Electron Microscopic Investigation of Liquid and Solid for Fenton Oxidation of Leachate

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University of Central Florida, Orlando, FL 32826

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Outline

- Problem Statement
- Liquid Hydrogen Peroxide Fenton
- Solid Calcium Peroxide Fenton
- Experiments
- Electron Microscopic Investigations
- Acknowledgments

Collecting Leachate

Preparing Leachate

Microscopic Aspects of Fenton Processes: Liquid vs. Solid Peroxides

- Raw leachate
- Leachate treatment options: liquid vs. solid peroxides
- Hydrogen peroxide system
- Calcium peroxide system
- Technical challenges
- Design criteria using solid vs. liquid peroxides

Statement of Problem

- No electron microscopic characterization of both leachate and CaO_2;
- Microscopic characterization of both leachate and CaO_2 provide insight into the oxidation mechanisms;
- Oxidation mechanisms may be unveiled through the change of composition of both leachate and sediments containing Ca after H_2O_2 is released.

Objectives

- To provide direct image of both leachate and CaO_2;
- To provide direct evidence of composition of leachate;
- To quantify the chemical composition of both leachate and CaO_2.

Characterization of Leachate

Conventional Pollutants in Typical Leachate

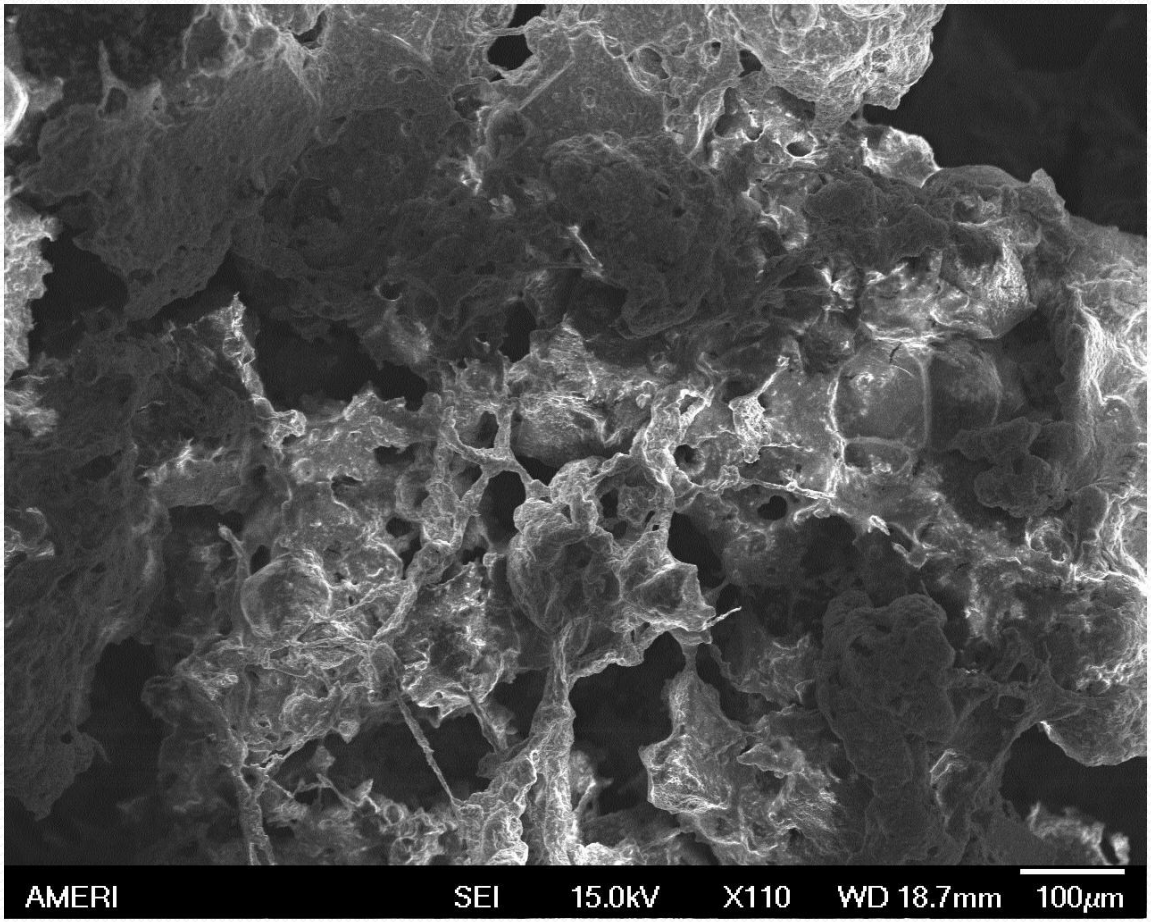
mg/L (except pH)

Constituent	New Landfill (< 2yrs) Range	New Landfill (< 2yrs) Typical	Mature Landfill (> 10 yrs)
BOD_5	2,000-30,000	10,000	100-200
TOC	1,500-20,000	6,000	80-160
COD	3,000-60,000	18,000	100-500
Total suspended solids	200-2,000	500	100-400
Organic nitrogen	10-800	200	80-120
Ammonia nitrogen	10-800	200	20-40
Nitrate	5-40	25	5-10
Total phosphorus	5-100	30	5-10
Ortho phosphorus	4-80	20	4-8
Alkalinity as $CaCO_3$	1,000-10,000	3,000	200-1,000
pH	4.5-7.5	6	6.6-7.5
Total hardness as $CaCO_3$	300-10,000	3,500	200-500
Calcium	200-3,000	1,000	100-400
Magnesium	50-1,500	250	50-200
Potassium	200-1,000	300	50-400
Sodium	200-2,500	500	100-200
Chloride	200-3,000	500	100-400
Sulfate	50-1,000	300	20-50
Total iron	50-1,200	60	20-200

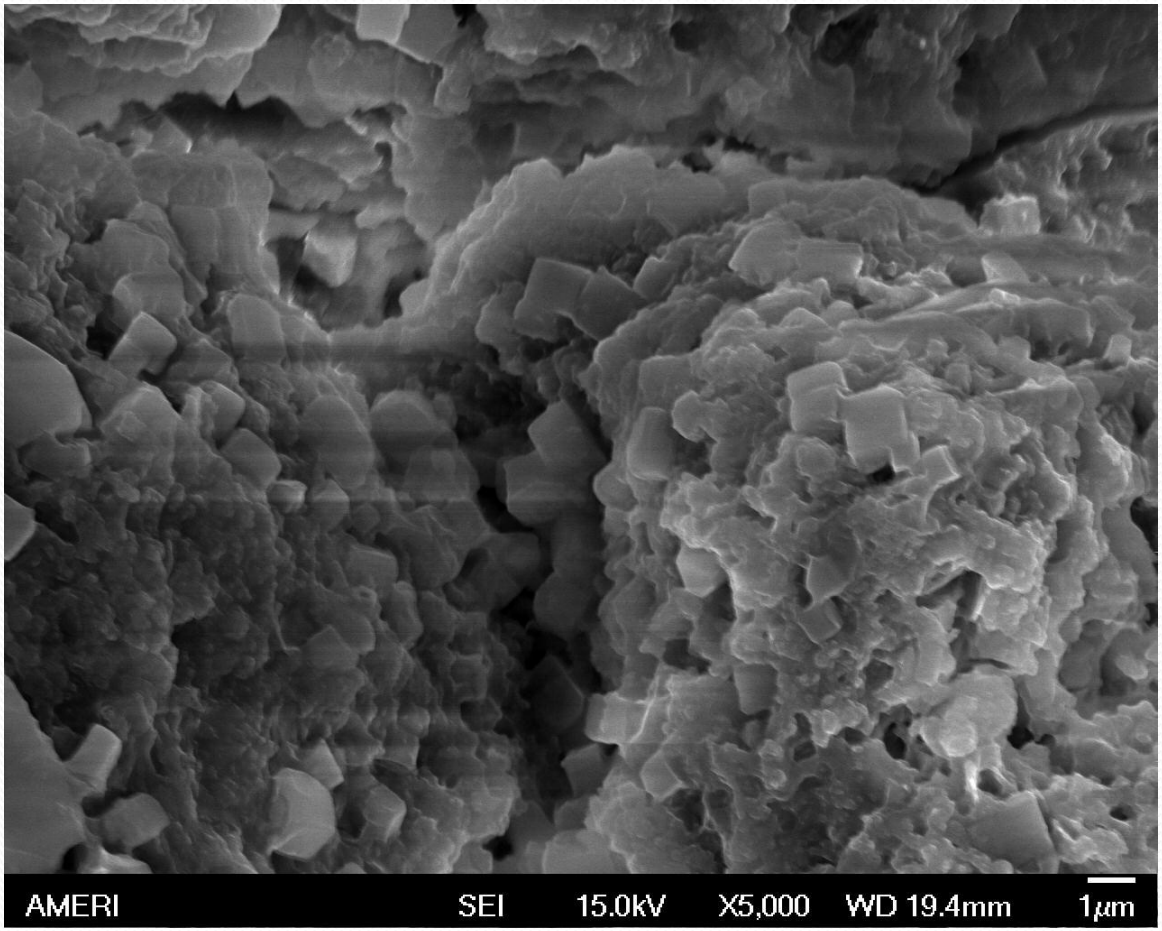
Relative Biodegradability of Leachate

Bio-degradability	BOD/COD	COD/TOC
Low	< 0.5	< 2
Medium	0.5 – 0.75	2 – 3
High	> 0.75	> 3

