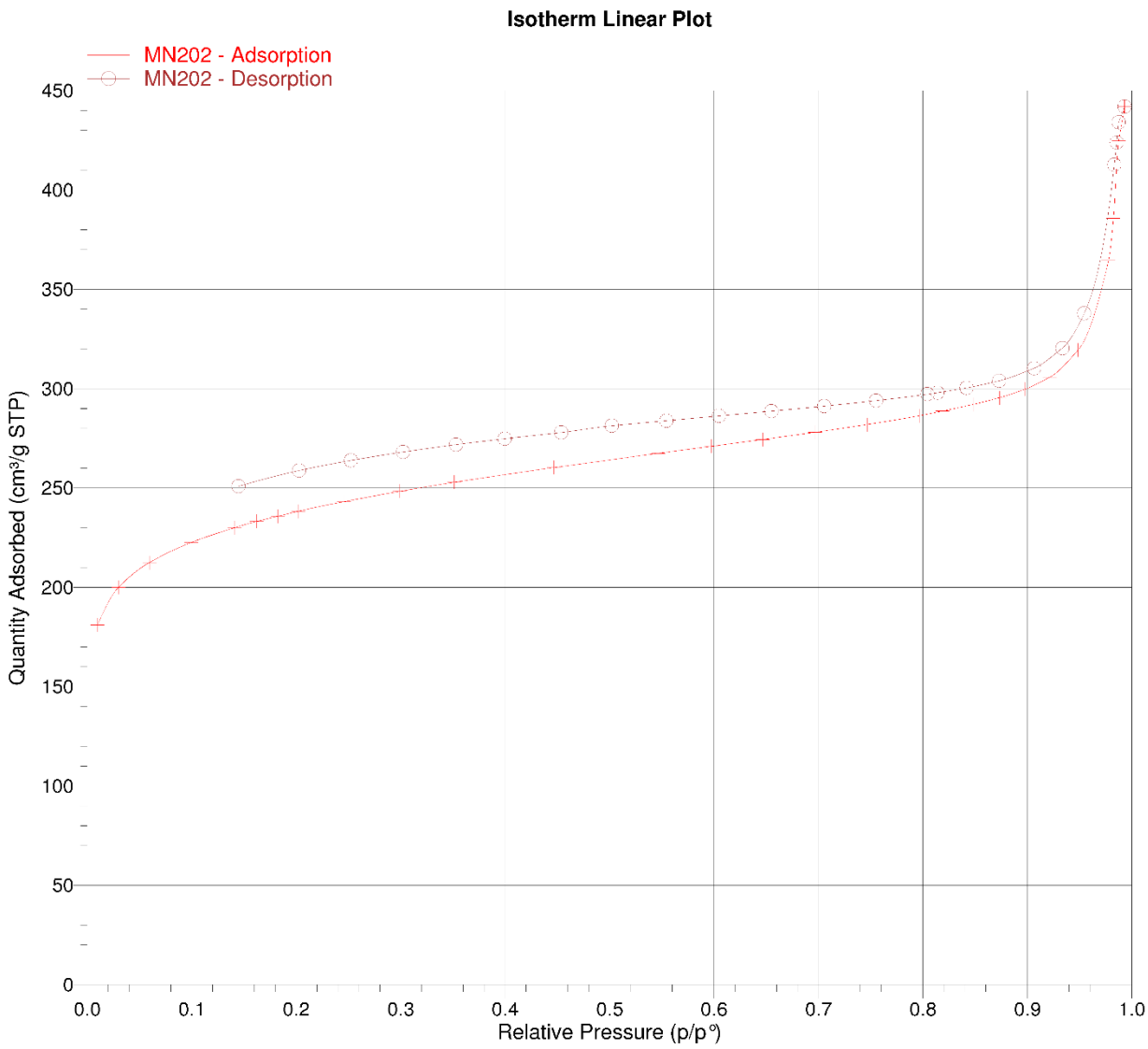


Figure S3. Isotherm linear plot for BET analysis of MN202.

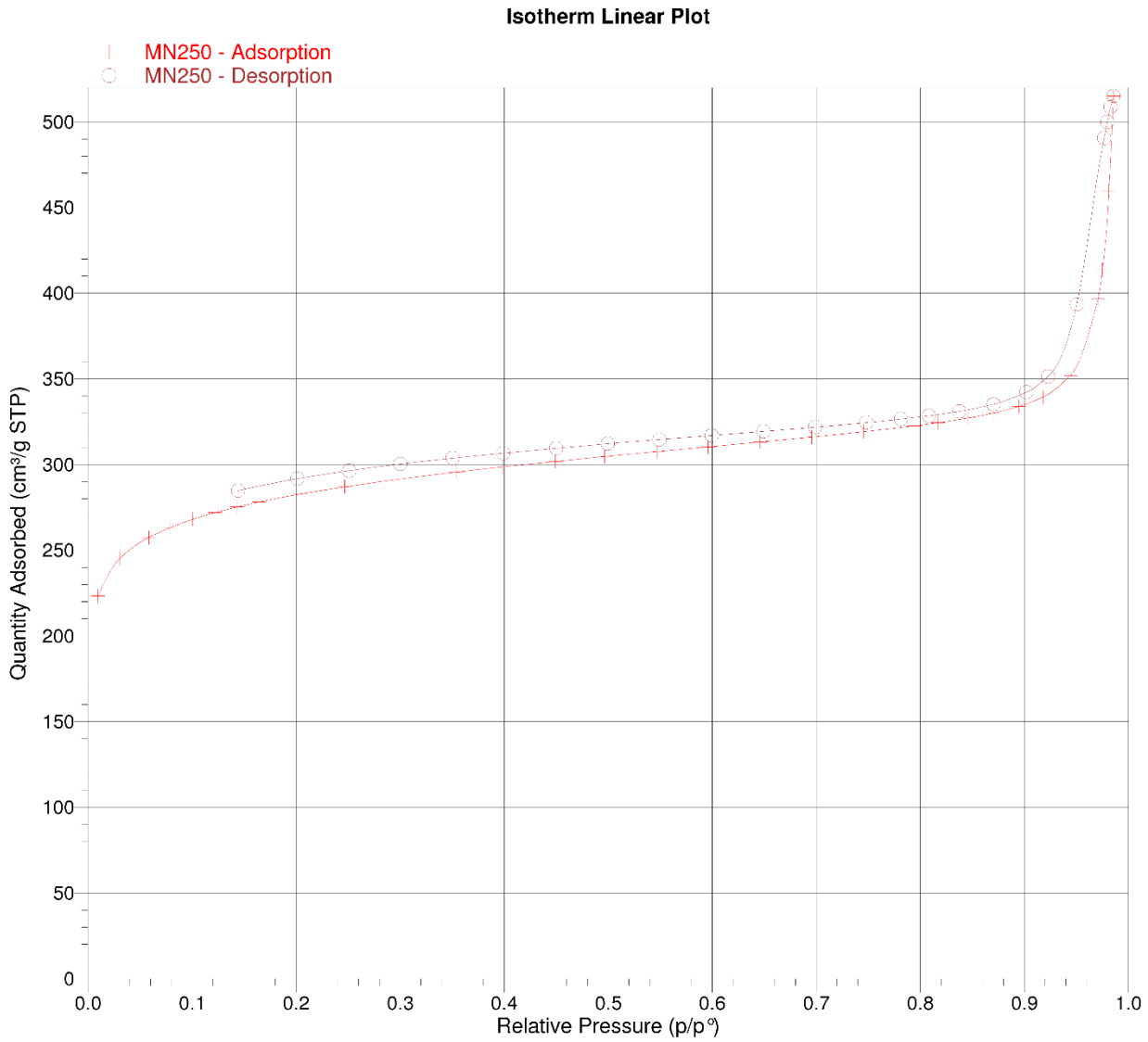


Figure S4. Isotherm linear plot for BET analysis of MN250.

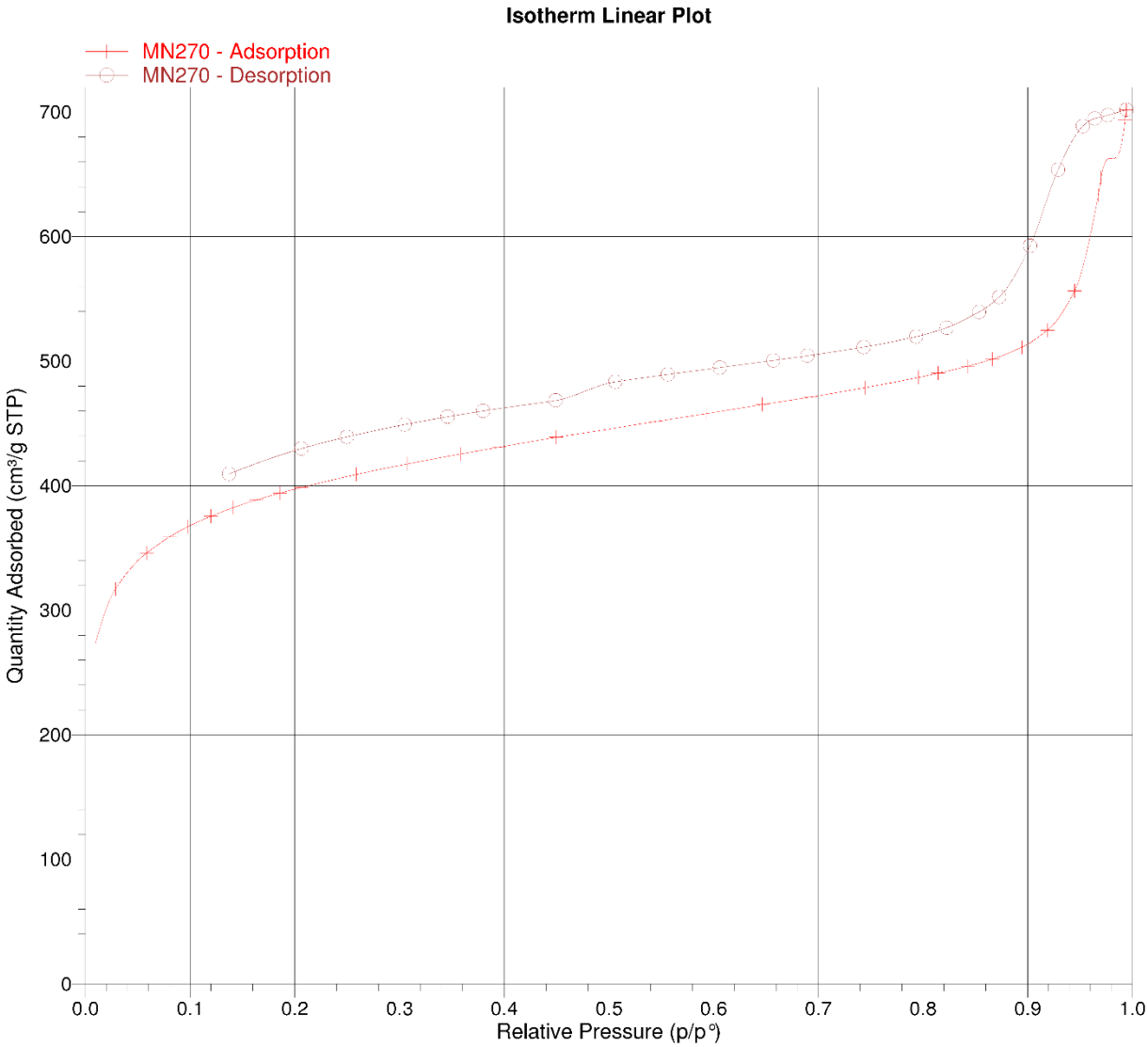


Figure S5. Isotherm linear plot for BET analysis of MN270.

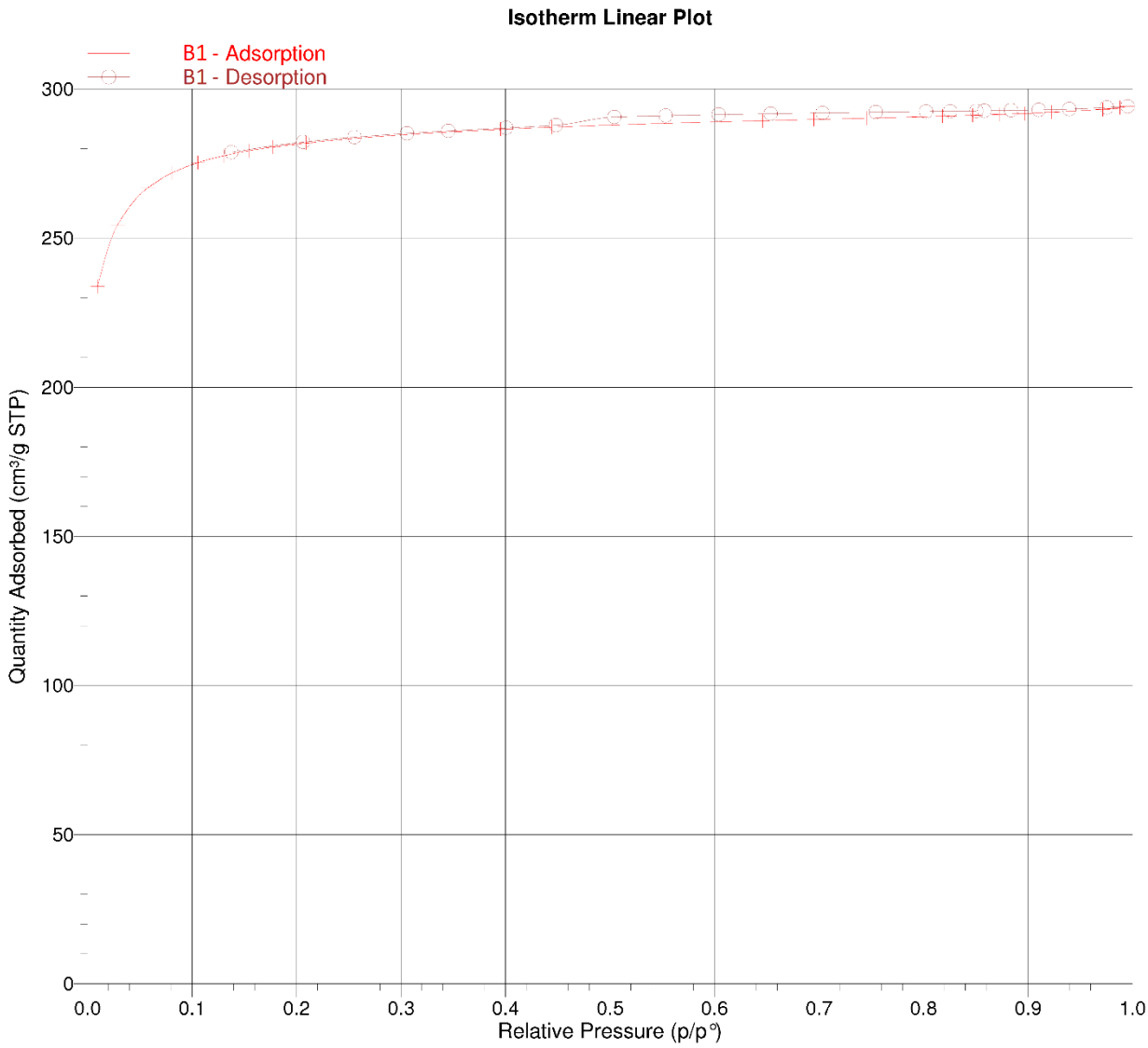


Figure S6. Isotherm linear plot for BET analysis of B1.