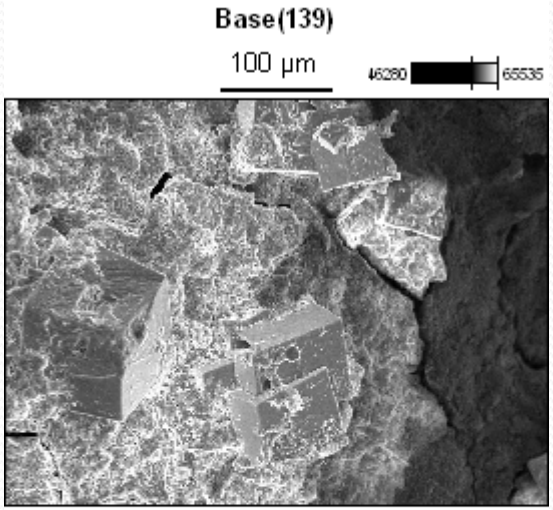
Raw Leachate without Filtration x110

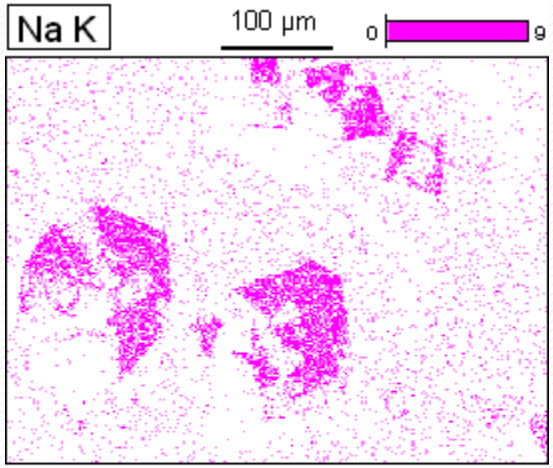


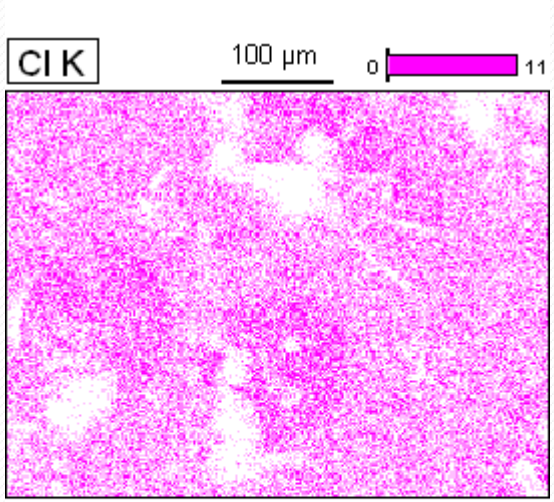
Raw Leachate without Filtration x5,000



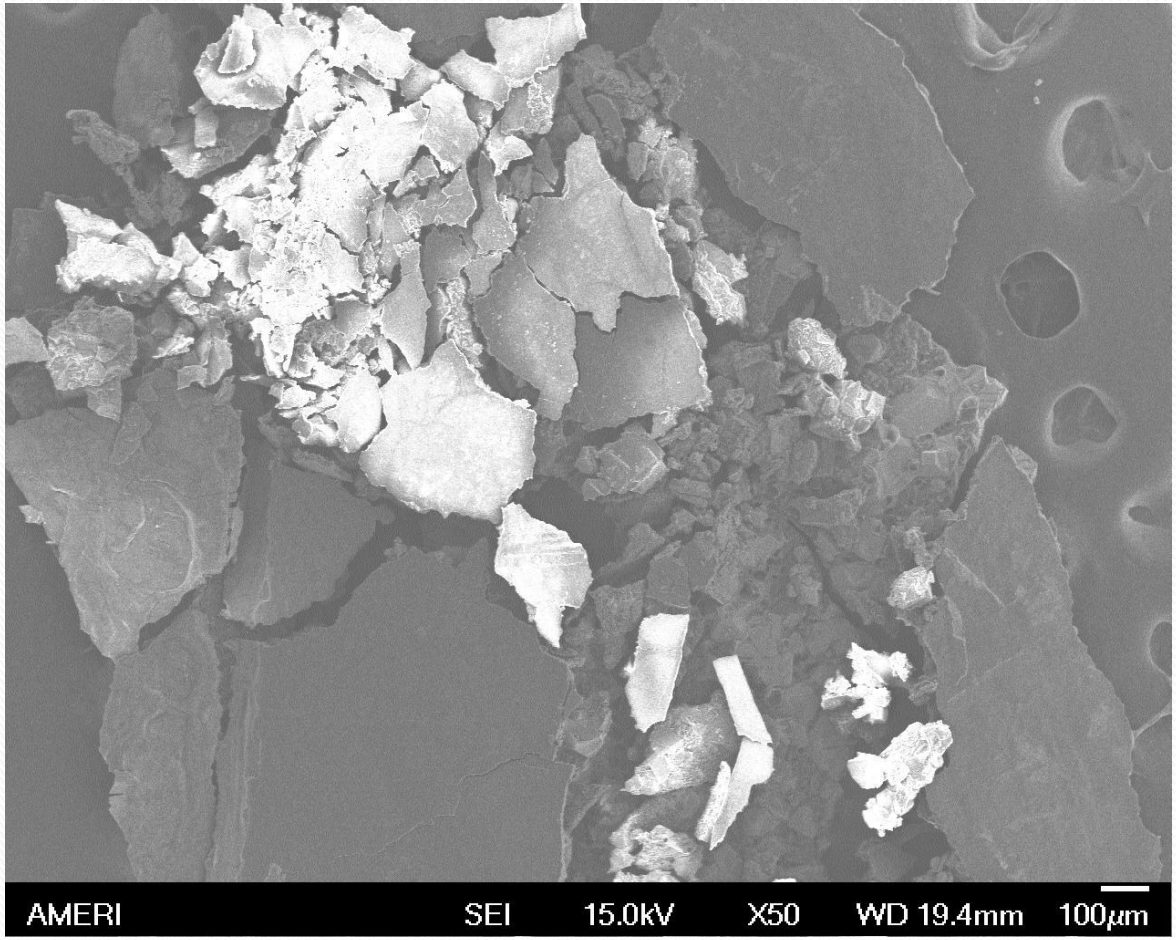
Mapping of Elements



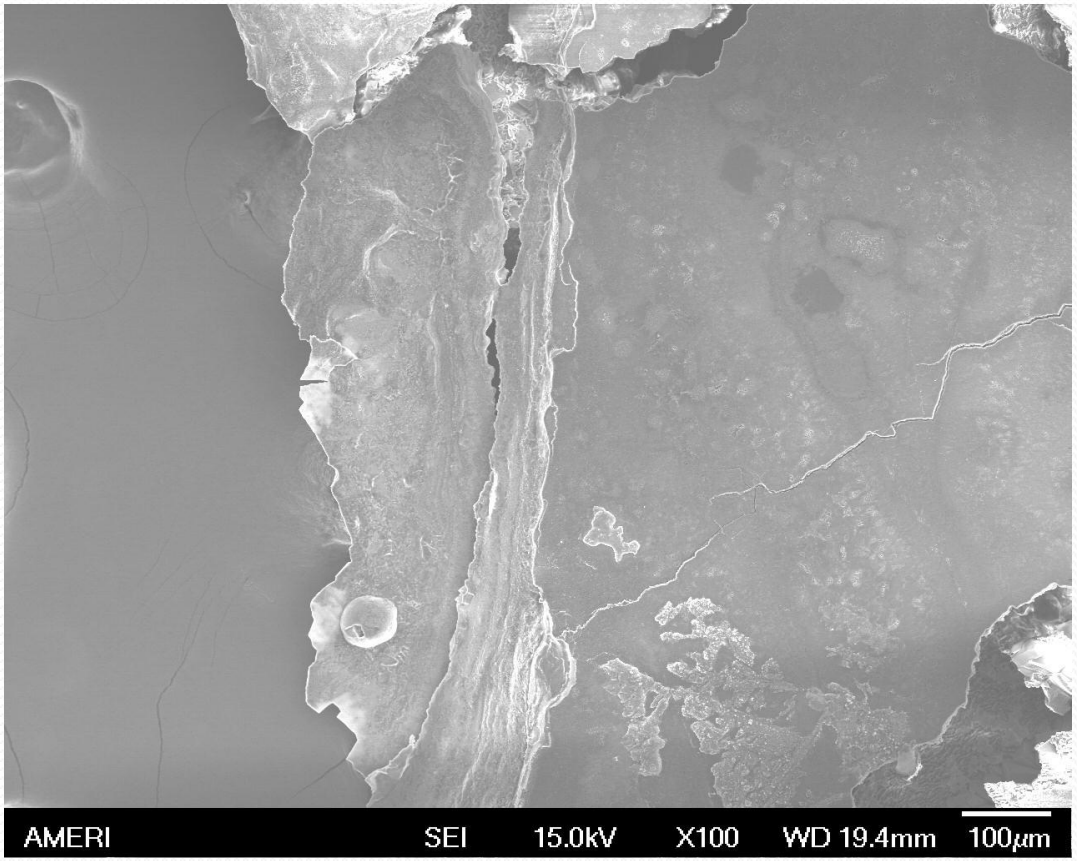




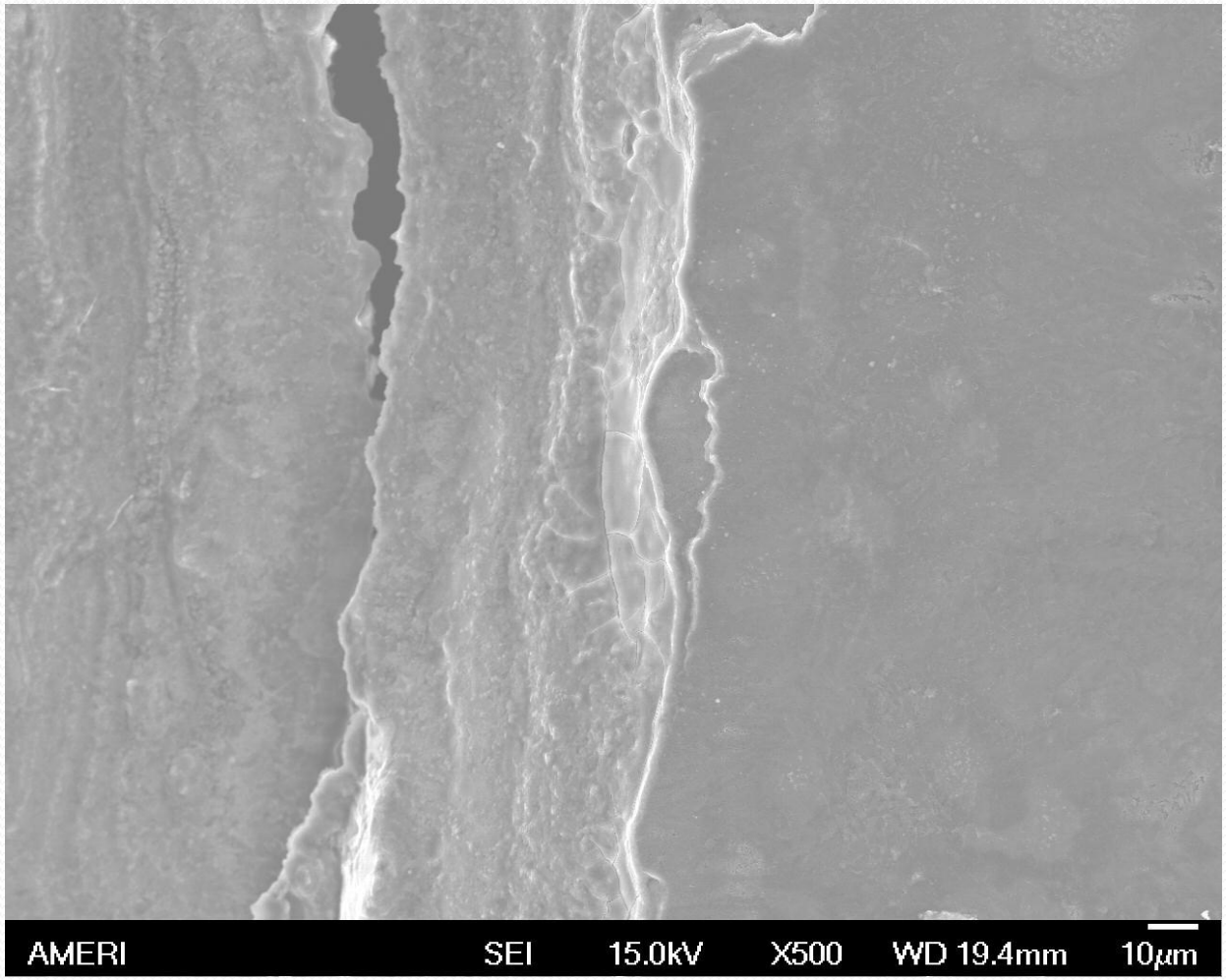
Raw Leachate after Filtration x50



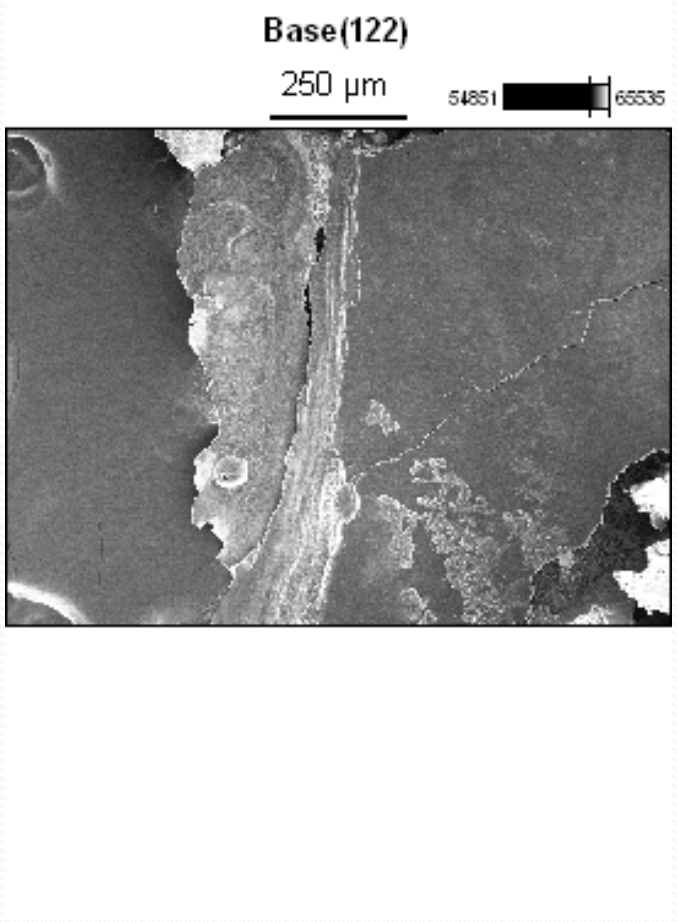
Raw Leachate after Filtration x100



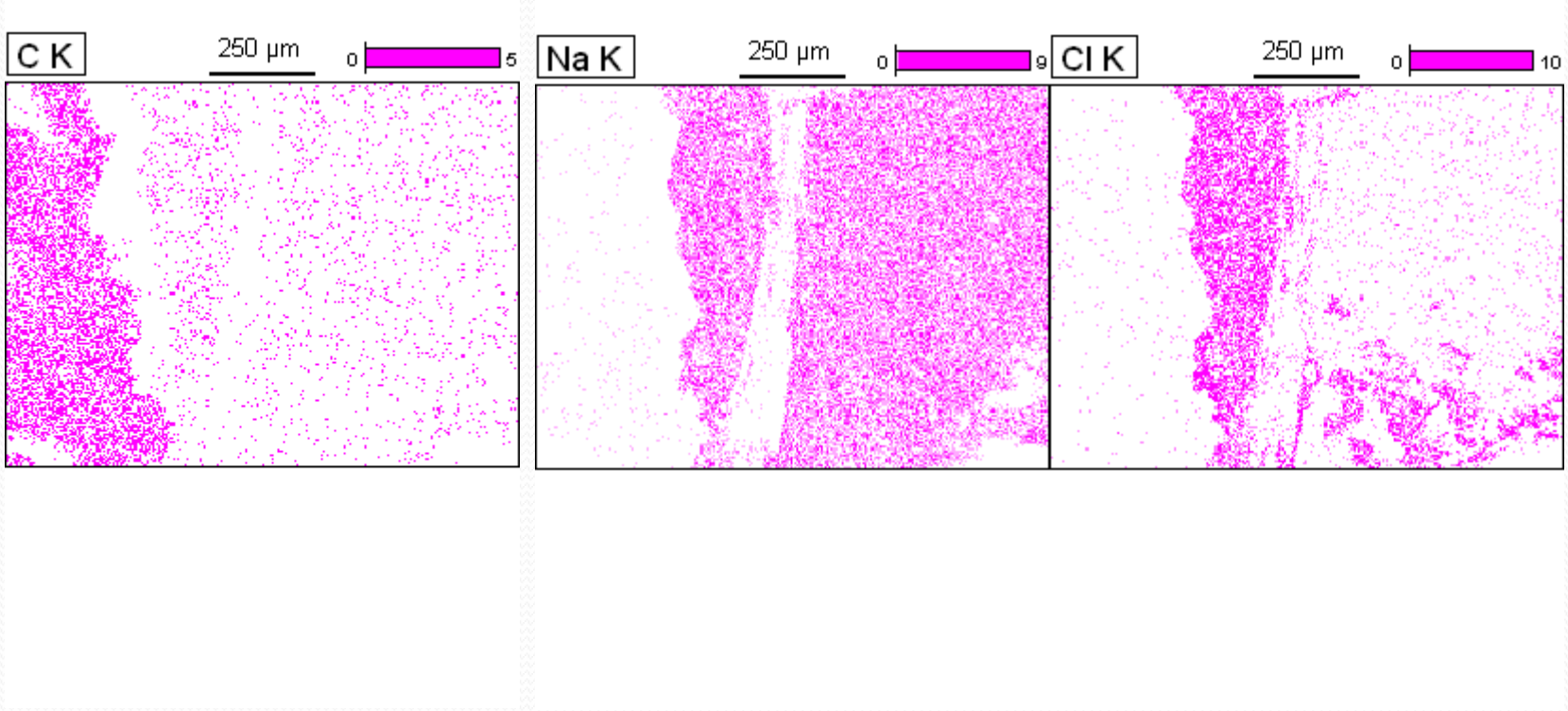
Raw Leachate after Filtration x500



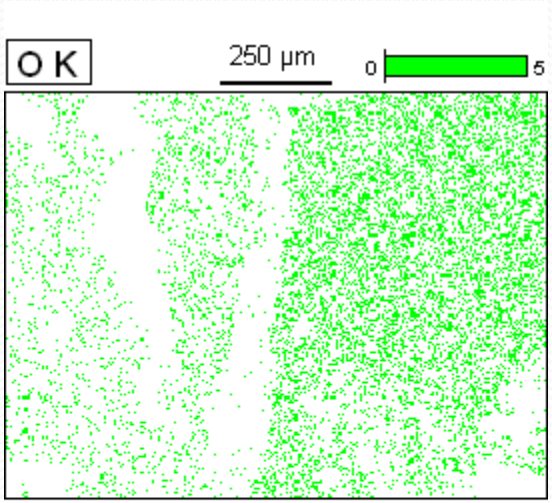
Electron Mapping of Filtered Leachate

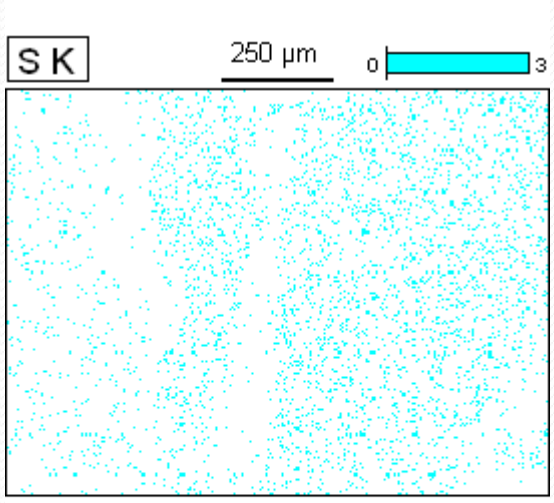


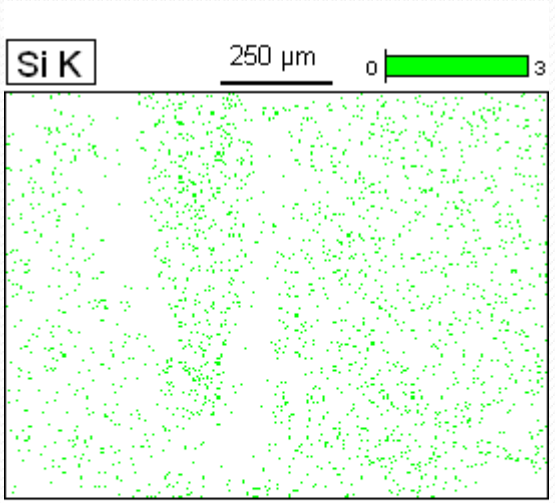
Electron Mapping of Filtered Leachate



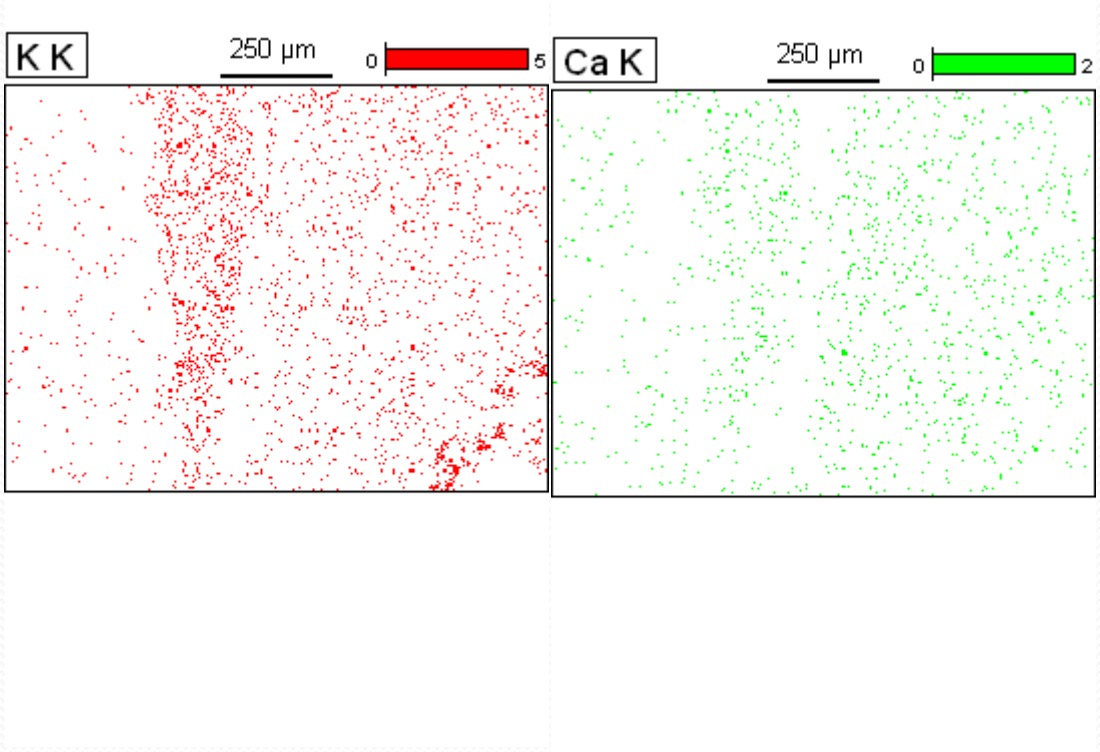
Electron Mapping of Filtered Leachate







Electron Mapping of Filtered Leachate



Classic Fenton Processes

Fenton Reaction Mechanism

$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH^- + HO^{\cdot}$ $k=55\ (M^{-1}s^{-1})$

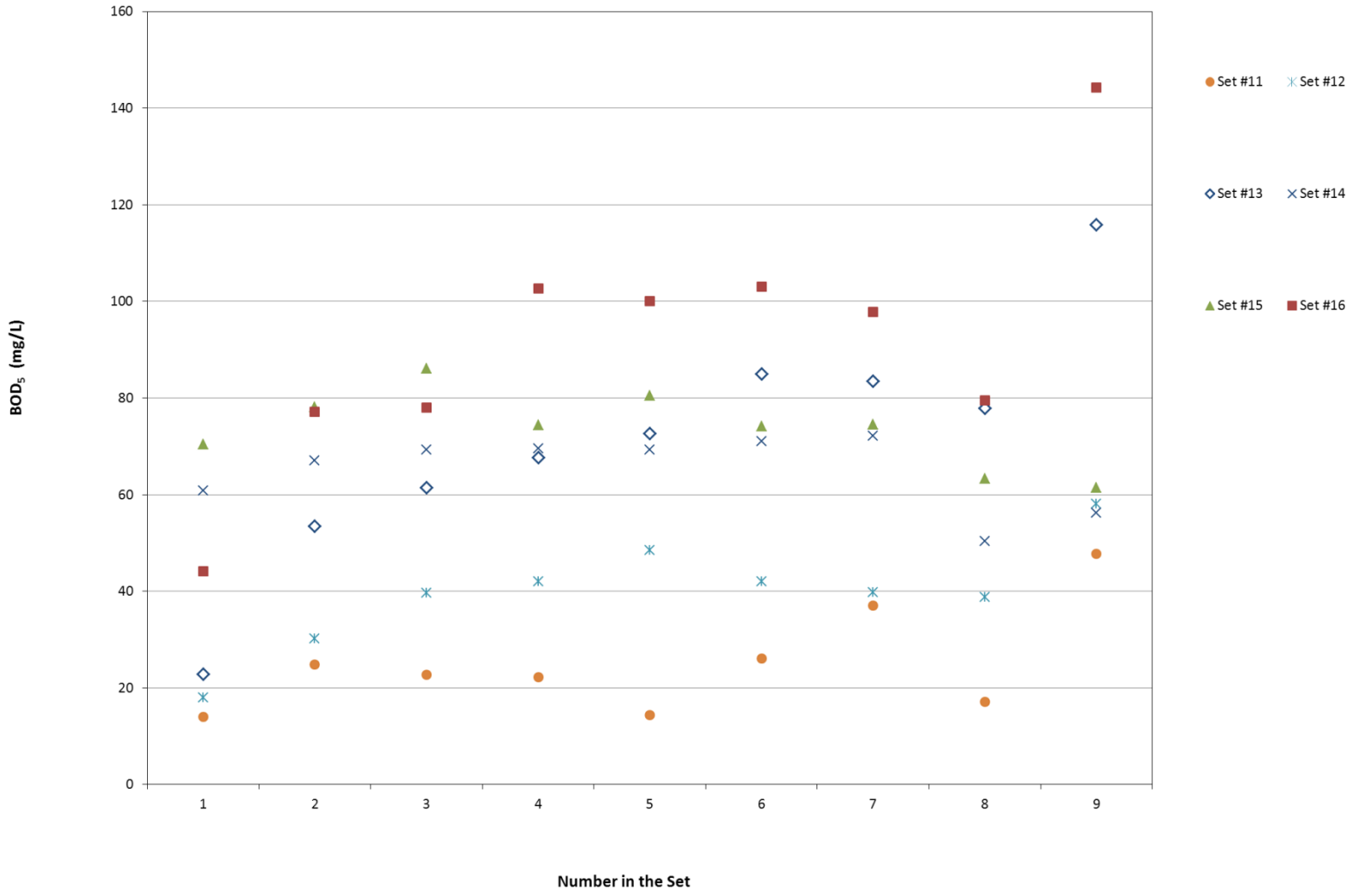
$HO^{\cdot} + H_2O_2 \rightarrow HO_2^{\cdot} + H_2O$ $k_{H2O2}=3.3*10^7\ (M^{-1}s^{-1})$

$HO^{\cdot} + Fe^{2+} \rightarrow Fe^{3+} + OH^-$ $k_{Fe2+}=3.2*10^8\ (M^{-1}s^{-1})$