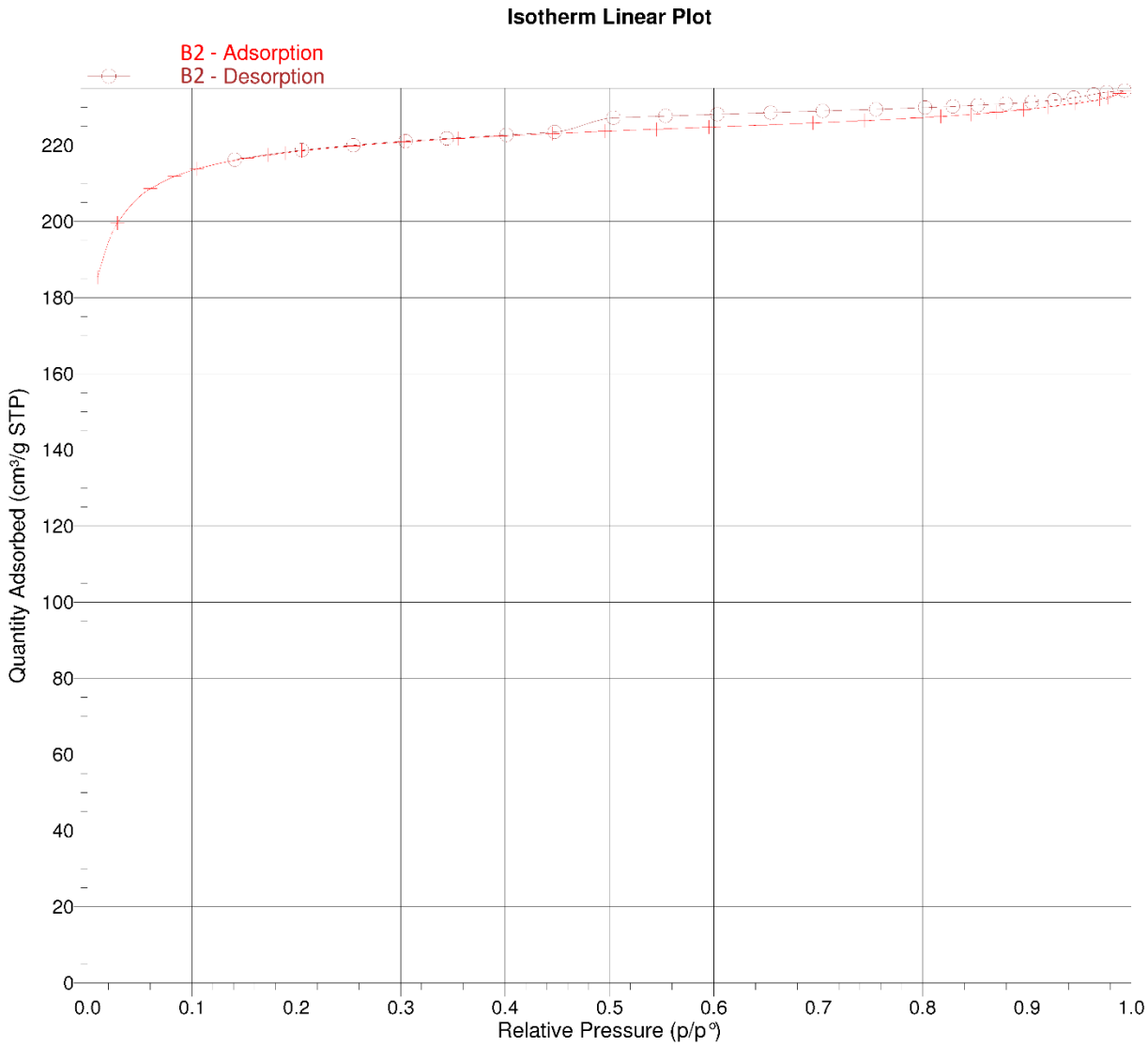


Figure S7. Isotherm linear plot for BET analysis of B2.

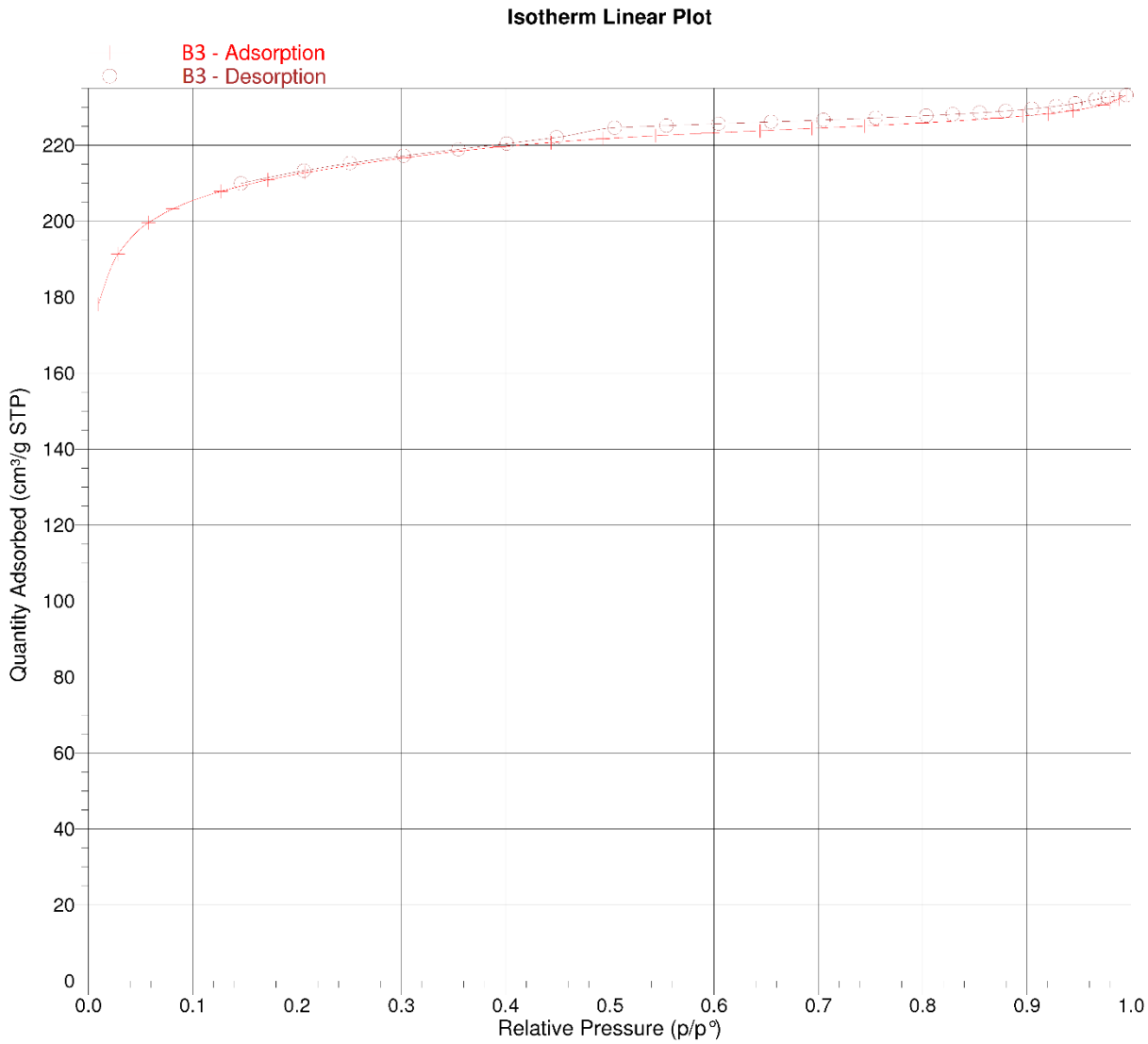


Figure S8. Isotherm linear plot for BET analysis of B3.

Supplemental Results of the Optical Microscopy Investigation of the Hyper-cross-linked Polystyrenic Sorbents (MN Sorbents)

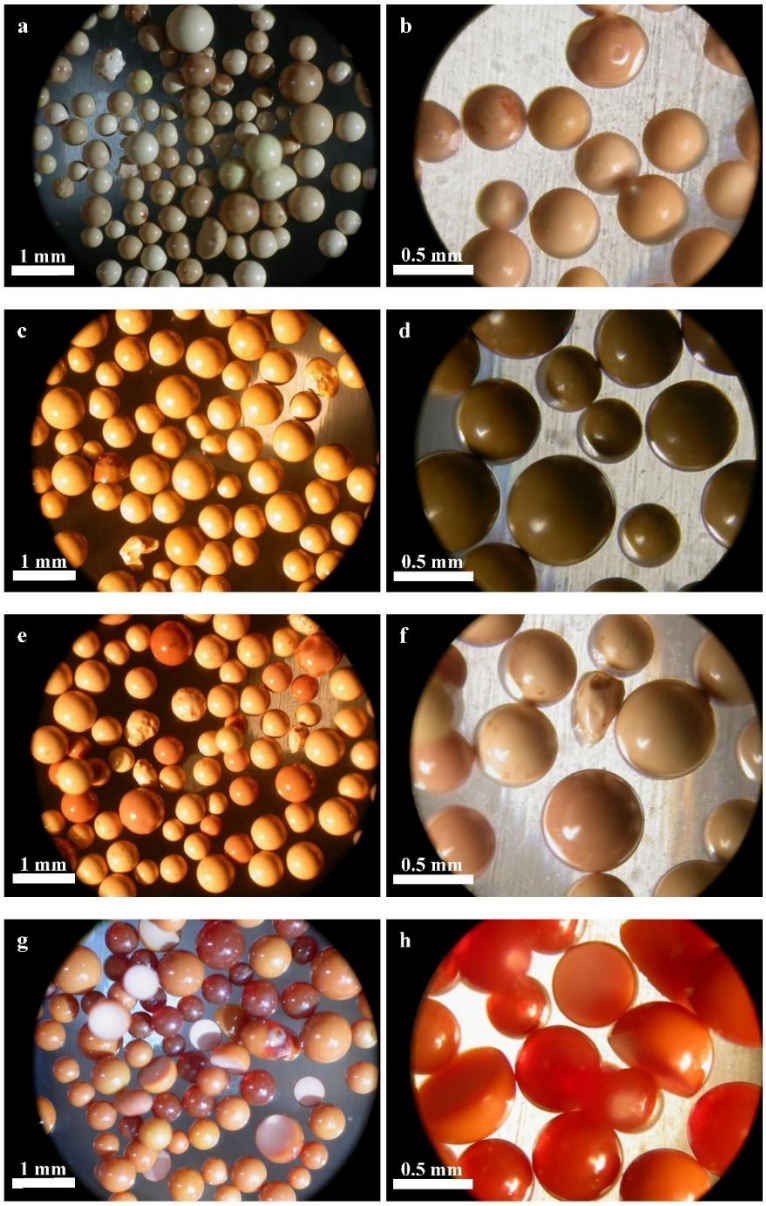


Figure S9. Supplemental optical microscopy images of the polymeric sorbents in reflected light. MN200 (a, b), MN202 (c, d), MN250 (e, f), and MN270 (g, h).

Supplemental Results of the Optical Microscopy Investigation of the Activated-Carbon-Based Sorbents (B Sorbents)

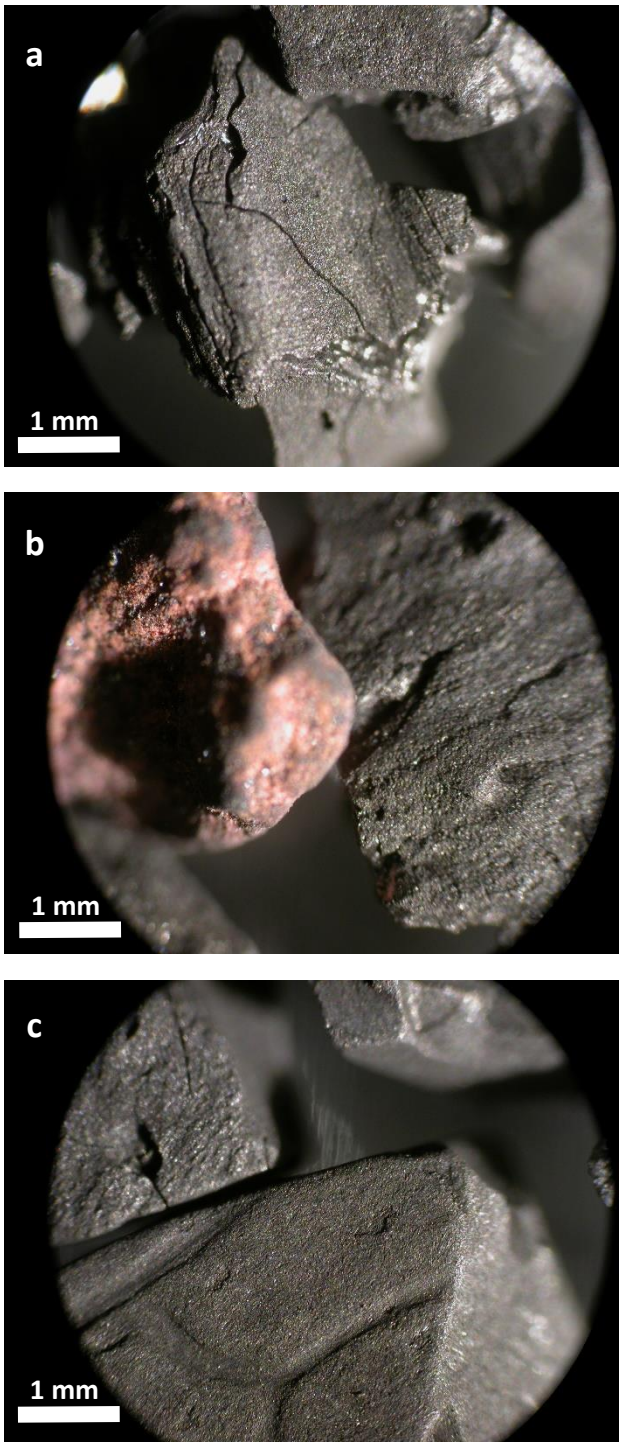


Figure S10. Supplemental optical microscopy images of the activated-carbon-based sorbents in reflected light. B1 (a), B2 (b), B3 (c).

Supplementary Tables

Table S1. Mean concentration of formaldehyde in the air passed through capsules filled with different sorbents.

Sorbent Type in Capsule	**Mean Formaldehyde Concentration in Air Passed through Capsule (mg/m^3)**	**Standard Error**	**N**
Empty Capsule, Formaldehyde	0.463	0.037	7
MN200, Formaldehyde	0.135	0.015	4
MN202, Formaldehyde	0.074	0.039	5
MN250, Formaldehyde	0.027	0.016	4
MN270, Formaldehyde	0.020	0.002	3
B1, Formaldehyde	0.031	0.009	5
B2, Formaldehyde	0.040	0.007	5
B3, Formaldehyde	0.016	0.007	5
MN200, Clean Air	0.002	0.002	4
MN202, Clean Air	0.002	0.002	4
MN250, Clean Air	0.004	0.002	4
MN270, Clean Air	0.015	0.002	4
B1, Clean Air	0.003	0.002	6
B2, Clean Air	0.000	0.000	5
B3, Clean Air	0.001	0.001	5

Table S2. Tukey Honestly Significant Difference (HSD) All Pairwise Comparisons for Sorbents and Sorbent Combinations.

Sorbent	-Sorbent	Difference	|Difference|	t Ratio	Prob>|t|	Lower 95%	Upper 95%
B2 Only (25g)	B3 (16.7 g) + MN270 (8.3 g)	-0.050037*	0.050037	-8.19	<.0001	-0.069021	-0.031053
B2 Only (25g)	B1 (16.7 g) + MN270 (8.3 g)	-0.042293*	0.042293	-6.9	<.0001	-0.061335	-0.023251
B2 (16.7 g) + MN270 (8.3 g)	B2 Only (25g)	0.034871*	0.034871	5.71	<.0001	0.015887	0.053855
B2 Only (25g)	B3 (20 g) + MN270 (5 g)	-0.033358*	0.033358	-5.46	<.0001	-0.052343	-0.014374
B3 (16.7 g) + MN270 (8.3 g)	B3 Only (25 g)	0.030529*	0.030529	4.97	<.0001	0.011456	0.049603
B2 Only (25g)	B1 (20 g) + MN270 (5 g)	-0.030042*	0.030042	-4.56	0.0002	-0.05051	-0.009574
B2 (20 g) + MN270 (5 g)	B3 (16.7 g) + MN270 (8.3 g)	-0.027312*	0.027312	-4.47	0.0003	-0.046296	-0.008328
B2 Only (25g)	B1 Only (25g)	-0.026366*	0.026366	-4.21	0.0009	-0.045834	-0.006898
B1 Only (25g)	B3 (16.7 g) + MN270 (8.3 g)	-0.023671*	0.023671	-3.78	0.0052	-0.043139	-0.004203
B1 (16.7 g) + MN270 (8.3 g)	B3 Only (25 g)	0.022785*	0.022785	3.7	0.0069	0.003654	0.041917
B2 (20 g) + MN270 (5 g)	B2 Only (25g)	0.022725*	0.022725	3.72	0.0065	0.003741	0.041709
B1 (20 g) + MN270 (5 g)	B3 (16.7 g) + MN270 (8.3 g)	-0.019995	0.019995	-3.04	0.0616	-0.040463	0.000473
B2 (20 g) + MN270 (5 g)	B1 (16.7 g) + MN270 (8.3 g)	-0.019568	0.019568	-3.19	0.0386	-0.03861	-0.000526
B2 Only (25g)	B3 Only (25 g)	-0.019508	0.019508	-3.18	0.0404	-0.038581	-0.000434
B3 (16.7 g) + MN270 (8.3 g)	B3 (20 g) + MN270 (5 g)	0.016679	0.016679	2.73	0.1384	-0.002306	0.035663
B1 (16.7 g) + MN270 (8.3 g)	B1 Only (25g)	0.015927	0.015927	2.53	0.2164	-0.003598	0.035451
B2 (16.7 g) + MN270 (8.3 g)	B3 Only (25 g)	0.015363	0.015363	2.5	0.2315	-0.00371	0.034437
B2 (16.7 g) + MN270 (8.3 g)	B3 (16.7 g) + MN270 (8.3 g)	-0.015166	0.015166	-2.48	0.2416	-0.03415	0.003818
B3 (20 g) + MN270 (5 g)	B3 Only (25 g)	0.013851	0.013851	2.26	0.3699	-0.005223	0.032924
B1 (16.7 g) + MN270 (8.3 g)	B1 (20 g) + MN270 (5 g)	0.012251	0.012251	1.85	0.6452	-0.008271	0.032772
B2 (16.7 g) + MN270 (8.3 g)	B2 (20 g) + MN270 (5 g)	0.012146	0.012146	1.99	0.5522	-0.006838	0.03113
B2 (20 g) + MN270 (5 g)	B3 (20 g) + MN270 (5 g)	-0.010633	0.010633	-1.74	0.7214	-0.029618	0.008351
B1 (20 g) + MN270 (5 g)	B3 Only (25 g)	0.010535	0.010535	1.59	0.809	-0.010016	0.031086
B1 (16.7 g) + MN270 (8.3 g)	B3 (20 g) + MN270 (5 g)	0.008935	0.008935	1.46	0.8747	-0.010108	0.027977
B2 (16.7 g) + MN270 (8.3 g)	B1 Only (25g)	0.008505	0.008505	1.36	0.9134	-0.010963	0.027973
B1 (16.7 g) + MN270 (8.3 g)	B3 (16.7 g) + MN270 (8.3 g)	-0.007744	0.007744	-1.26	0.9416	-0.026786	0.011298
B2 (16.7 g) + MN270 (8.3 g)	B1 (16.7 g) + MN270 (8.3 g)	-0.007422	0.007422	-1.21	0.9542	-0.026464	0.01162
B2 (20 g) + MN270 (5 g)	B1 (20 g) + MN270 (5 g)	-0.007317	0.007317	-1.11	0.9727	-0.027785	0.013151
B1 Only (25g)	B3 (20 g) + MN270 (5 g)	-0.006992	0.006992	-1.12	0.9719	-0.02646	0.012476
B1 Only (25g)	B3 Only (25 g)	0.006859	0.006859	1.09	0.9757	-0.012696	0.026414
B2 (16.7 g) + MN270 (8.3 g)	B1 (20 g) + MN270 (5 g)	0.004829	0.004829	0.73	0.9983	-0.015639	0.025297
B1 (20 g) + MN270 (5 g)	B1 Only (25g)	0.003676	0.003676	0.55	0.9998	-0.017241	0.024594
B2 (20 g) + MN270 (5 g)	B1 Only (25g)	-0.003641	0.003641	-0.58	0.9997	-0.023109	0.015827
B1 (20 g) + MN270 (5 g)	B3 (20 g) + MN270 (5 g)	-0.003316	0.003316	-0.5	0.9999	-0.023784	0.017152
B2 (20 g) + MN270 (5 g)	B3 Only (25 g)	0.003217	0.003217	0.52	0.9999	-0.015856	0.022291
B2 (16.7 g) + MN270 (8.3 g)	B3 (20 g) + MN270 (5 g)	0.001513	0.001513	0.25	1	-0.017472	0.020497

Difference is the estimated difference between the means.

t Ratio is the ratio of the estimate to its standard error. Given the usual assumptions about the model, the t Ratio has a Student's t distribution under the null hypothesis. The test is whether the difference is zero.

Prob > |t| is the p-value for the test that the true parameter value is zero, against the two-sided alternative that it is not.

Table S3. Grouping by Letters, Tukey HSD All Pairwise Comparisons by Sorbent/Sorbent Combination. There is no Evidence of Difference for the Groups with Overlapping Letters.

Sorbent	Letters	Least Squares Mean	Std Error	Lower 95%	Upper 95%
B3 (16.7 g) + MN270 (8.3 g)	A	0.148956	0.004321	0.14048	0.157432
B1 (16.7 g) + MN270 (8.3 g)	AB	0.141212	0.004347	0.132685	0.14974
B2 (16.7 g) + MN270 (8.3 g)	ABC	0.13379	0.004321	0.125314	0.142266
B3 (20 g) + MN270 (5 g)	ABC	0.132278	0.004321	0.123802	0.140754
B1 (20 g) + MN270 (5 g)	ABC	0.128962	0.004973	0.119206	0.138718
B1 Only (25g)	BC	0.125286	0.004538	0.116383	0.134188
B2 (20 g) + MN270 (5 g)	C	0.121644	0.004321	0.113168	0.13012
B3 Only (25 g)	C	0.118427	0.004361	0.109871	0.126982
B2 Only (25g)	D	0.098919	0.004321	0.090443	0.107395

Details of Statistical Analysis[1]

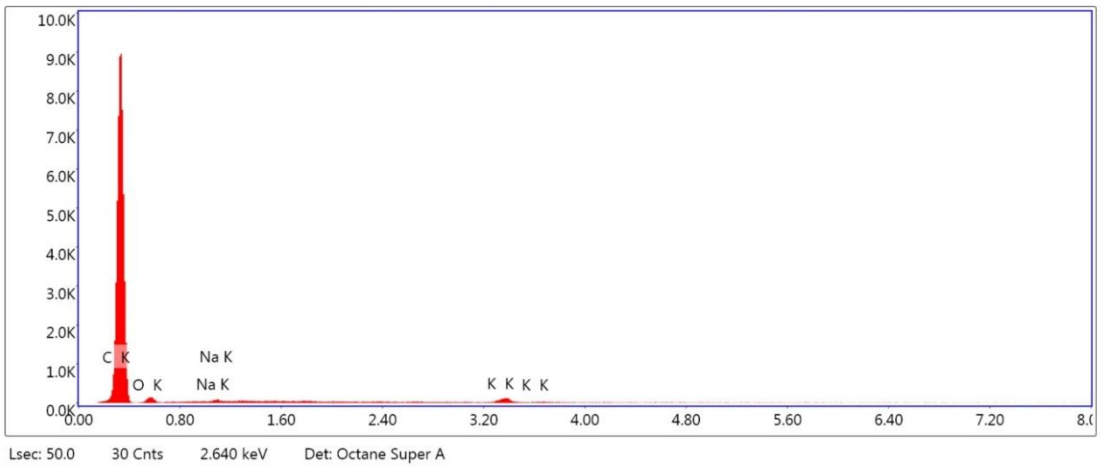
The slopes of each level of the interaction effect are compared to the overall slope. Analysis of means (ANOM) with the overall average is used in the ANCOVA comparison. "The overall average slope is a weighted average of the slopes. The weights are inversely proportional to the variances of the slope estimates. These variances are the squared values of the Std Error column in the Differences from Overall Average Slope table." Least-squares Means Tukey HSD (honestly significant difference) test performed pairwise comparisons of the linear model effects. "For these comparisons, the significance level applies to the entire collection of pairwise comparisons." The sample sizes are equal, so the significance level is exact. The data table provides the levels of the effect, the connecting letters, the least-squares means, their standard errors, and confidence intervals. The connection indicated by overlapping letters means that the levels do not differ at the 0.05 significance level.

[1] SAS Institute. JMP 14 Fitting Linear Models: SAS Institute; 2018

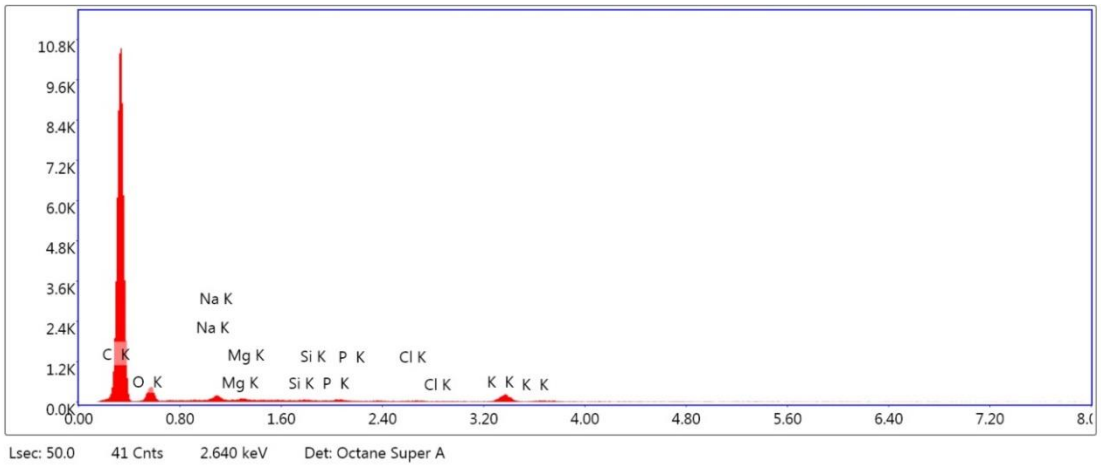
Table S4. Supplemental electron dispersion spectroscopy (EDS) data for the scanning electron microscopy (SEM) analysis of the surface of the activated-carbon-based sorbent B1 (Image a).

Net Int.	Error %	K_{ratio}	Z	A	F
Spot 1 in Main Article Figure 8 (**Image a**)					
902.12	2.97	0.9225	1.0032	0.9665	1.0000
15.31	14.97	0.0088	0.9490	0.2094	1.0000
0.00	99.99	0.0000	0.8516	0.7301	1.0015
2.34	49.76	0.0033	0.7733	1.0209	1.0483
Spot 2 in Main Article Figure 8 (**Image a**)					
471.75	5.58	0.5917	1.0292	0.7464	1.0000
31.82	13.51	0.0225	0.9746	0.2187	1.0000
9.26	23.16	0.0075	0.8752	0.6967	1.0018
14.98	14.02	0.0105	0.8875	0.8178	1.0029
10.24	16.20	0.0080	0.8687	0.9477	1.0079
5.61	28.62	0.0058	0.8323	0.9754	1.0121
37.65	6.69	0.0661	0.7957	1.0137	1.0135
Spot 3 in Main Article Figure 8 (**Image a**)					
718.41	5.48	0.5778	1.0261	0.7206	1.0000
52.50	11.83	0.0238	0.9715	0.2230	1.0000
24.24	10.06	0.0126	0.8723	0.7006	1.0017
14.69	11.07	0.0066	0.8845	0.8148	1.0029
9.95	17.97	0.0050	0.8657	0.9488	1.0081
10.01	14.18	0.0066	0.8294	0.9781	1.0121
5.89	28.45	0.0049	0.8007	1.0052	1.0275
42.68	5.87	0.0480	0.7929	1.0131	1.0161
Spot 4 in Main Article Figure 8 (**Image a**)					
1196.07	3.03	0.8921	1.0036	0.9530	1.0000
32.31	13.55	0.0136	0.9494	0.2148	1.0000
0.00	99.99	0.0000	0.8519	0.7240	1.0014
0.46	77.84	0.0005	0.7737	1.0205	1.0520

EDS <u>Spot 1 in Figure 7a</u> in the Main Article (Sorbent B1)



EDS <u>Spot 3 in Figure 7a</u> in the Main Article (Sorbent B1)



EDS <u>Spot 4 in Figure 7a</u> in the Main Article (Sorbent B1)

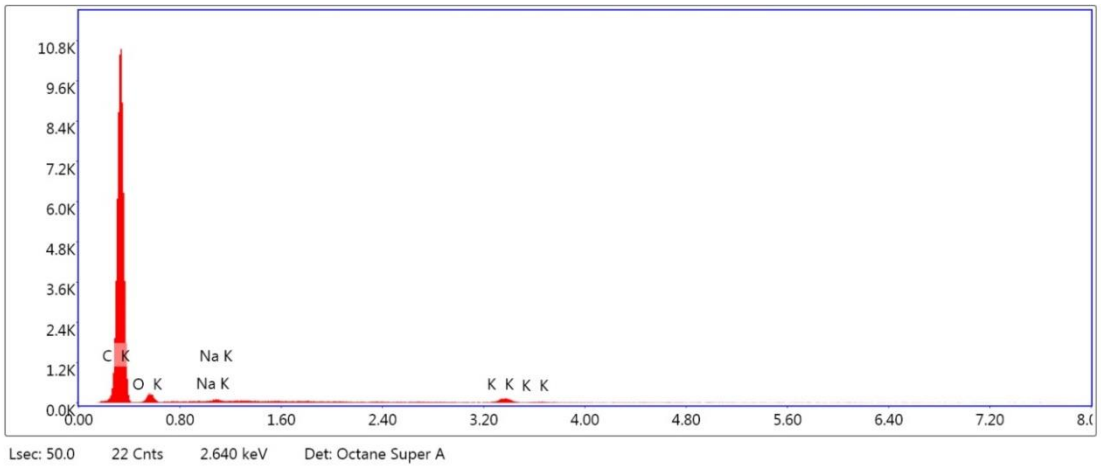
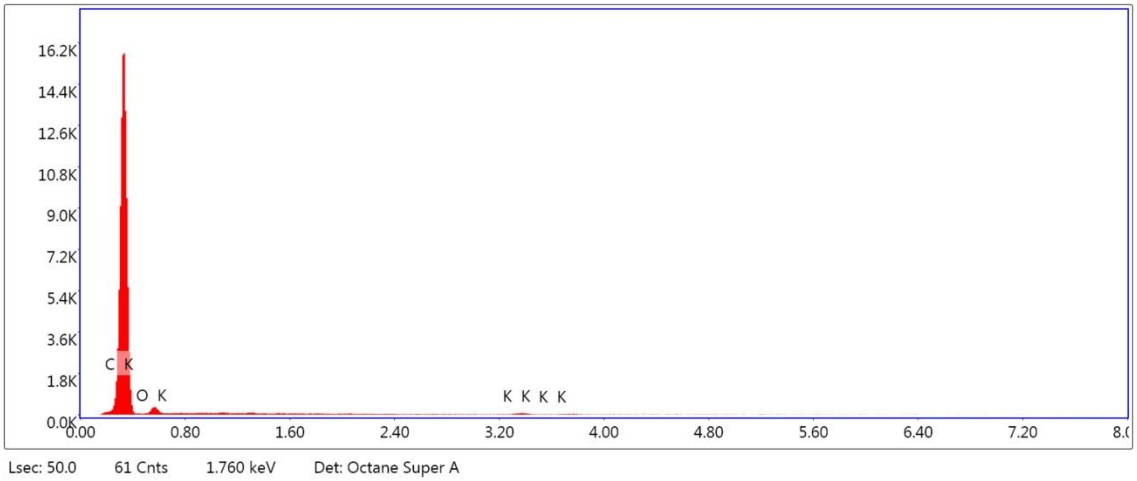


Figure S11. Electron dispersion analysis of the activated-carbon-based sorbent B1.

Table S5. Supplemental electron dispersion spectroscopy (EDS) data for the scanning electron microscopy (SEM) analysis of the surface of the activated-carbon-based sorbent B2 (Image b).