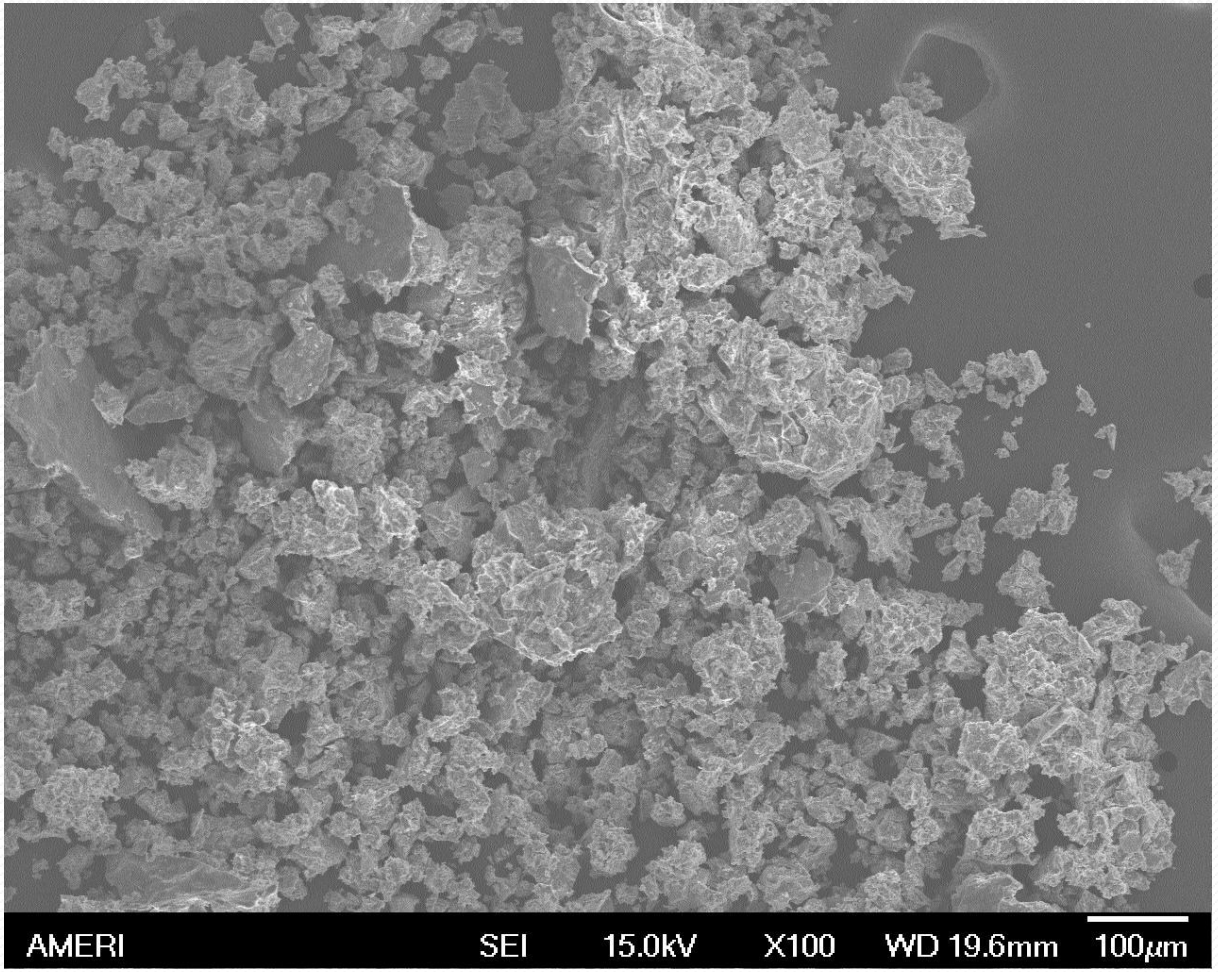
$H_2O_2/Fe^{2+}_{Opt.} = k_{OH,\ Fe2+}/k_{OH,\ H2O2} = 3*10^8/2.7*10^7=11$

(Tang 2004)