Net Int.	Error %	K_{ratio}	Z	A	F
Area 1 in Main Article Figure 8 (**Image b**)					
1859.80	2.75	0.9080	1.0030	0.9596	1.0000
40.99	12.28	0.0112	0.9488	0.2096	1.0000
0.00	99.99	0.0000	0.7731	1.0211	1.0535
Area 2 in Main Article Figure 8 (**Image b**)					
162.15	9.10	0.1610	1.2154	0.4836	1.0000
33.18	37.88	0.0185	1.1566	0.2952	1.0000
8.74	37.43	0.0056	1.0438	0.4434	1.0007
7.93	29.71	0.0049	1.0398	0.8106	1.0043
142.52	4.93	0.1962	0.9574	0.9858	1.0157
91.53	6.52	0.3799	0.8439	0.9962	1.0056
Area 3 in Main Article Figure 8 (**Image b**)					
17.17	13.67	0.0213	1.2889	0.4501	1.0000
31.27	14.92	0.0218	1.2275	0.2473	1.0000
0.75	99.99	0.0006	1.1087	0.4240	1.0008
19.71	10.92	0.0152	1.1053	0.7985	1.0050
262.13	3.53	0.4506	1.0189	0.9806	1.0097
73.33	6.39	0.3801	0.9013	0.9829	1.0059

EDS <u>Area 1 in Figure 7b</u> in the Main Article (Sorbent B2)



EDS <u>Area 3 in Figure 7b</u> in the Main Article (Sorbent B2)

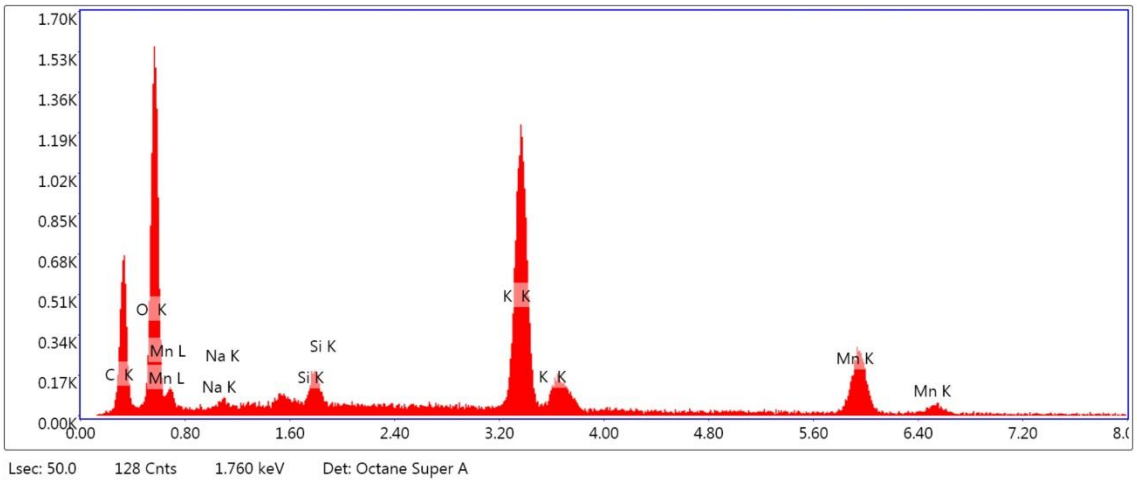


Figure S12. Electron dispersion analysis of the activated-carbon-based sorbent B2.

Table S6. Supplemental electron dispersion spectroscopy (EDS) data for the scanning electron microscopy (SEM) analysis of the surface of the activated-carbon-based sorbent B3 (Image c).

Net Int.	Error %	K_{ratio}	Z	A	F
Area 1 in Main Article Figure 8 **Image c**					
797.55	3.99	0.6462	1.0304	0.8480	1.0000
71.01	11.68	0.0317	0.9757	0.2077	1.0000
78.43	4.77	0.0851	0.7968	1.0178	1.0120
Area 2 in Main Article Figure 8 **Image c**					
509.51	6.30	0.4661	1.0422	0.6639	1.0000
79.65	11.70	0.0402	0.9874	0.2274	1.0000
14.00	18.05	0.0069	0.8997	0.7809	1.0029
21.12	11.05	0.0109	0.8641	0.8699	1.0046
33.29	7.38	0.0183	0.8808	0.9235	1.0062
55.15	5.61	0.0676	0.8072	1.0101	1.0172
3.70	29.89	0.0119	0.5774	1.0676	0.9992
Area 3 in Main Article Figure 8 **Image c**					
690.53	5.88	0.4977	1.0291	0.6936	1.0000
118.85	10.65	0.0473	0.9744	0.2328	1.0000
10.83	21.33	0.0042	0.8872	0.7942	1.0032
27.76	9.49	0.0113	0.8519	0.8842	1.0049
30.22	7.77	0.0131	0.8683	0.9342	1.0065
48.80	5.93	0.0471	0.7952	1.0135	1.0166

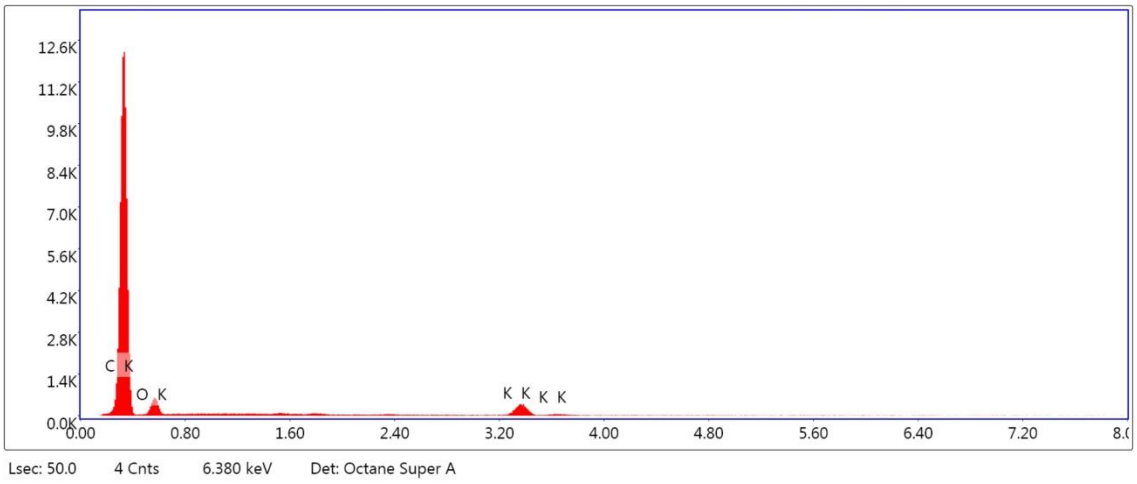
Net Int. (net intensity that is a difference of peak intensity and background intensity, in kcps (kilocounts per second);

Z is the mean atomic number correction applied to the K_{ratio} to obtain the element content;

A is the absorption correction applied to the K_{ratio} to obtain the element content;

F is the flurescence correction applied to the K_{ratio} to obtain the element content.

EDS <u>Area 1 in Figure 7c</u> in the Main Article (Sorbent B3)



EDS <u>Area 3 in Figure 7c</u> in the Main Article (Sorbent B3)

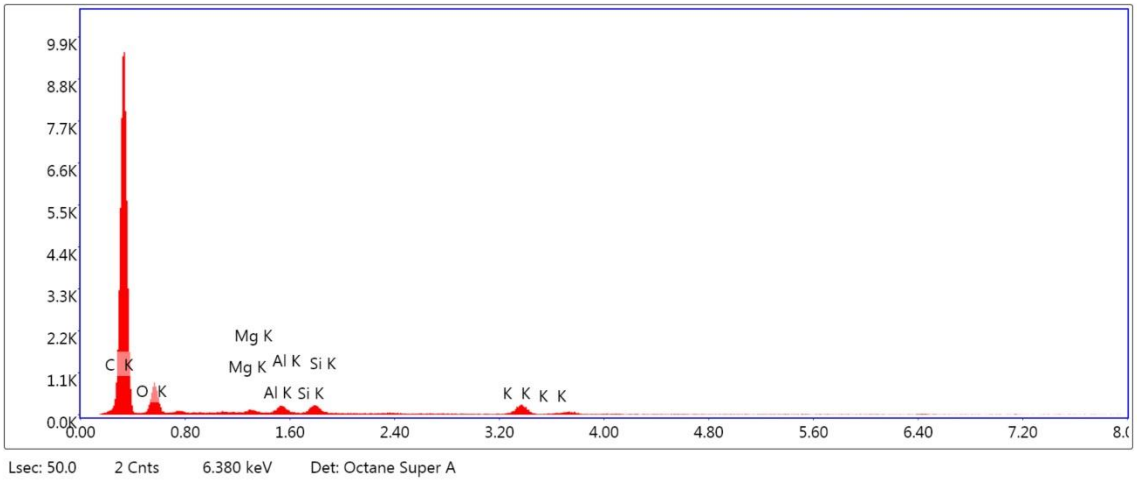


Figure S13. Electron dispersion analysis of the activated-carbon-based sorbent B3.

Supplementary Data

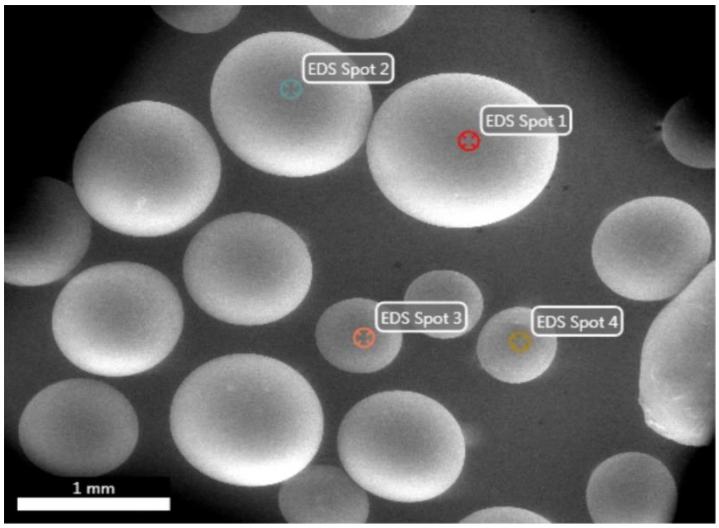
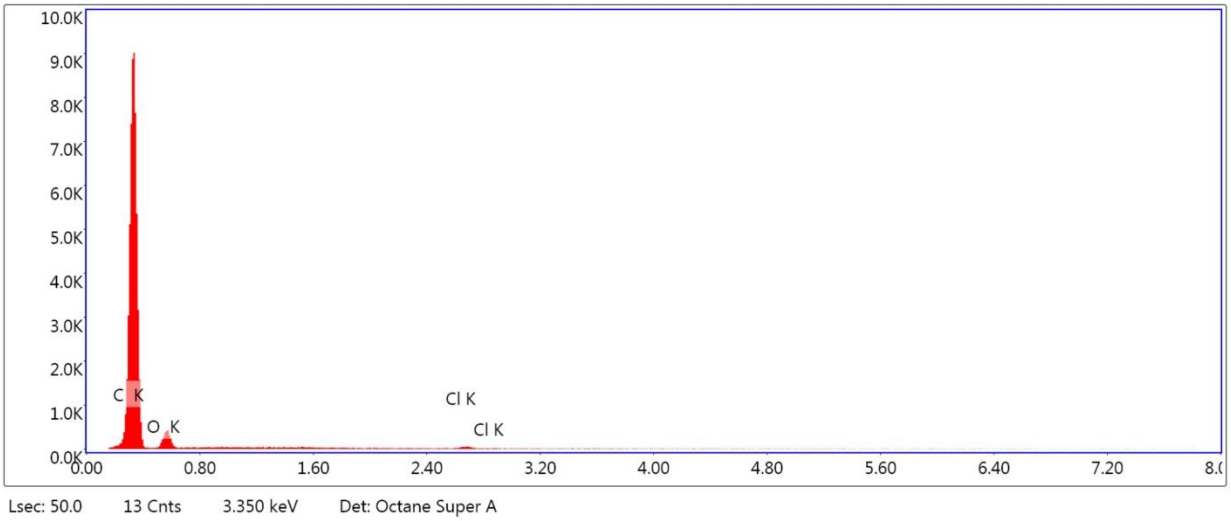


Figure S14. Supplemental Results of the Scanning Electron Microscopy Investigation of the Outer Granule Surface of MN270.

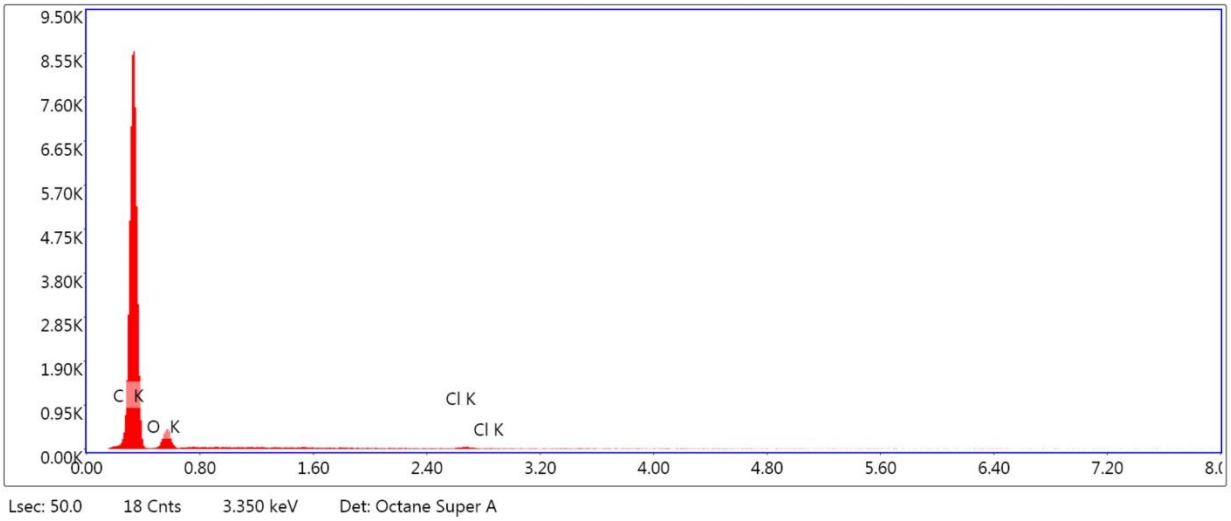
EDS Spot 1

eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int.	Error %	K_{ratio}	Z	A	F
C K	88.91	91.46	1056.81	2.74	0.8187	1.0059	0.9154	1.0000
O K	11.04	8.52	52.12	11.90	0.0223	0.9517	0.2126	1.0000
ClK	0.05	0.02	0.54	73.22	0.0004	0.7832	1.0170	1.0248



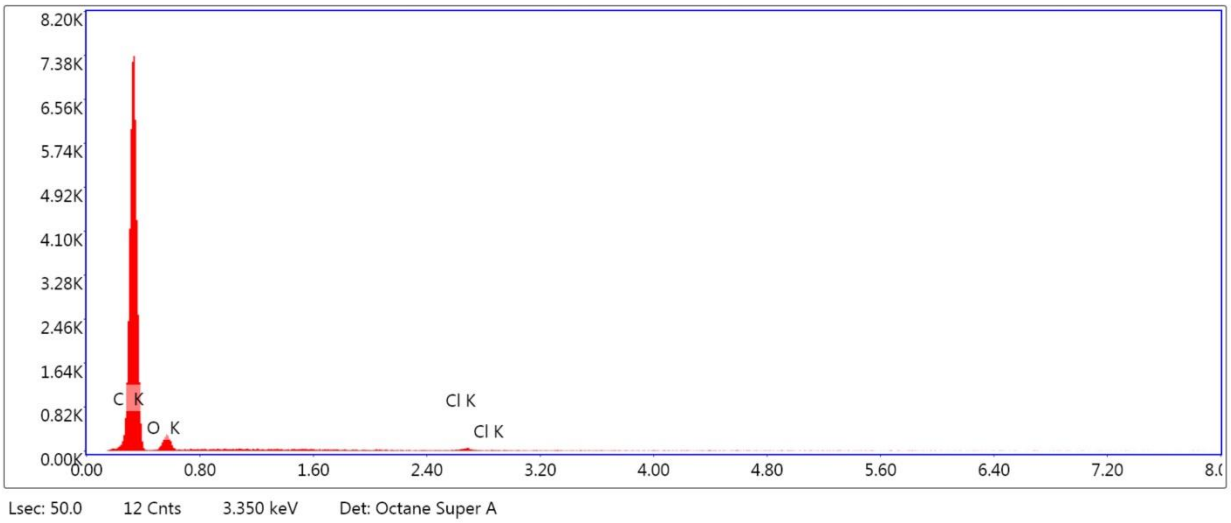
EDS Spot 2



eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int.	Error %	K_{ratio}	Z	A	F
C K	88.10	90.80	1012.15	2.76	0.8106	1.0063	0.9144	1.0000
O K	11.89	9.20	54.89	11.83	0.0243	0.9520	0.2146	1.0000
ClK	0.00	0.00	0.02	99.99	0.0000	0.7835	1.0166	1.0248

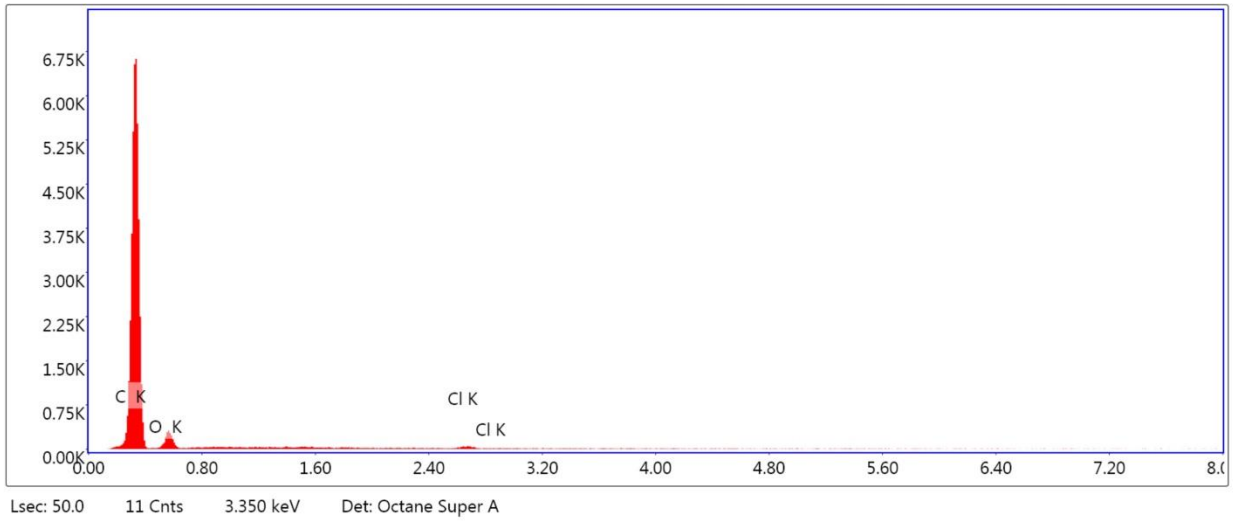
EDS Spot 3



eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int.	Error %	K_{ratio}	Z	A	F
C K	90.02	92.31	854.97	2.67	0.8394	1.0053	0.9276	1.0000
O K	9.98	7.69	36.76	12.34	0.0200	0.9510	0.2101	1.0000
ClK	0.00	0.00	0.00	99.99	0.0000	0.7827	1.0174	1.0253

EDS Spot 4



eZAF Smart Quant Results

Element	Weight %	Atomic %	Net Int.	Error %	K_{ratio}	Z	A	F
C K	89.41	91.85	766.43	2.80	0.8268	1.0056	0.9195	1.0000
O K	10.55	8.14	35.58	12.38	0.0212	0.9514	0.2114	1.0000
ClK	0.04	0.01	0.33	75.91	0.0003	0.7830	1.0172	1.0250

Net Int. (net intensity that is a difference of peak intensity and background intensity, in kcps (kilocounts per second);

Z is the mean atomic number correction applied to the K_{ratio} to obtain the element content;

A is the absorption correction applied to the K_{ratio} to obtain the element content;

F is the flurescence correction applied to the K_{ratio} to obtain the element content.

Figure S15. Supplemental Results of the Electron Dispersion Spectroscopy Investigation of the Outer Granule Surface of MN270 pictured in Figure S14.

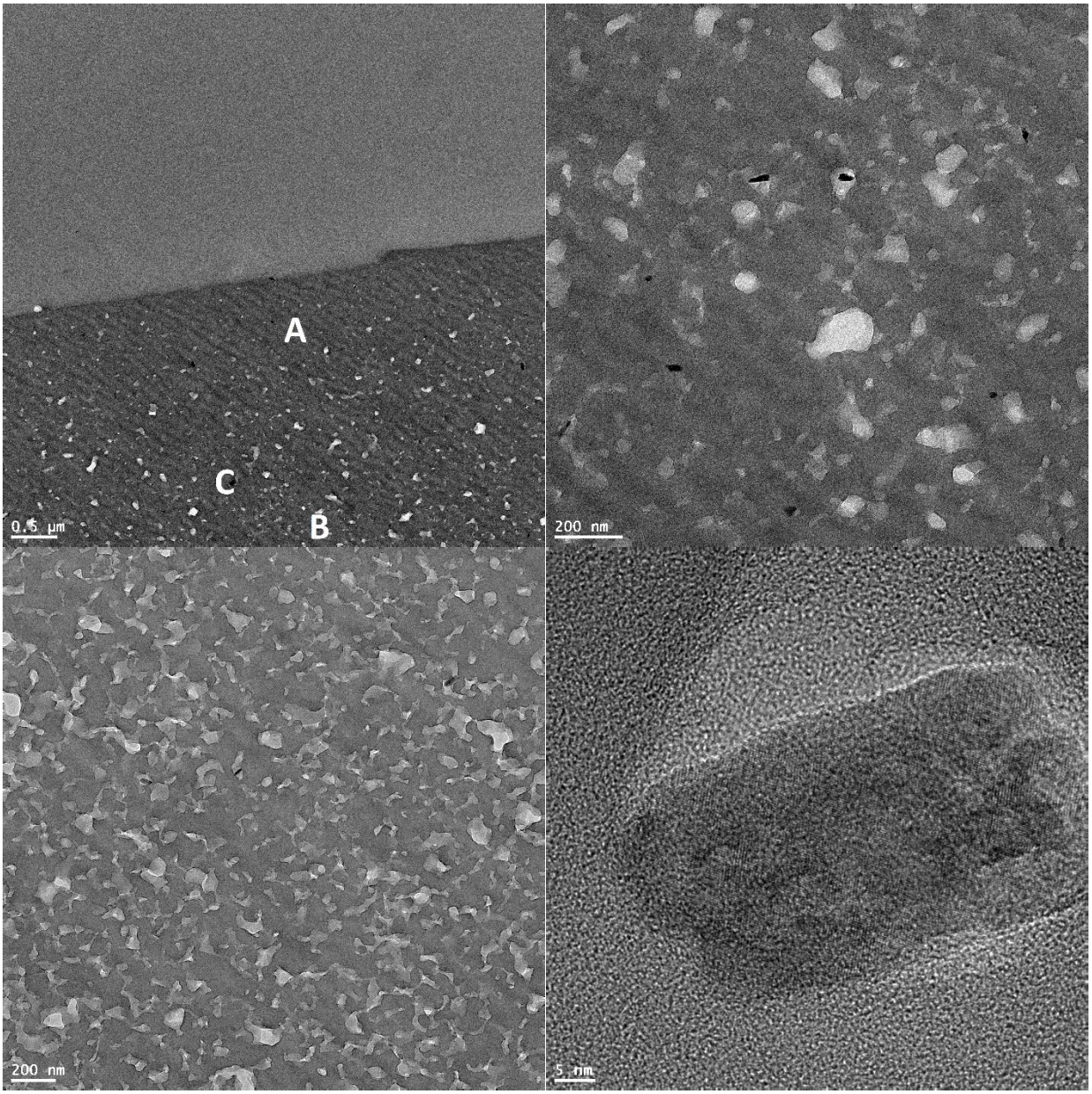


Figure S16. Supplemental Results of the Transmission Electron Microscopy Investigation of MN270.

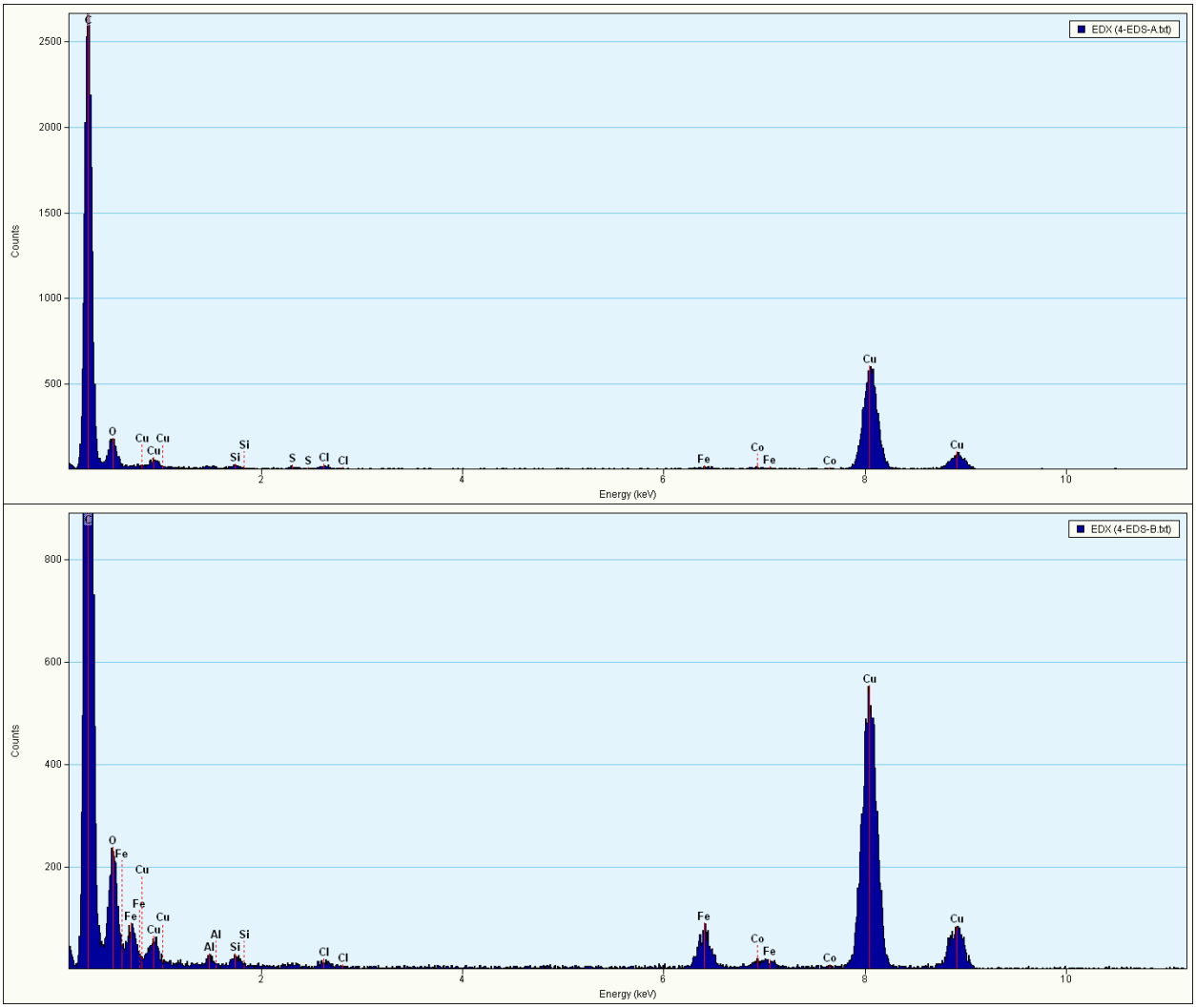


Figure S17. Supplemental Results of the Electron Dispersion Spectroscopy Investigation of MN270 pictured in Figure S16.

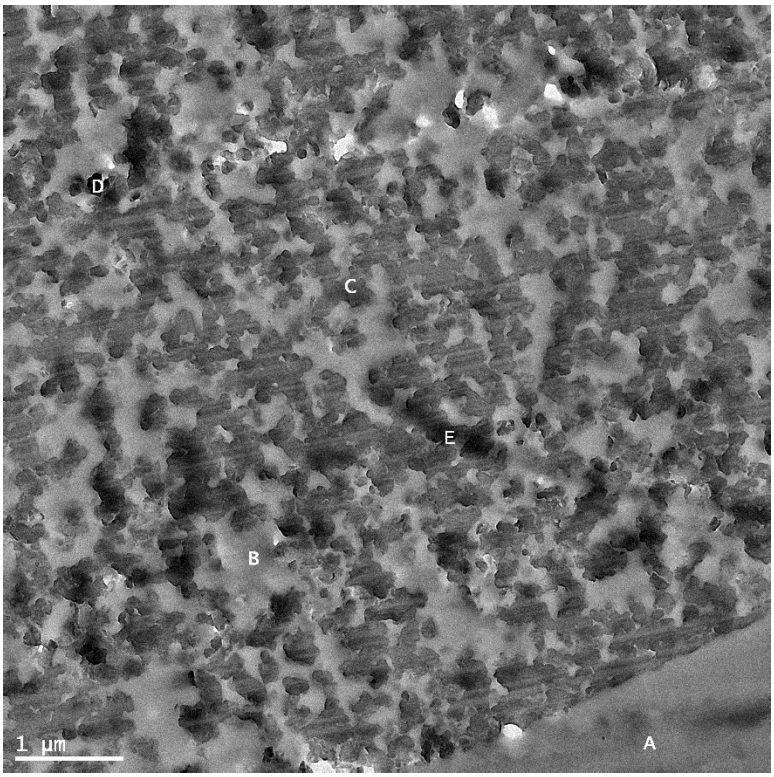
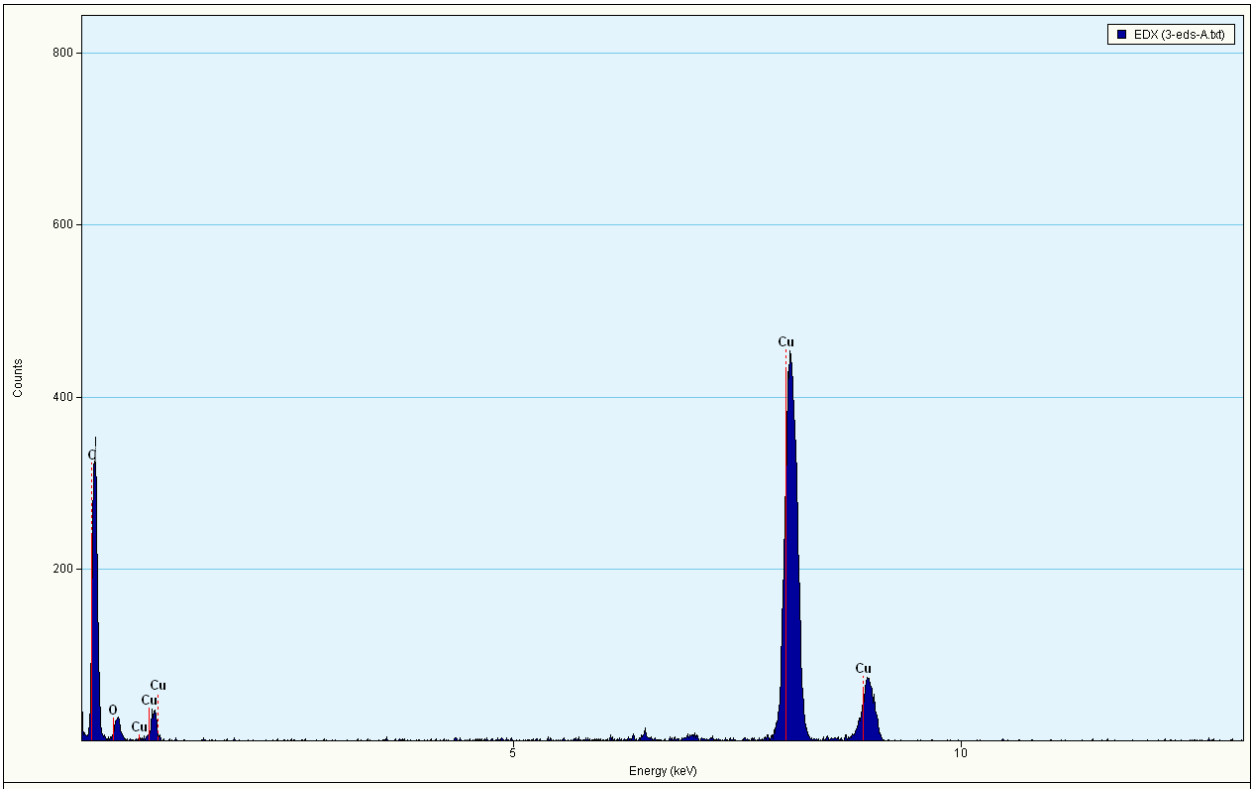
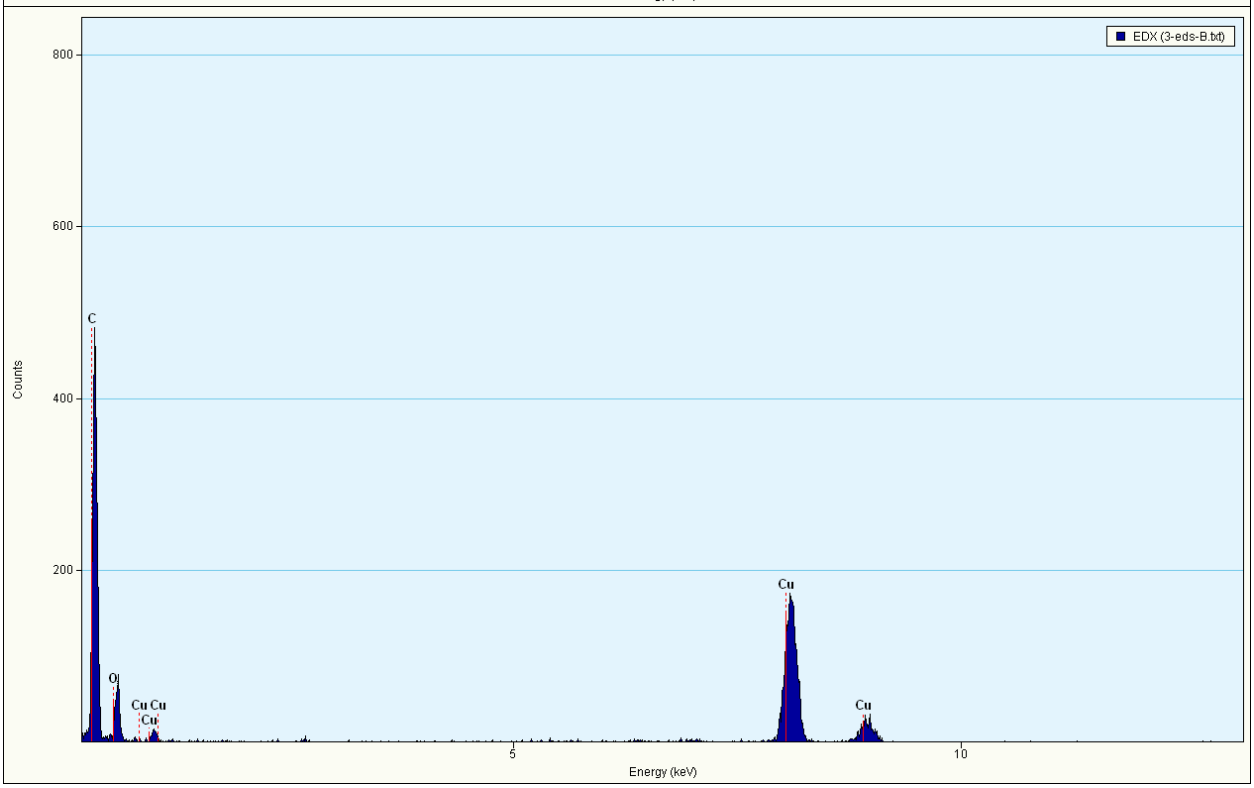