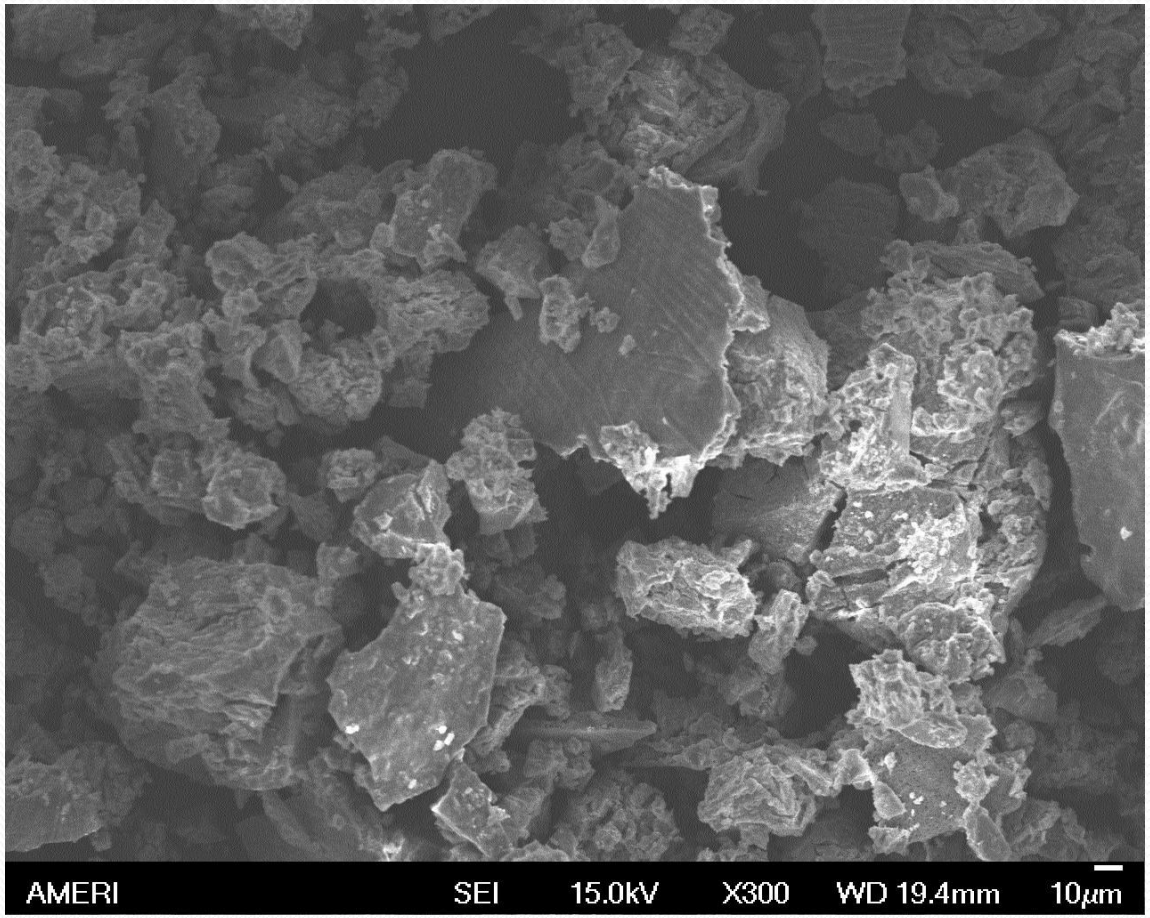
Biodegradability Enhancement



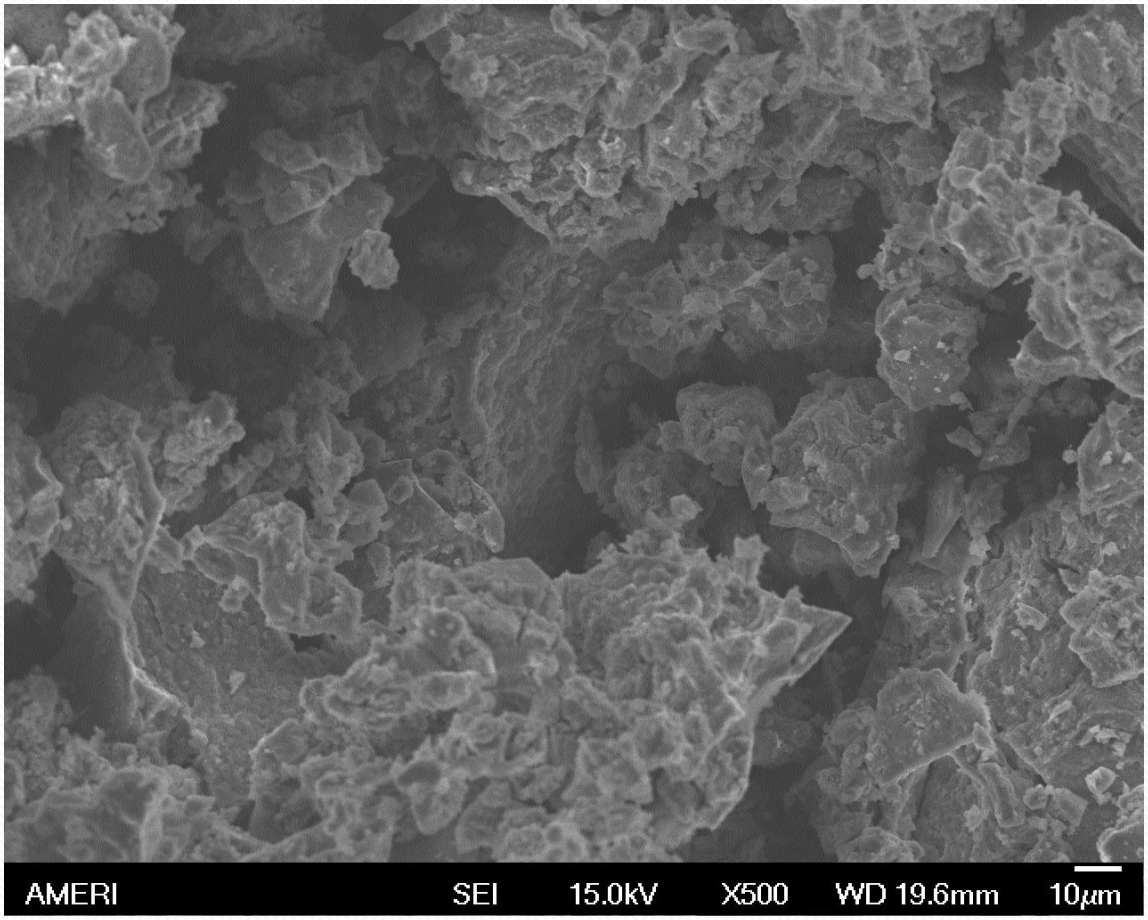
SEM Image of $Fe(OH)_3$ at x100



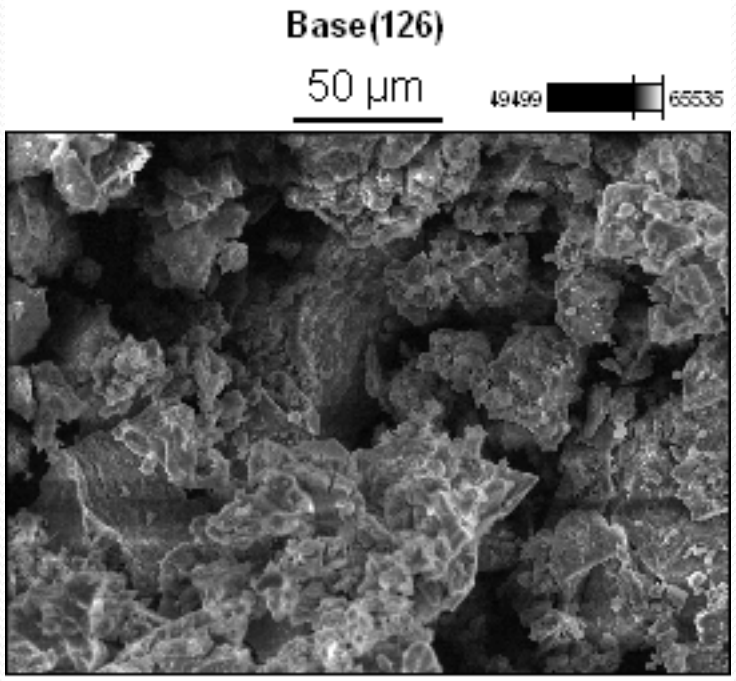
SEM Image of $Fe(OH)_3$ at x300

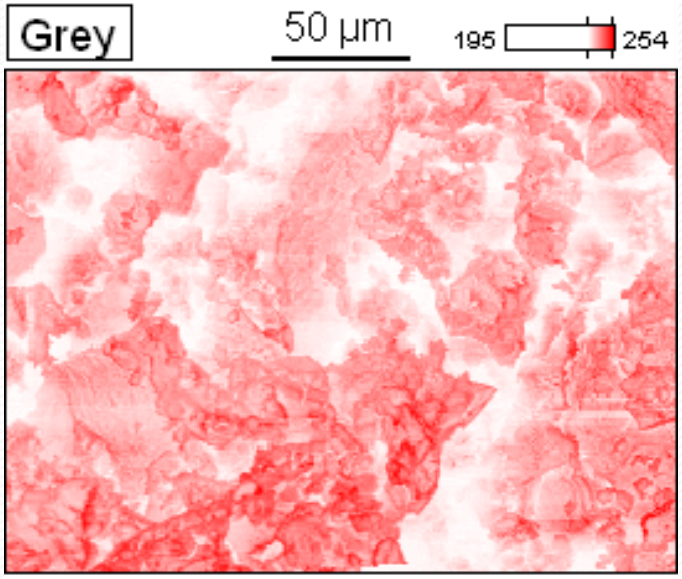


SEM Image of $Fe(OH)_3$ at x500

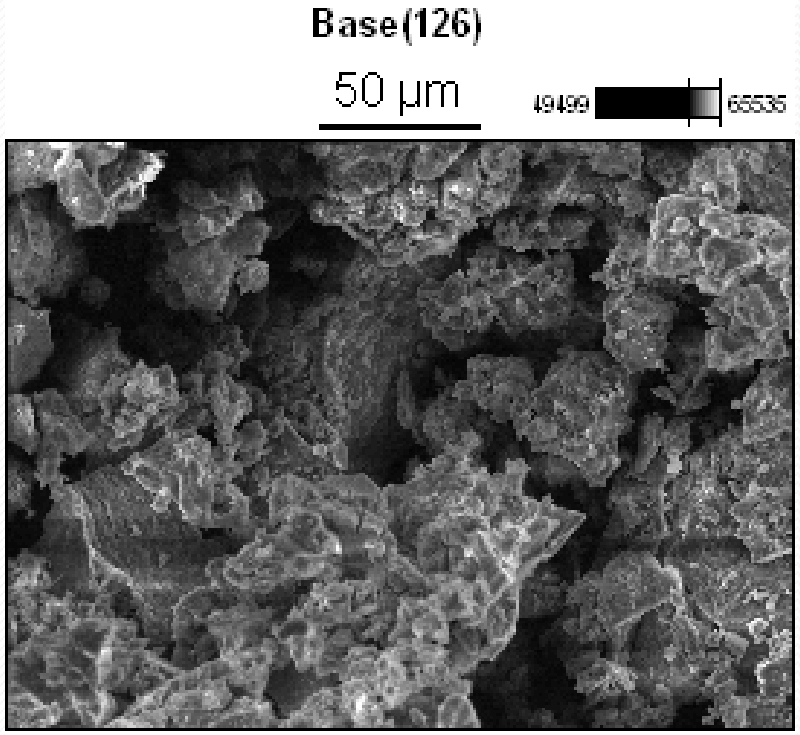


Electron Mapping of Elements in $Fe(OH)_3$ Sediment

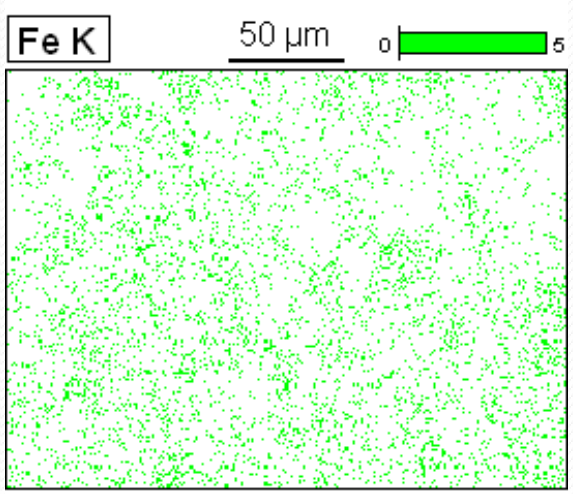


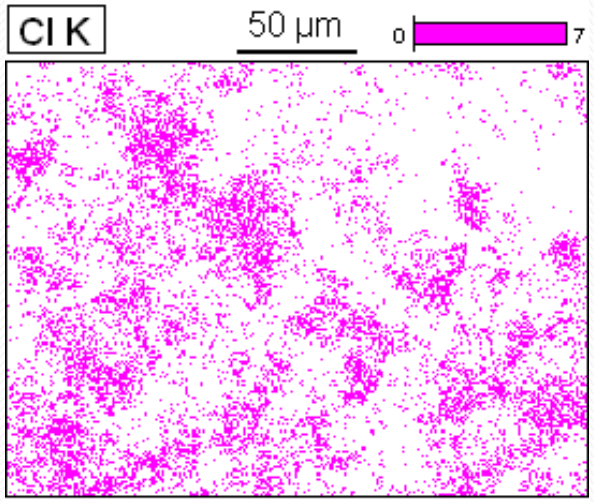


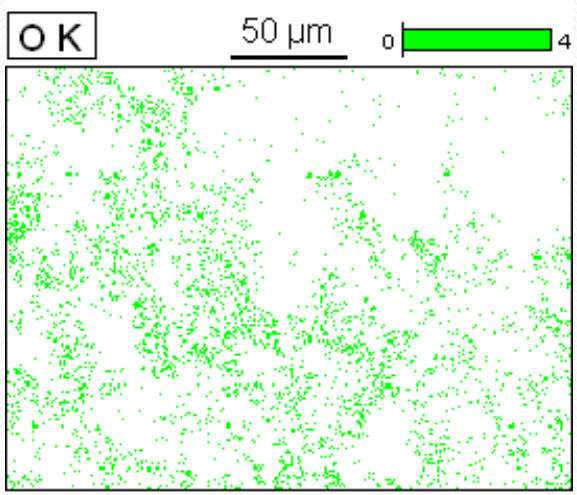
Electron Mapping of Sediments



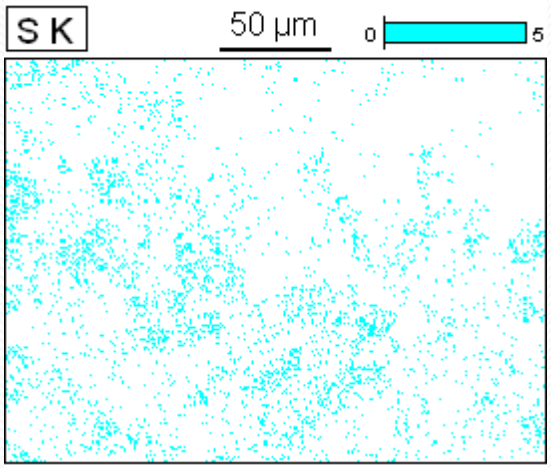
Dominant Elements are Fe, O, and Cl by Electron Mapping

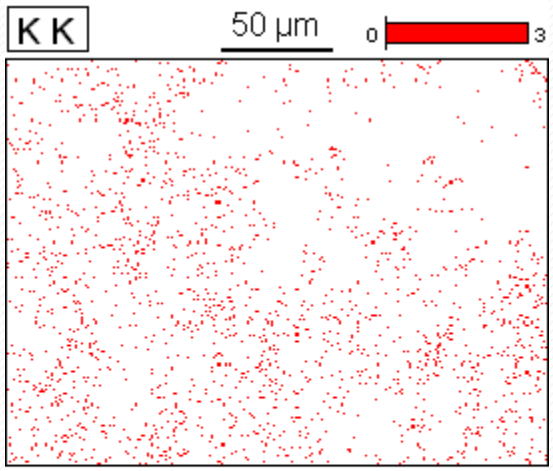


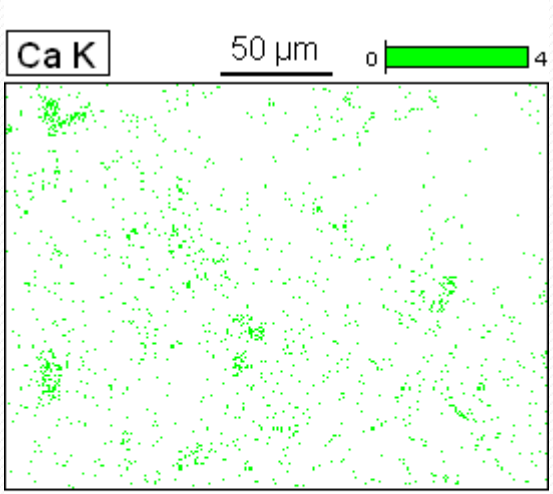




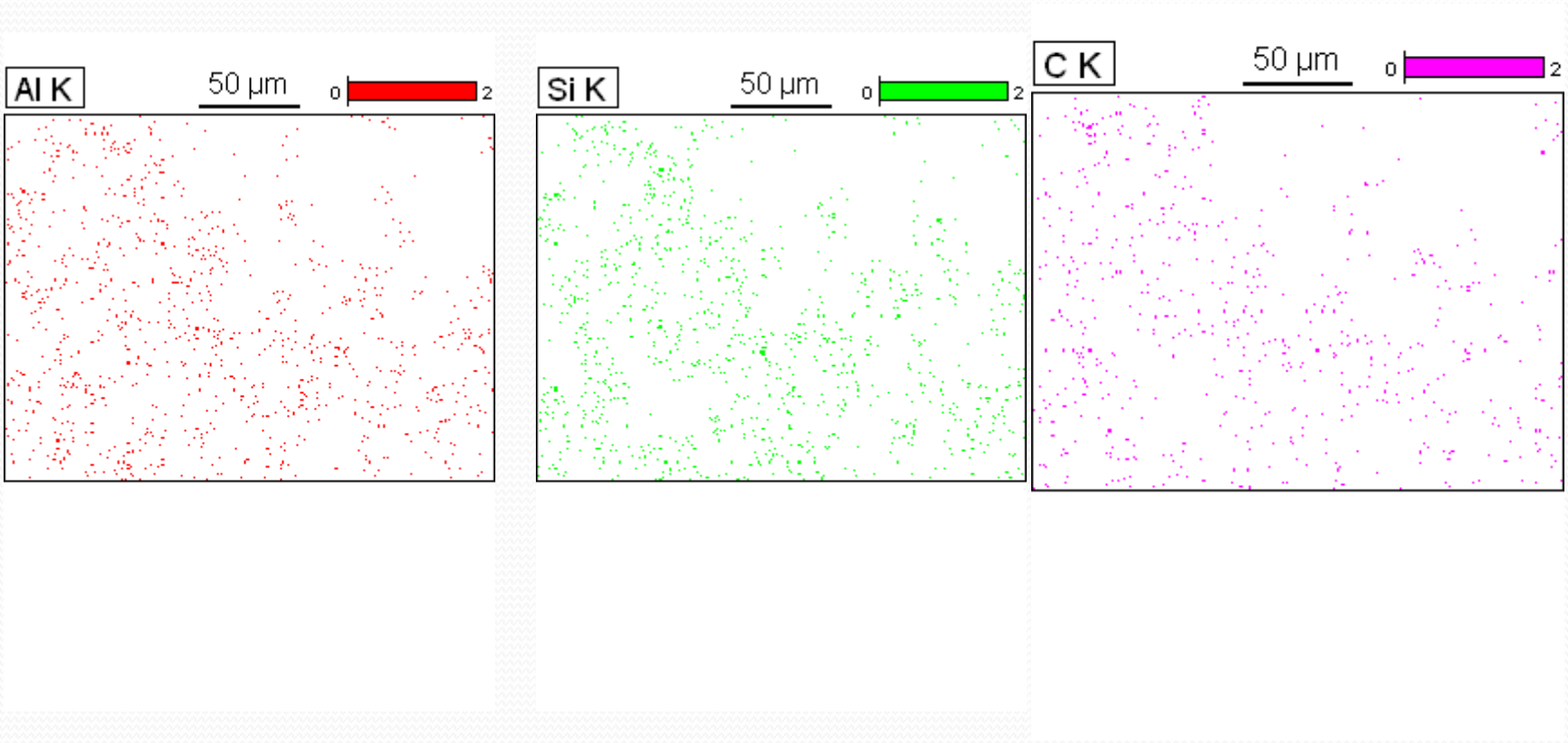
Secondary Elements are S, K, and Ca by Electron Mapping