Figure S18. Supplemental Results of the Transmission Electron Microscopy Investigation of MN250.


EDX (3-eds-A.txt)
Counts
800
600
400
200
C
O
Cu
Cu
Cu
Cu
Cu
5
10
Energy (keV)


EDX (3-eds-B.txt)
Counts
800
600
400
200
C
O
Cu
Cu
Cu
Cu
Cu
5
10
Energy (keV)

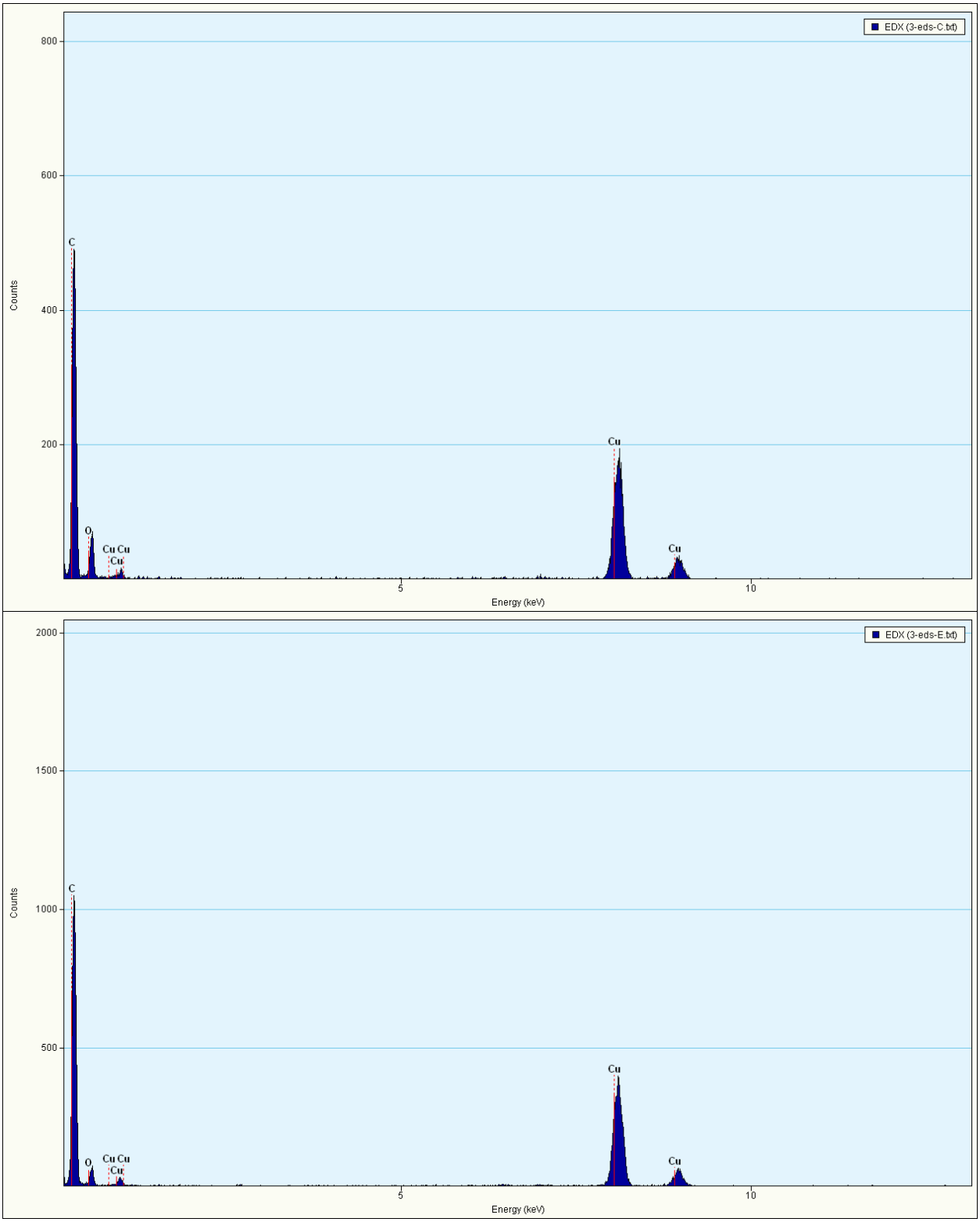


Figure S19. Supplemental Results of the Electron Dispersion Spectroscopy Investigation of MN250 pictured in Figure S18.

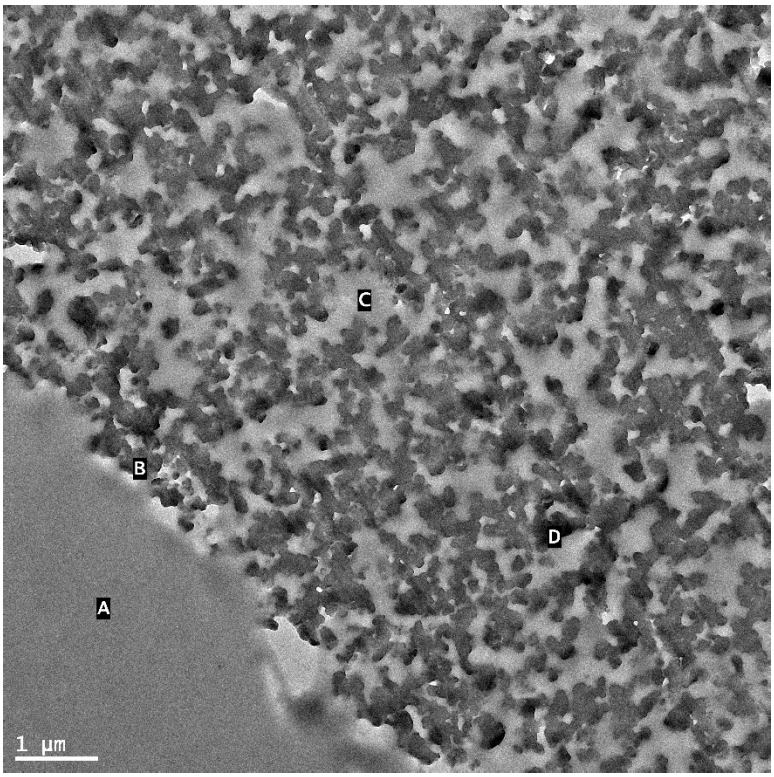
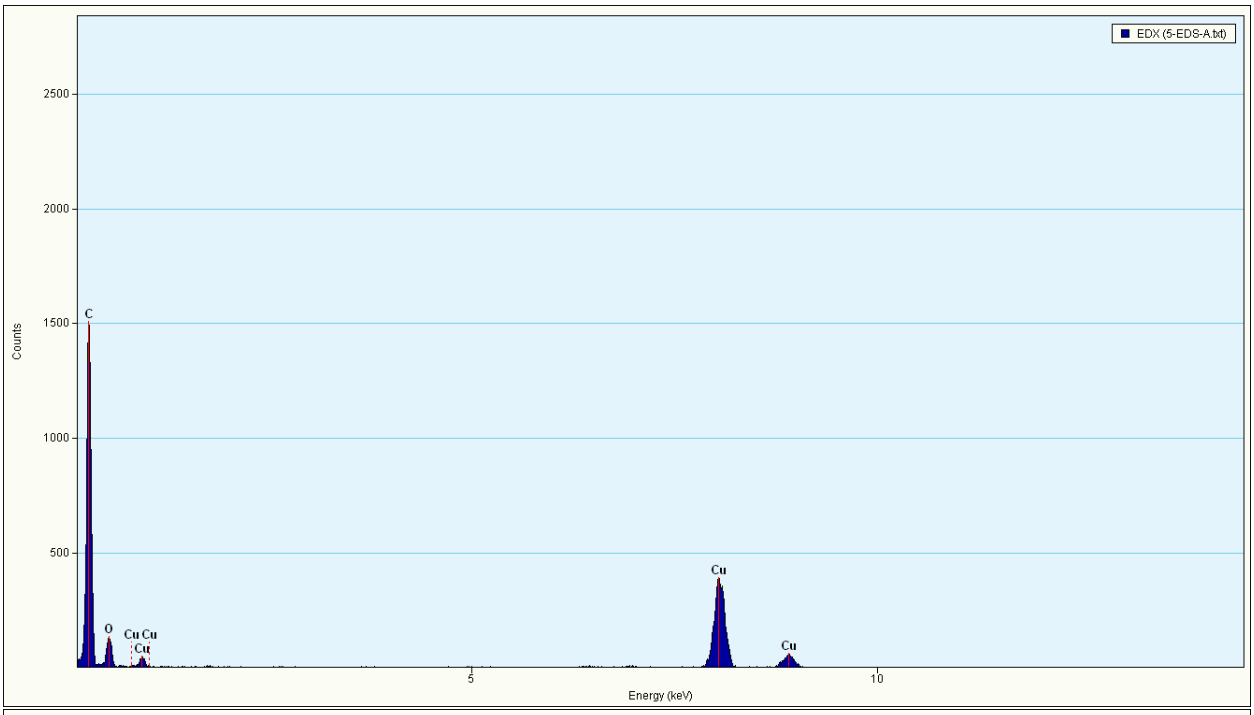
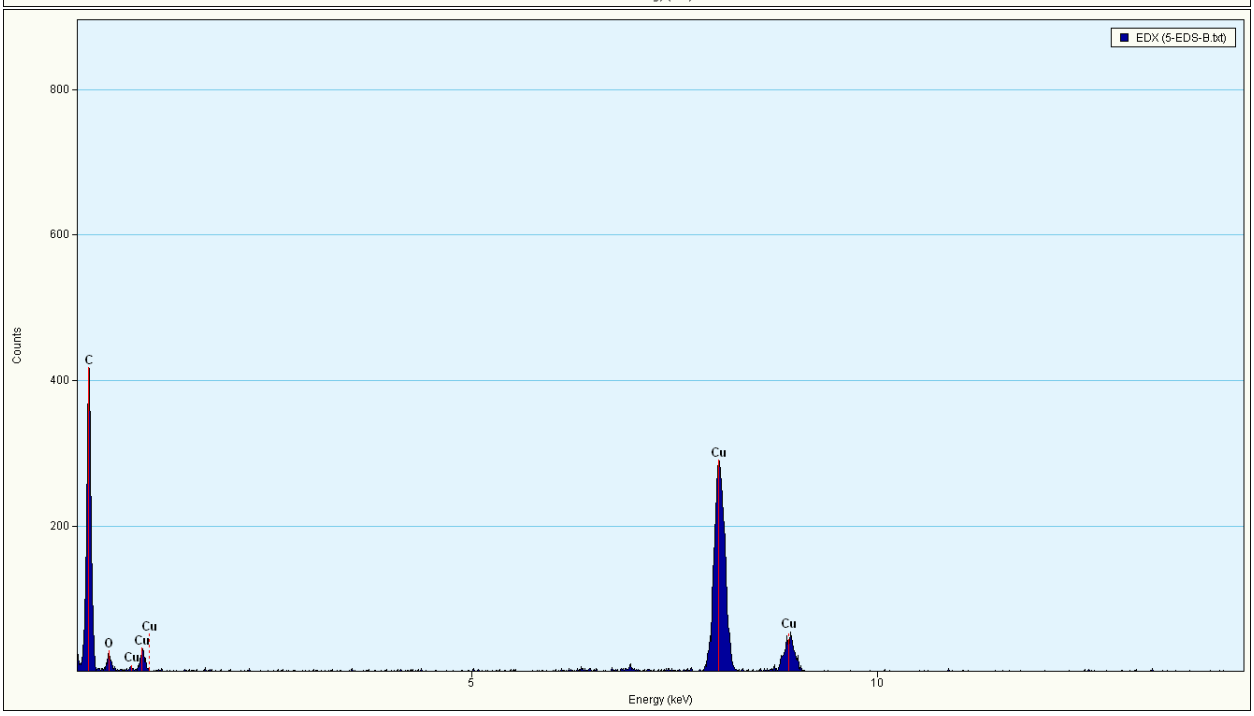


Figure S20. Supplemental Results of the Transmission Electron Microscopy and Electron Dispersion Spectroscopy Investigation of MN202.


EDX (5-EDS-A.txt)
Counts
2500
2000
1500
1000
500
C
O
Cu Cu
Cu
Cu
Cu
5
10
Energy (keV)


EDX (5-EDS-B.txt)
Counts
800
600
400
200
C
O
Cu
Cu
Cu
Cu
Cu
5
10
Energy (keV)

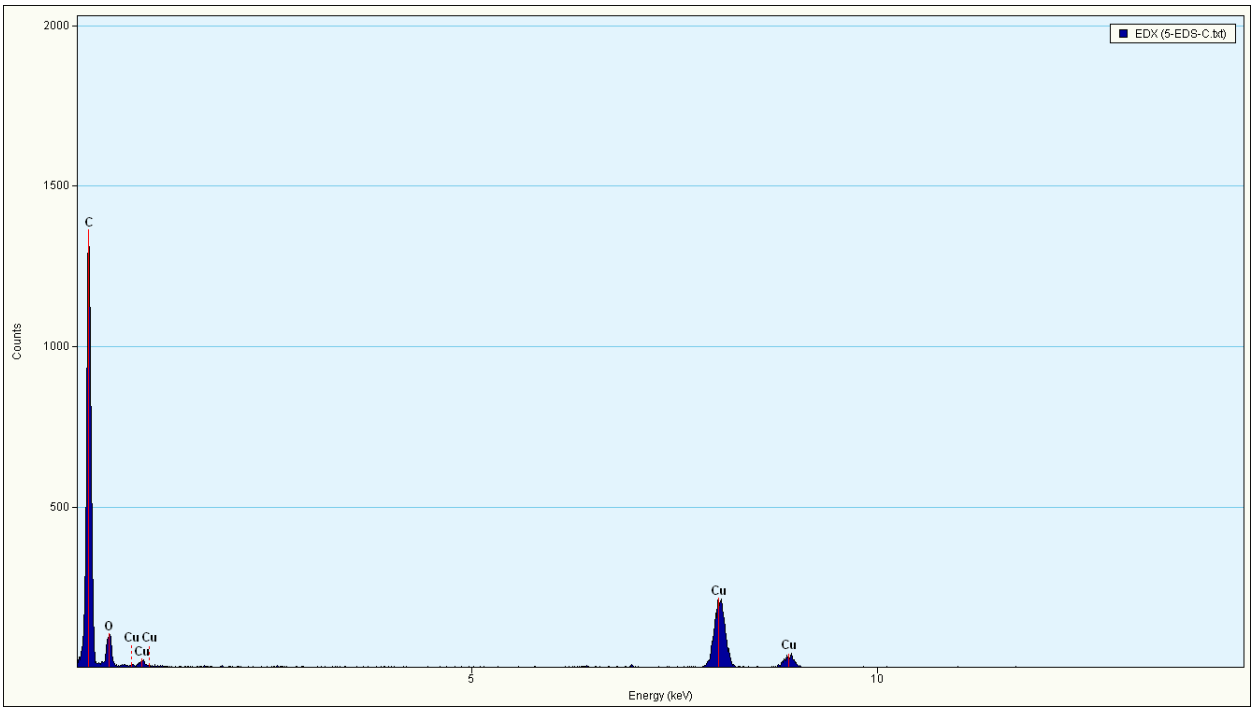


Figure S21. Supplemental Results of the Electron Dispersion Spectroscopy Investigation of MN202 pictured in Figure S20.

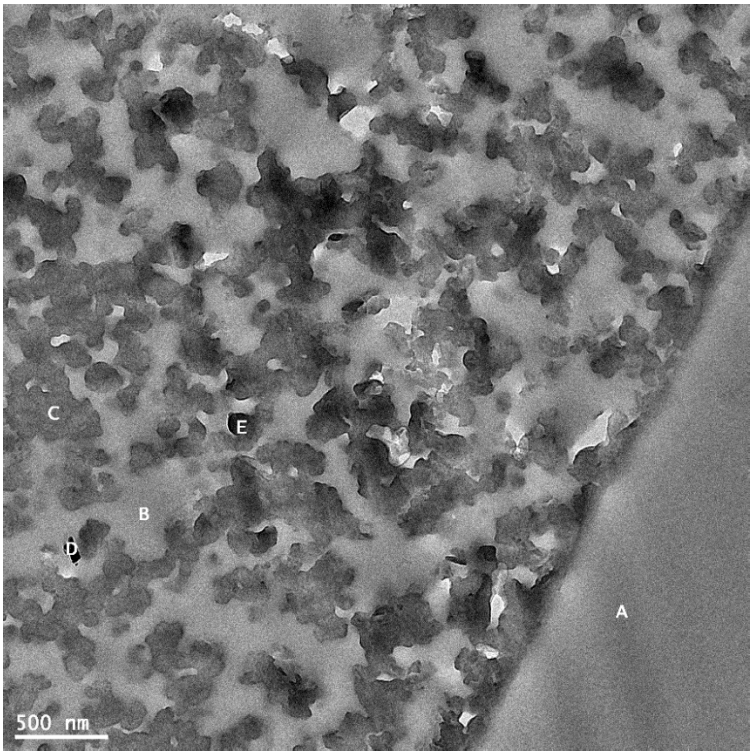
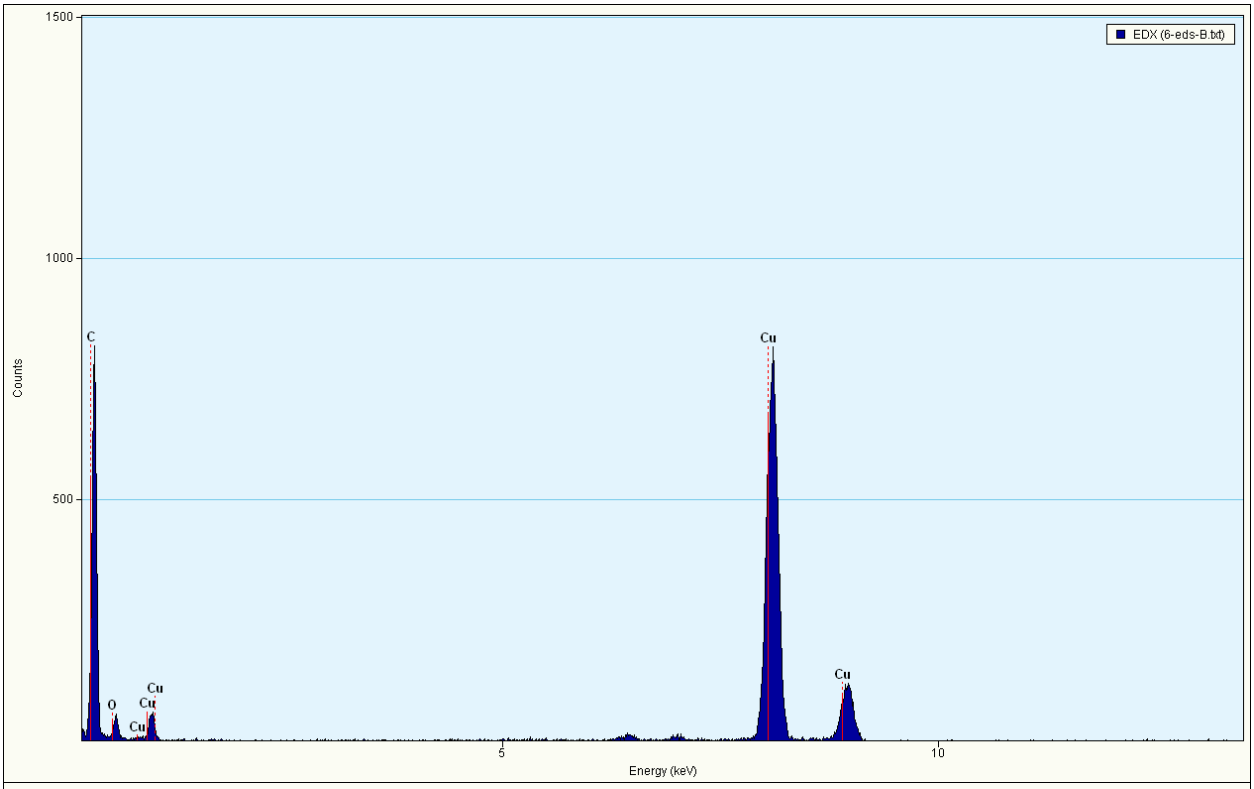
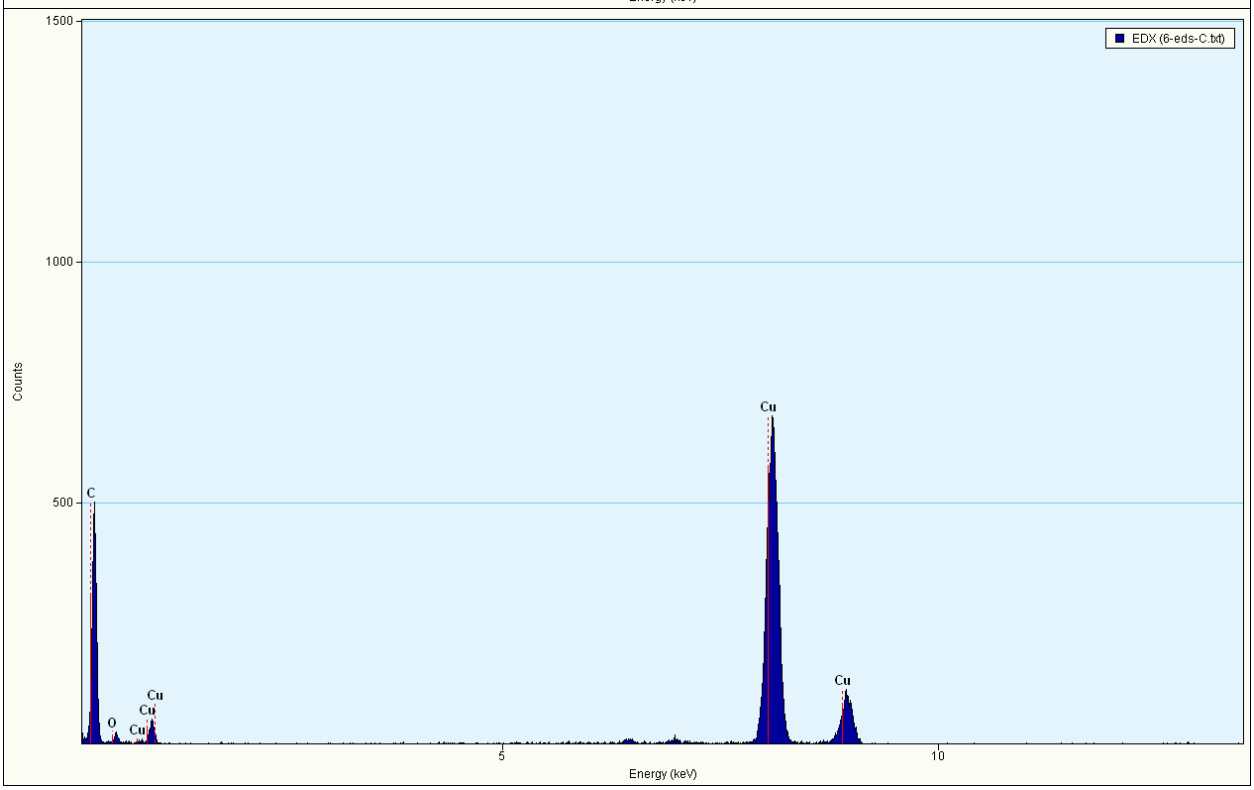
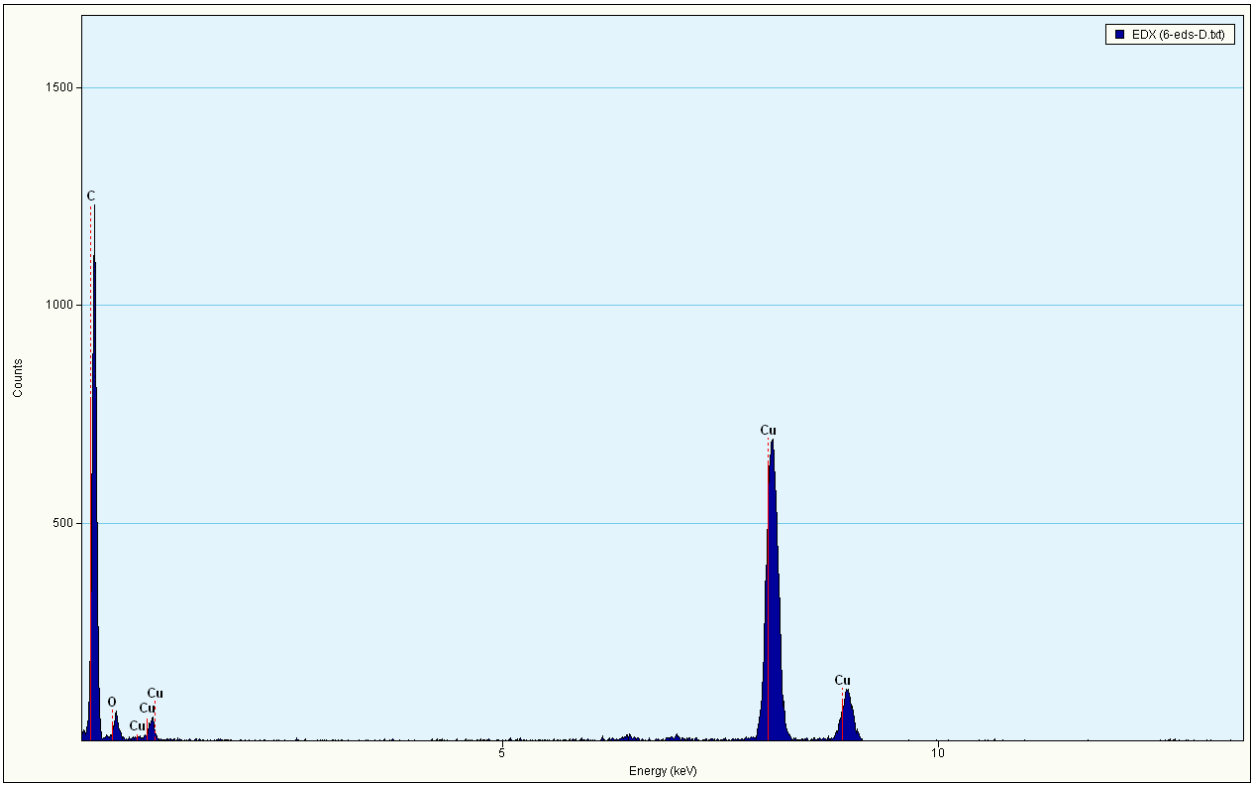


Figure S22. Supplemental Results of the Transmission Electron Microscopy Investigation of MN200.


EDX (6-eds-B.txt)
1500
1000
500
Counts
C
O
Cu
Cu
Cu
Cu
Cu
5
10
Energy (keV)


EDX (6-eds-C.txt)
1500
1000
500
Counts
C
O
Cu
Cu
Cu
Cu
Cu
5
10
Energy (keV)



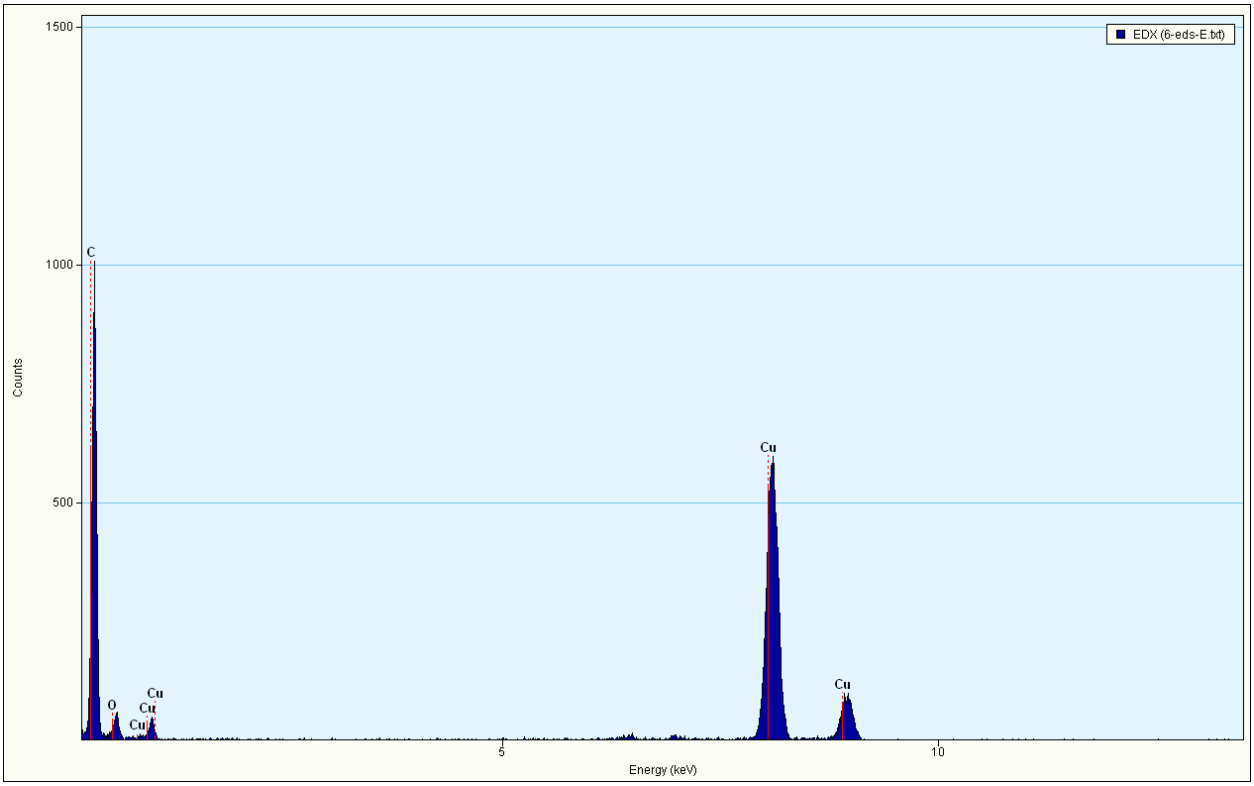


Figure S23. Supplemental Results of the Electron Dispersion Spectroscopy Investigation of MN200 (for the spots identified in Figure S22).