Minor Elements are Al, Si, and C by Electron Mapping



Solid Peroxide Systems

Raw Leachate

CaO_2 +Fe^{2+} + leachate

CaO_2 +Fe^{0} + leachate

CaO_2 +Fe^{2+}

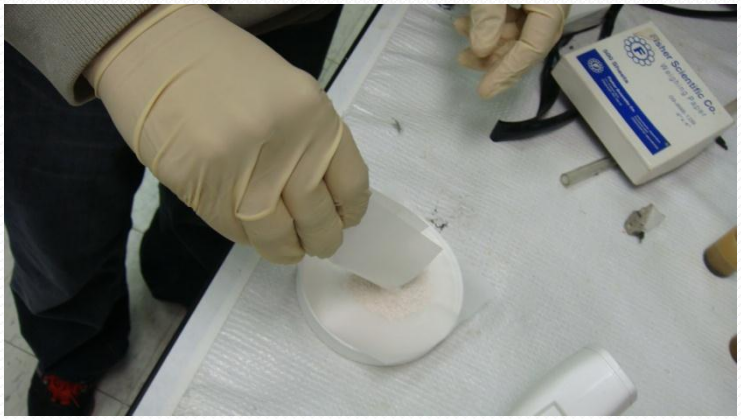
CaO_2 +Fe^{0}

Solid Peroxides

$$CaO_2(s) + 2H_2O == 2H_2O_2 + Ca(OH)_2(s)$$

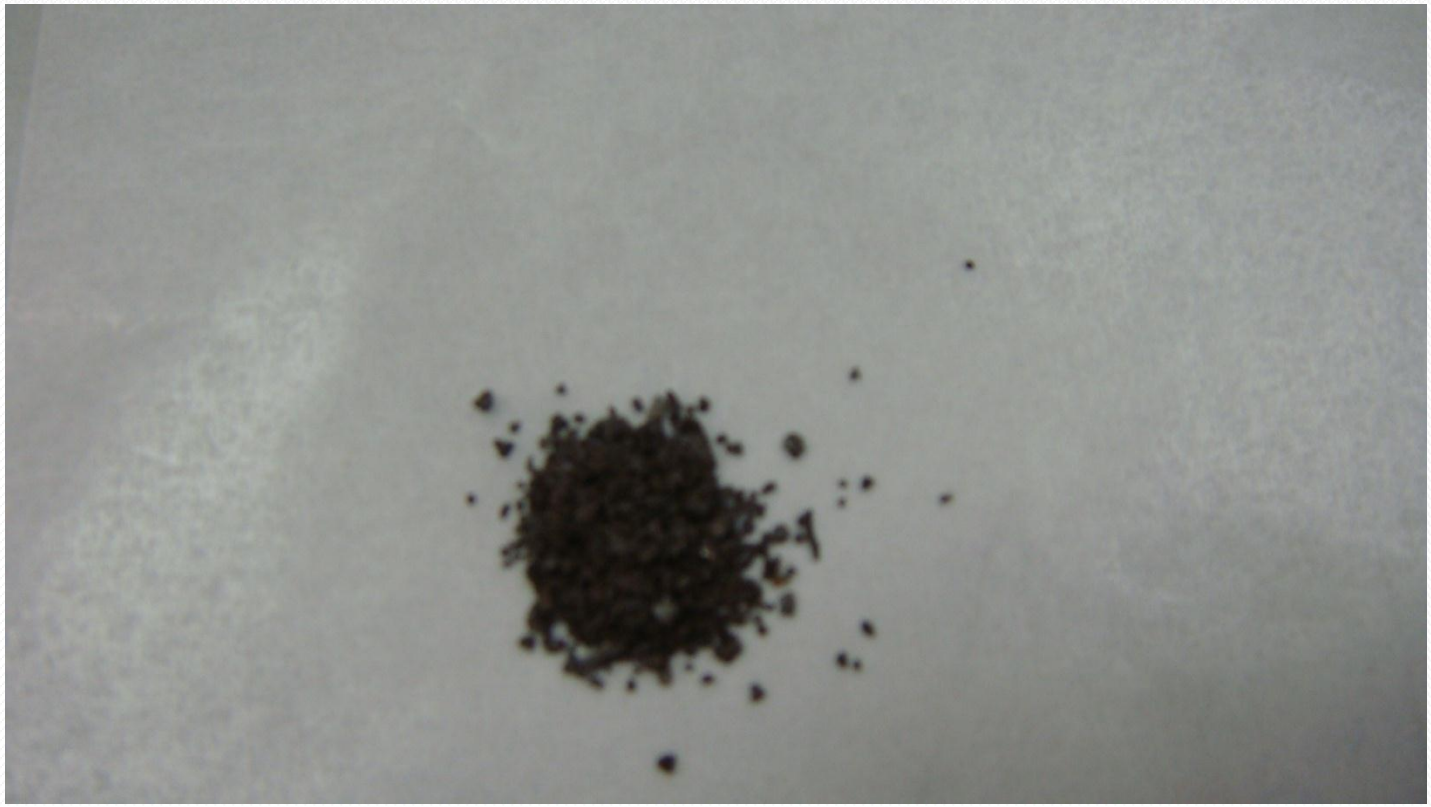
CaO_2


PFALTZ & BAUER, INC.
172 EAST AURORA STREET, WATERBURY, CT 06708
500GM
C01700
CALCIUM PEROXIDE TECH GRADE
LOT B05802

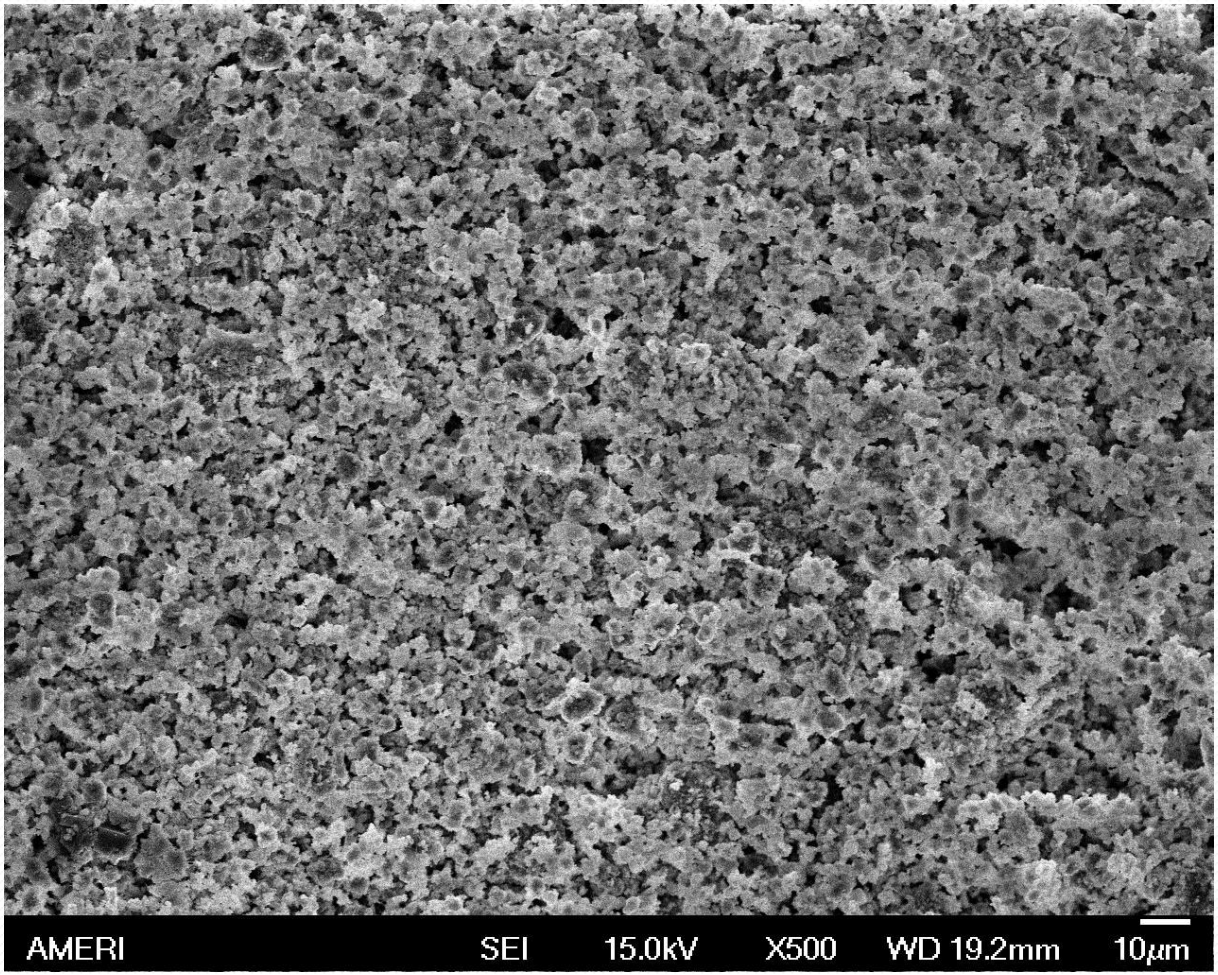



PFALTZ & BAUER, INC.
500GM
CALCIUM PEROXIDE TECH GRADE
LOT B05802

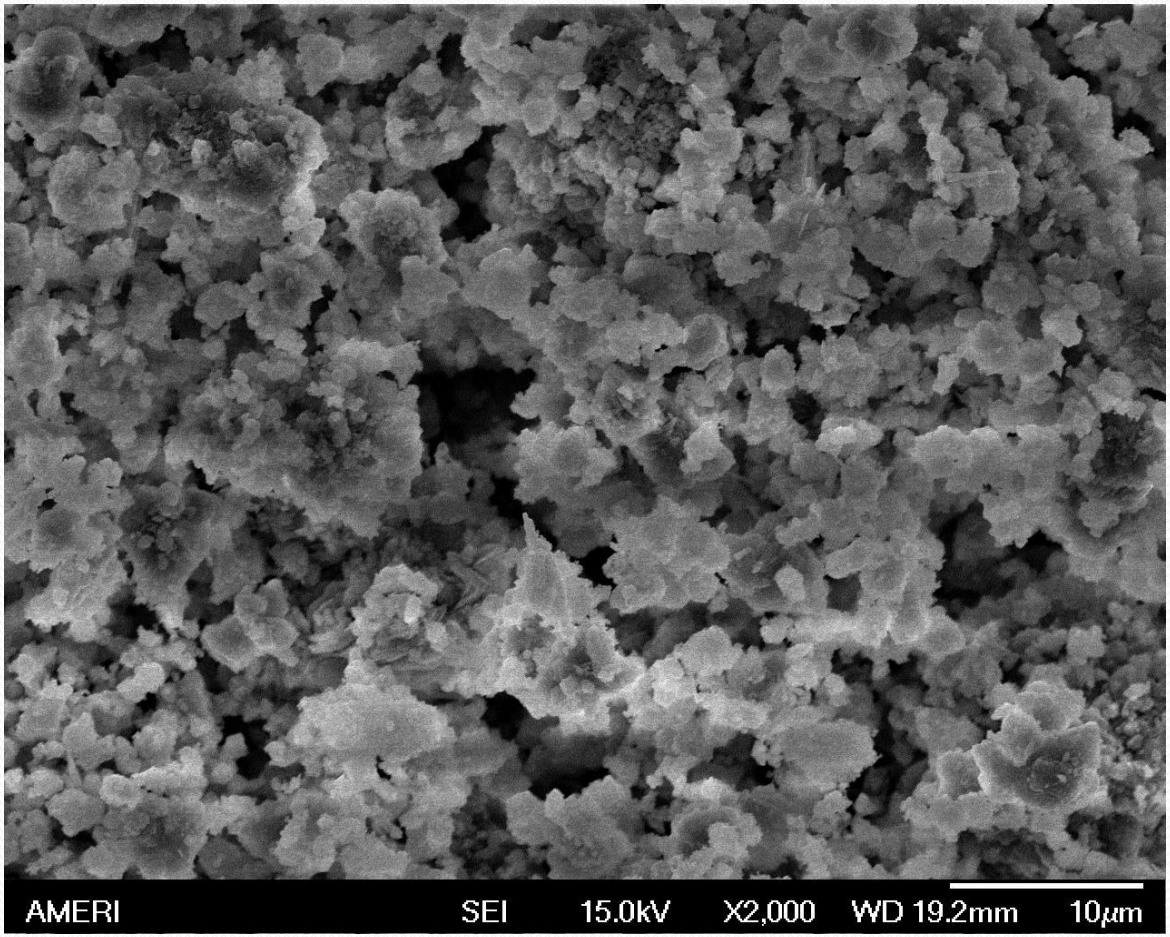
Elemental Iron Powder



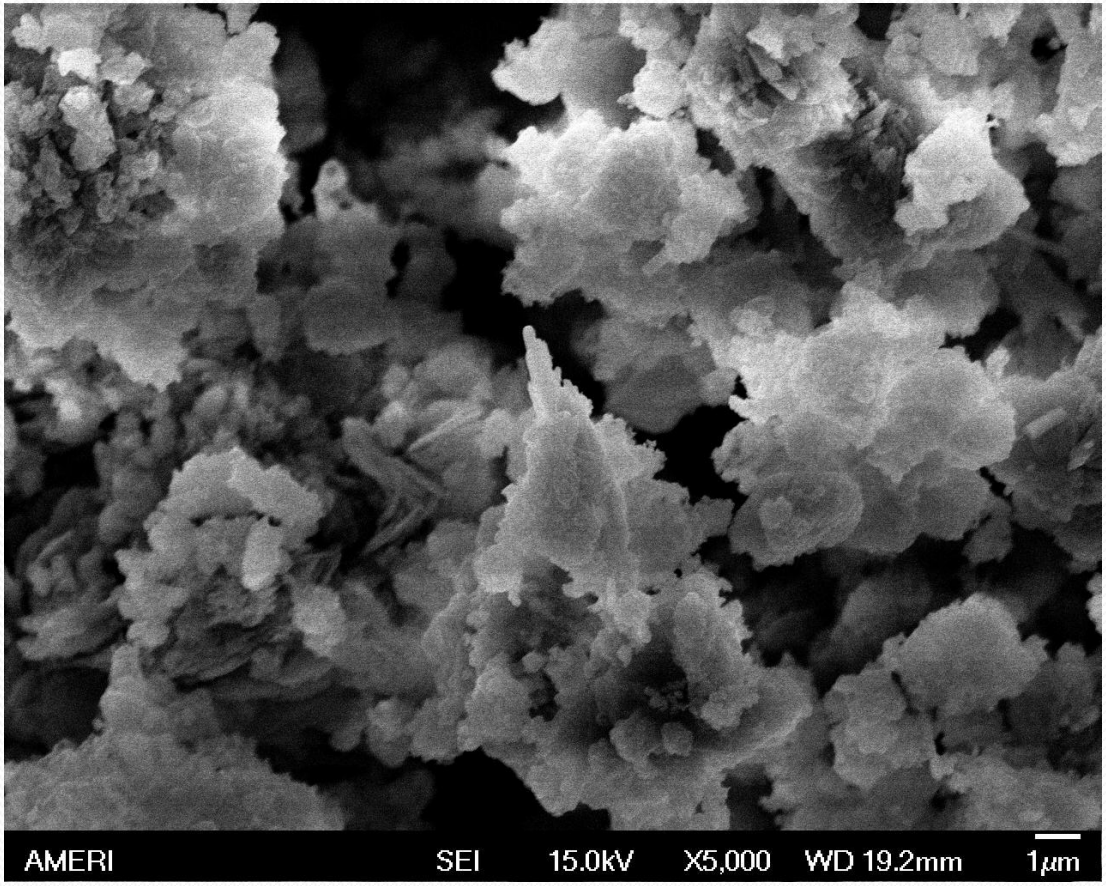
SEM Image of CaO_2 at x500



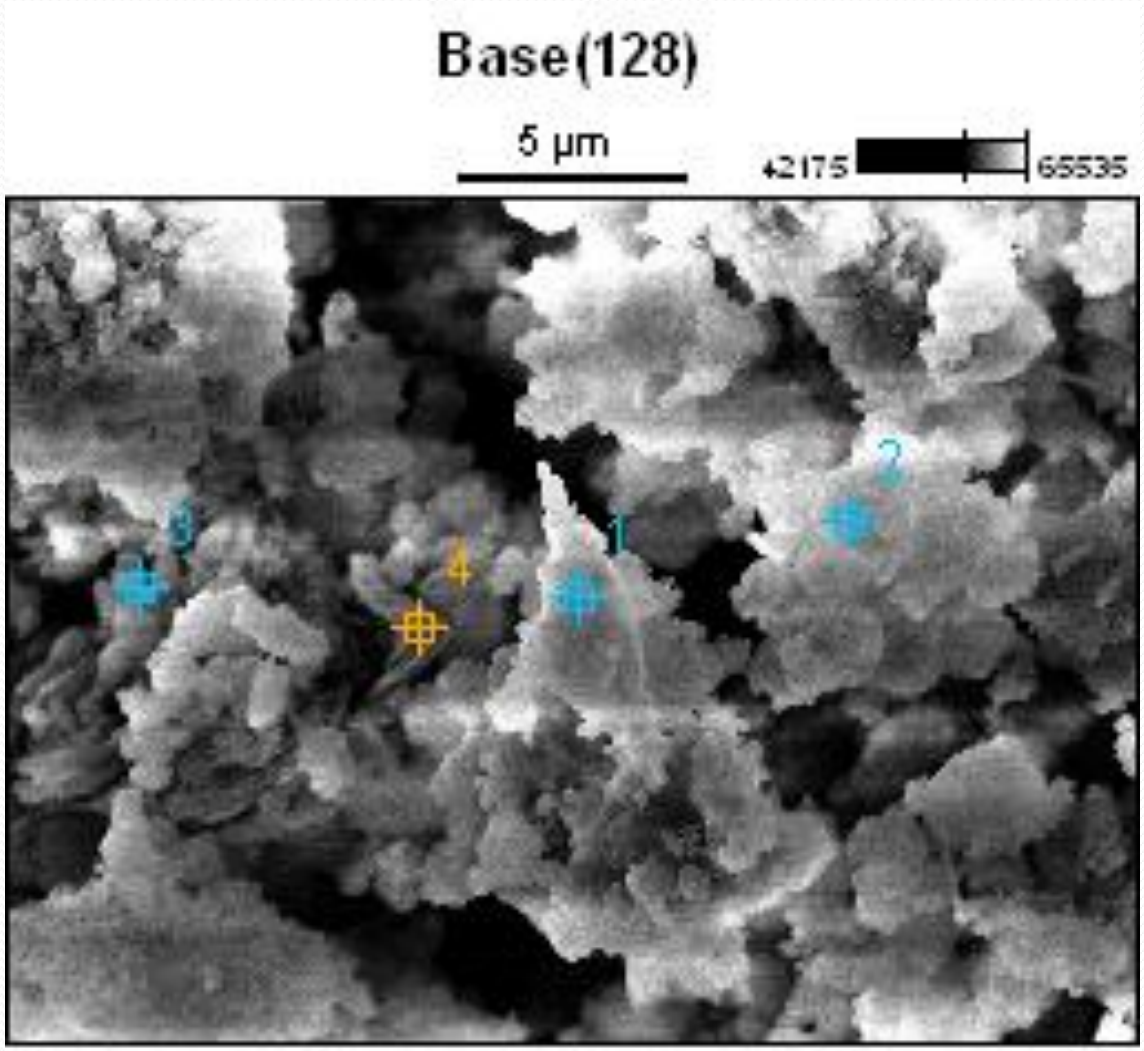
ESM Image of CaO_2 at x2000



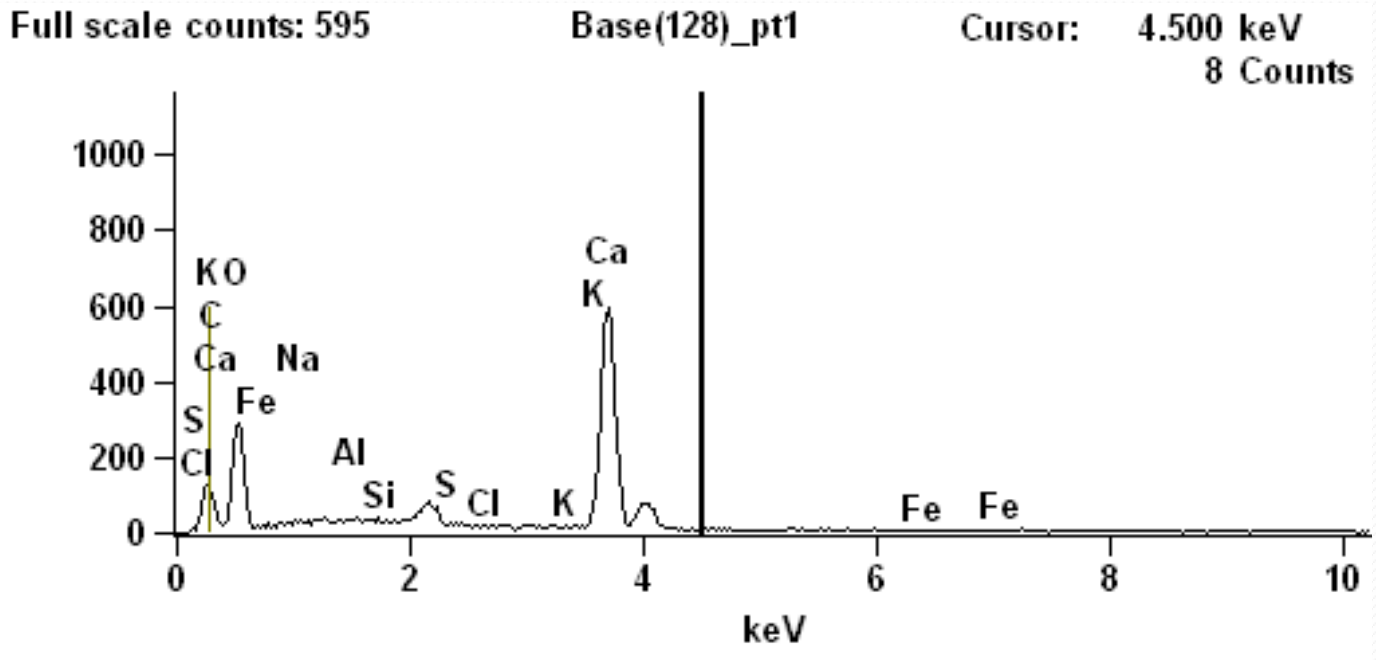
SEM Image of CaO_2 at x5000



Specific Points of the CaO_2 Sample



Electron Density of Ca and O



Chemical Composition

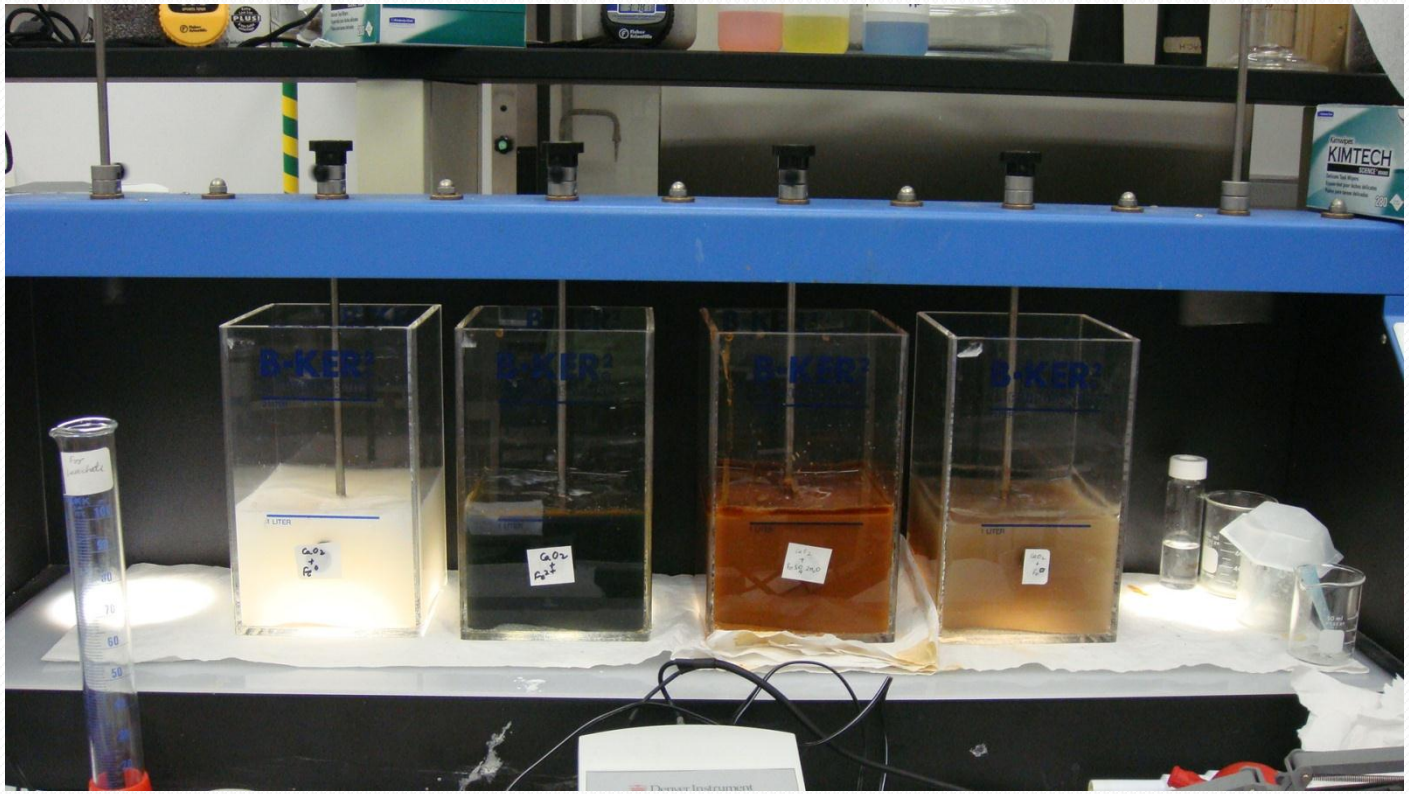
Table 1: Chemical composition by weight % at 4 different points of CaO_2