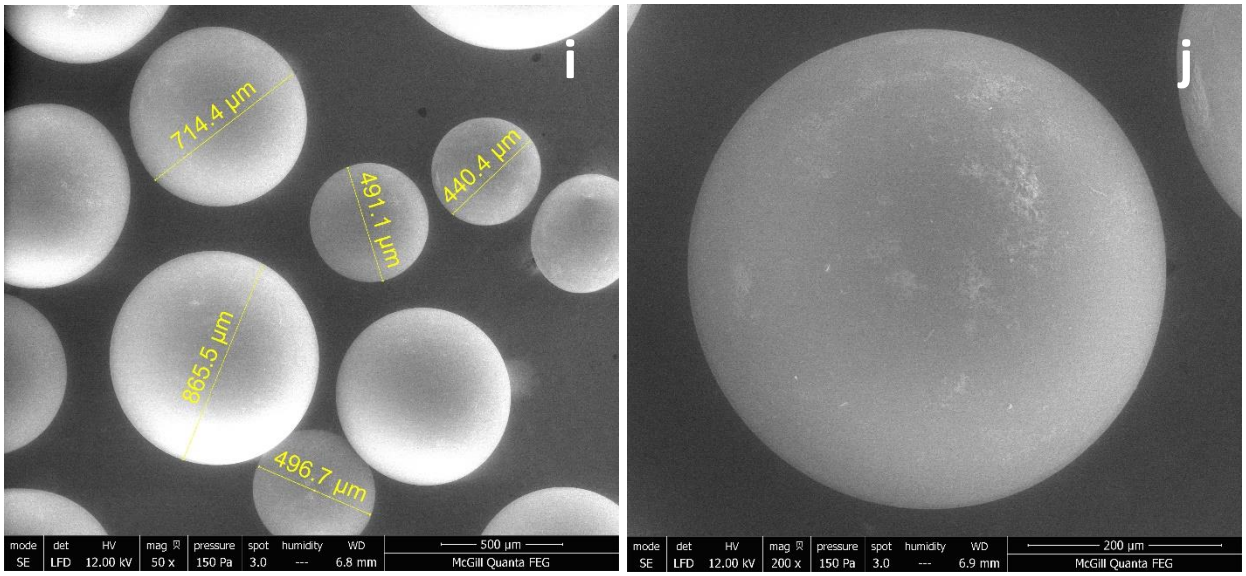


Figure S24. Supplemental Results of the Scanning Electron Microscopy Investigation of MN270.

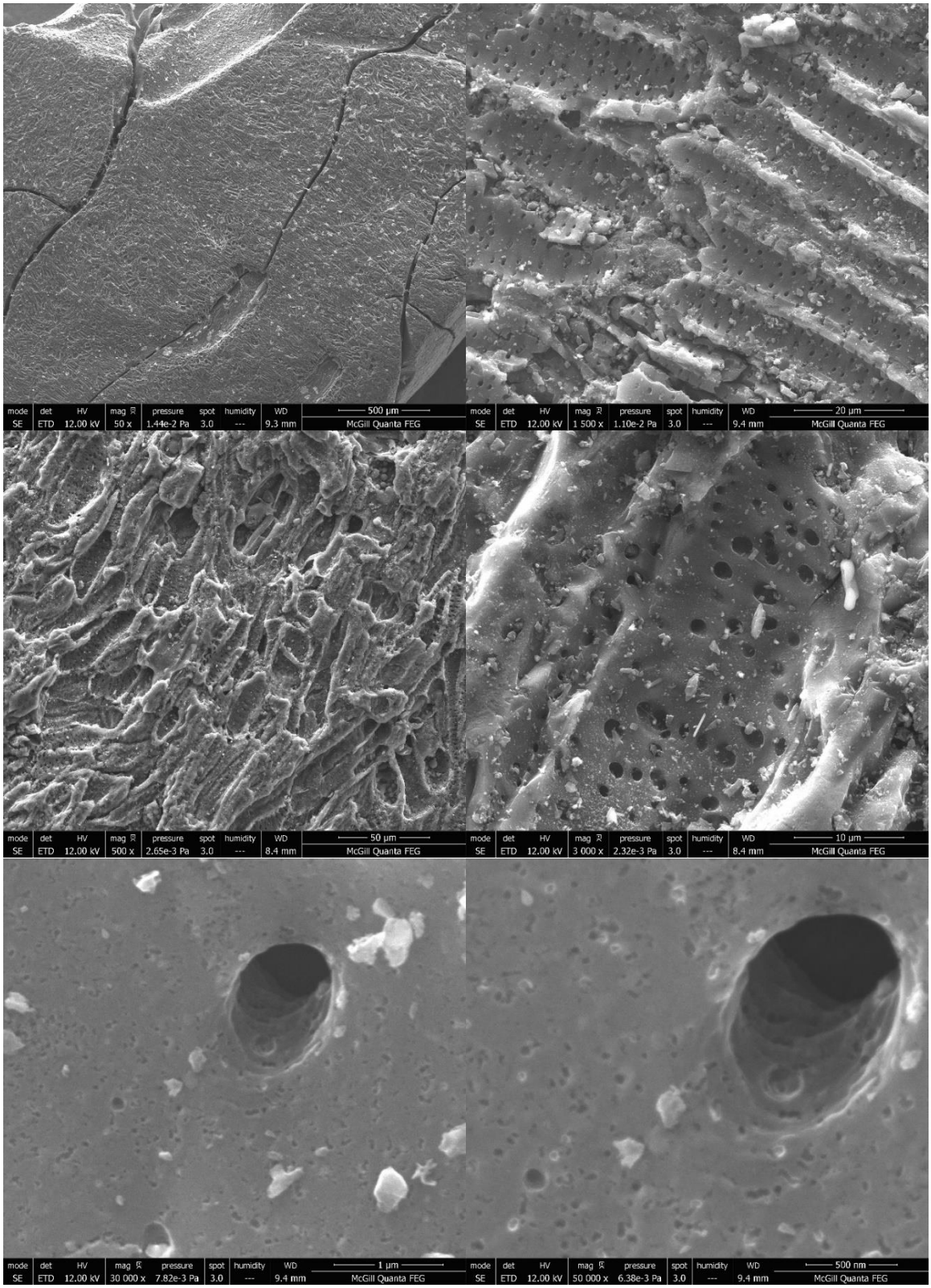


Figure S25. Supplemental Results of the Scanning Electron Microscopy Investigation of B1.

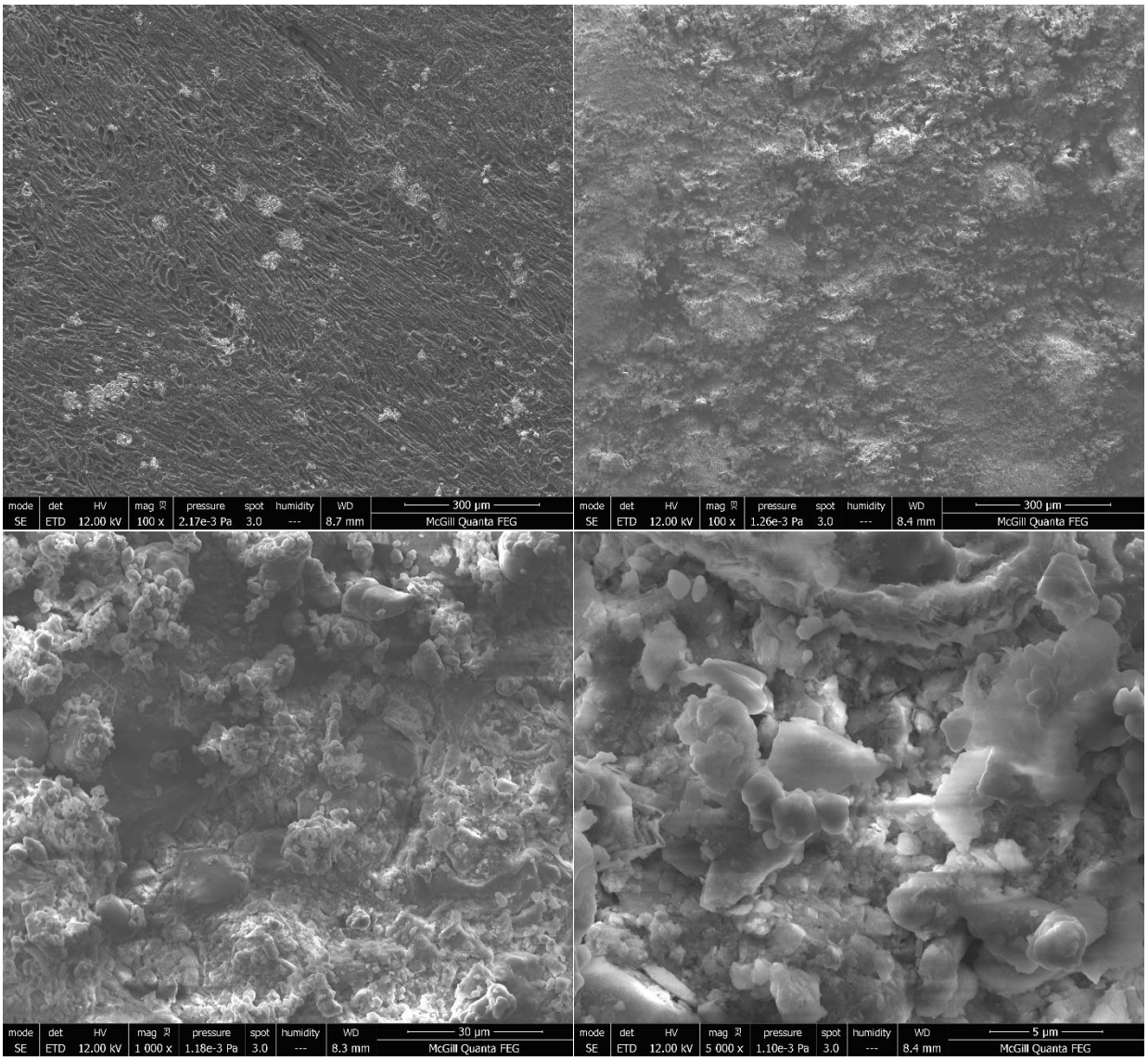


Figure S26. Supplemental Results of the Scanning Electron Microscopy Investigation of B2.

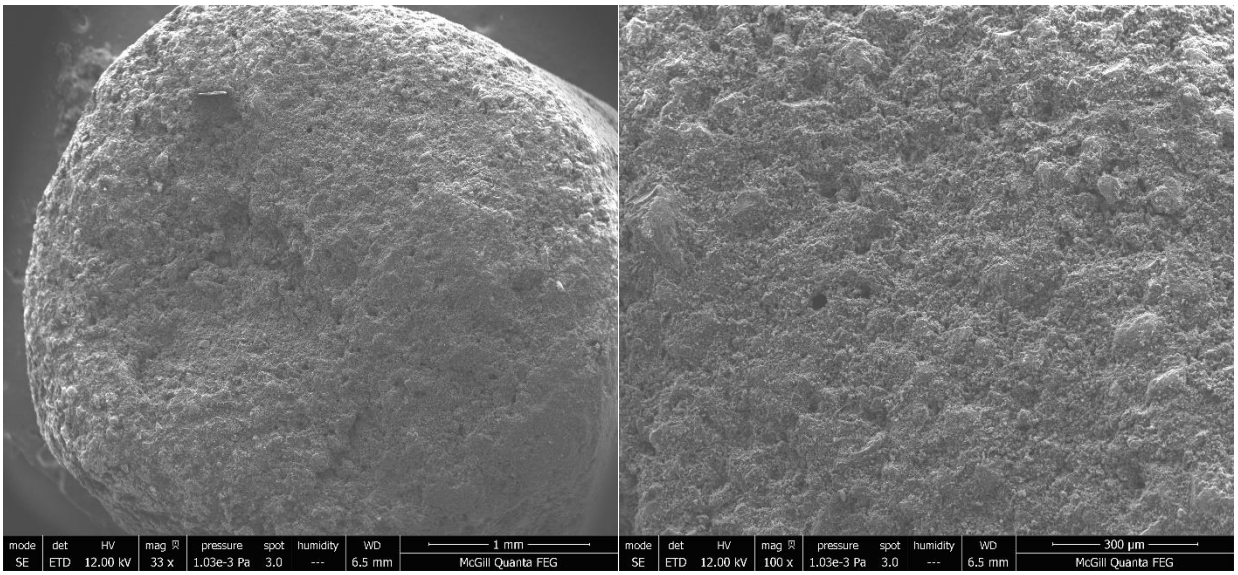


Figure S27. Supplemental Results of the Scanning Electron Microscopy Investigation of B3.

Script to automatically detect sorbent beads and calculate the bead radii

```
import numpy as np
import cv2
import pandas as pd

imgs = [200, 202, 250, 270]

#Array to store circle parameters for each image
circImgs = []

for im in imgs:
    imgName = 'MN' + str(im) + 'Transmitted.jpg'
    img = cv2.imread(imgName)
    cv2.imshow('input', img)

    # Copy image to display output
    output = img.copy()

    # Convert image to greyscale
    gray = cv2.cvtColor(img,cv2.COLOR_BGR2GRAY)
    gray = cv2.GaussianBlur(gray, (3,3), 0)

    # Detect circles
    circles = cv2.HoughCircles(image=gray,
                               method=cv2.HOUGH_GRADIENT,
                               dp=1.1,
                               param1=100,
                               param2=30,
                               minDist=30,
                               minRadius=10,
                               maxRadius=60)

    #Array to store the radius of all circles identified in a given image
    CircParam=[]

    if circles is not None:
        circles = np.round(circles[0, :]).astype("int")
        circles1 = sorted(circles, key = lambda x:x[2])

        # Count circles
        count=1
        for (x, y, r) in circles1:
            #Calculate radius in mm based on 150 dpi image and 1 mm scale bar:
            r_mm = round(r/109, 2)
```

```
            # Create outer circle
            cv2.circle(output, (x,y), r, (0, 0, 0), 1)
            # Identify center of circle
            cv2.circle(output, (x,y), 1, (0,0,0), 1)
            # Add radius to center
            cv2.putText(output, str(r_mm),
                        (x-15, y-5),
                        cv2.FONT_HERSHEY_COMPLEX_SMALL,
                        0.6, (0, 0, 0), 1)
            CircParam.append(r_mm)
            count += 1

        #Create output image name
        outName = 'circles_MN' + str(im) + 'Transmitted.jpg'
        #Write output image file showing detected circles and their radii in millimeter
        cv2.imwrite('%s'%outName, output, [int(cv2.IMWRITE_JPEG_QUALITY), 100])

    circImgs.append(CircParam)

#Create transposed dataframe with data for all images shown in columns
df = pd.DataFrame.from_records(circImgs)
dfT.columns=['MN200', 'MN202', 'MN250', 'MN270']
dfT.index = np.arange(1, len(dfT) + 1)
# Save output to CSV file for further analyses
dfT.to_csv('bead_radii_MN_Sorbents.csv')
```