	C-K	O-K	Na-K	Al-K	Si-K	S-K	Cl-K	K-K	Ca-K
Base(128)_pt1	24.83	46.46	0.12	0.08	0.03	0.00	0.00	0.00	28.48
Base(128)_pt2	22.54	42.33	0.10	0.15	0.44	0.00	0.00	0.00	34.45
Base(128)_pt3	10.07	27.69	0.02	0.05	0.19	0.00	0.00	0.00	61.98
Base(128)_pt4	18.50	38.56	0.02	0.22	0.51	0.00	0.00	0.07	42.13

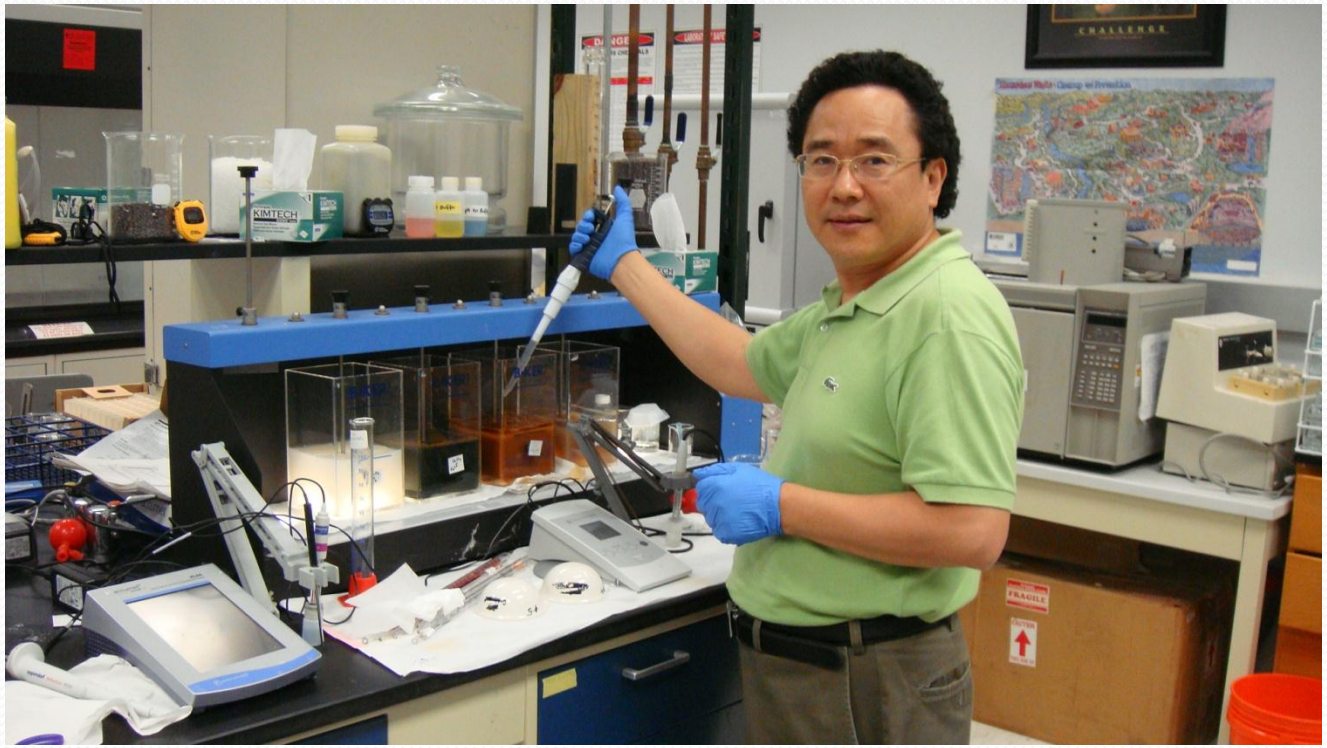
Table 2: Chemical composition by Atom % at 4 different points of CaO_2

	C-K	O-K	Na-K	Al-K	Si-K	S-K	Cl-K	K-K	Ca-K
Base(128)_pt1	36.33	51.02	0.09	0.05	0.02	0.00	0.00	0.00	12.49
Base(128)_pt2	34.70	48.93	0.08	0.10	0.29	0.00	0.00	0.00	15.89
Base(128)_pt3	20.33	41.95	0.02	0.04	0.17	0.00	0.00	0.00	37.49
Base(128)_pt4	30.62	47.91	0.01	0.16	0.36	0.00	0.00	0.04	20.90

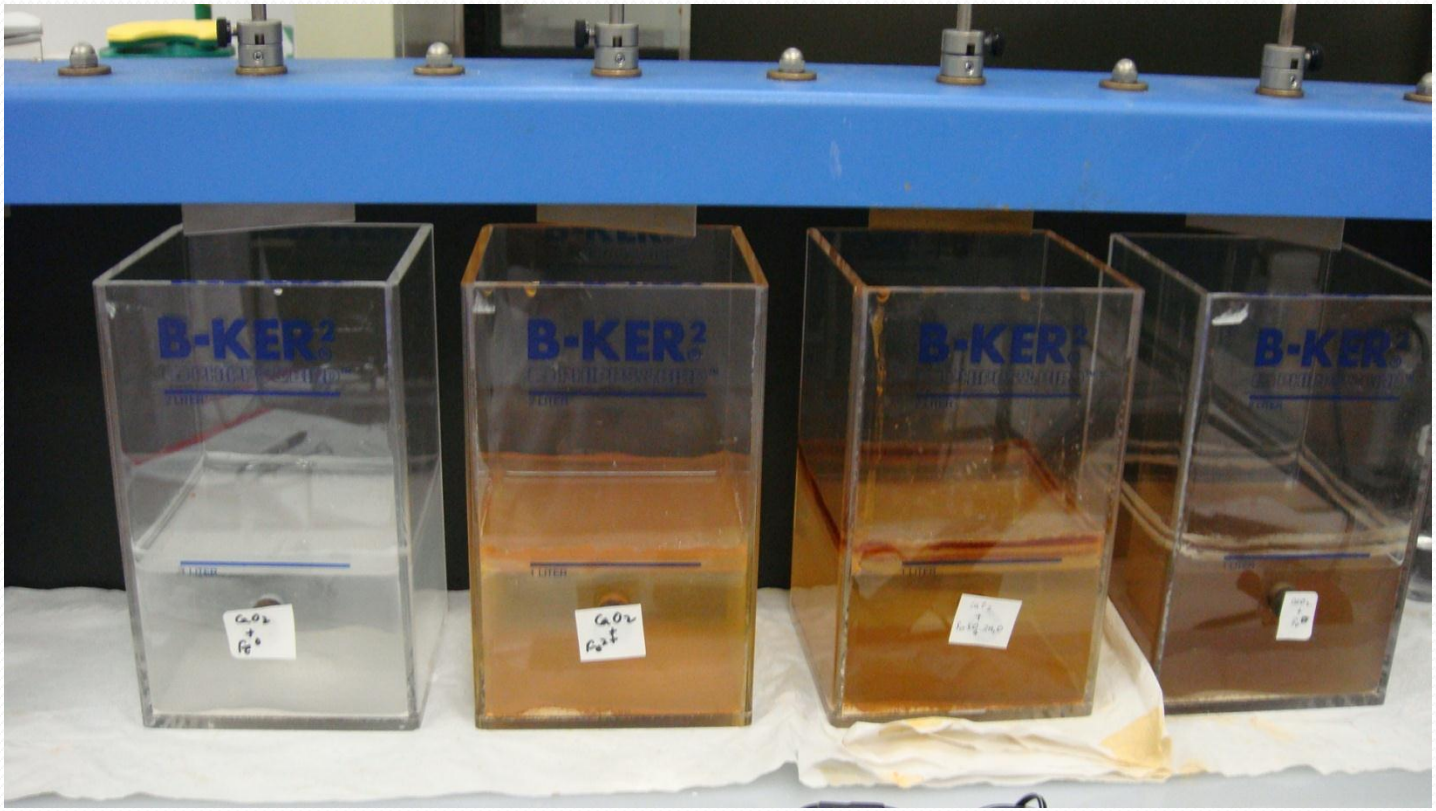
One Hour after Reaction



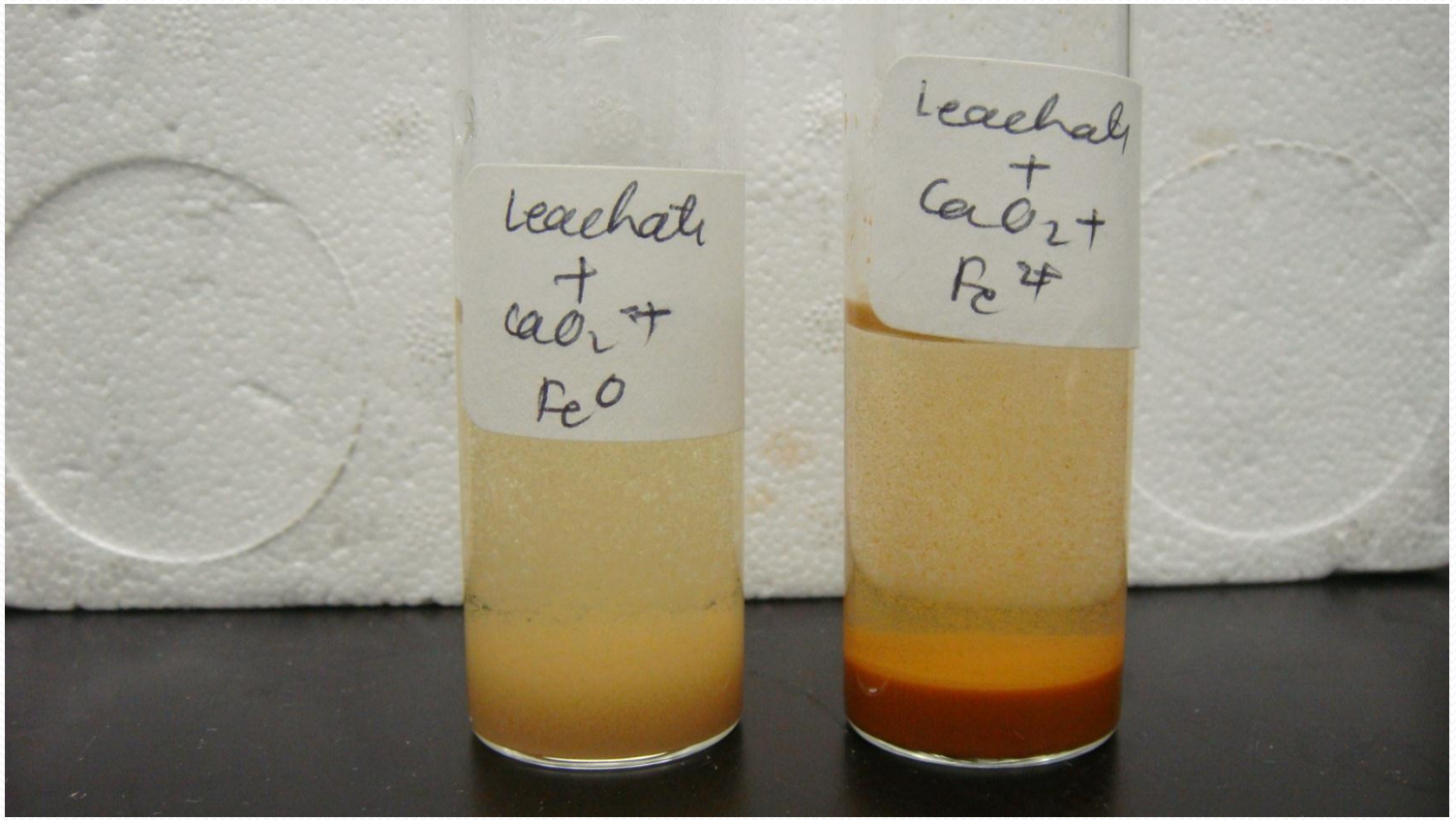
Taking Samples after Reaction



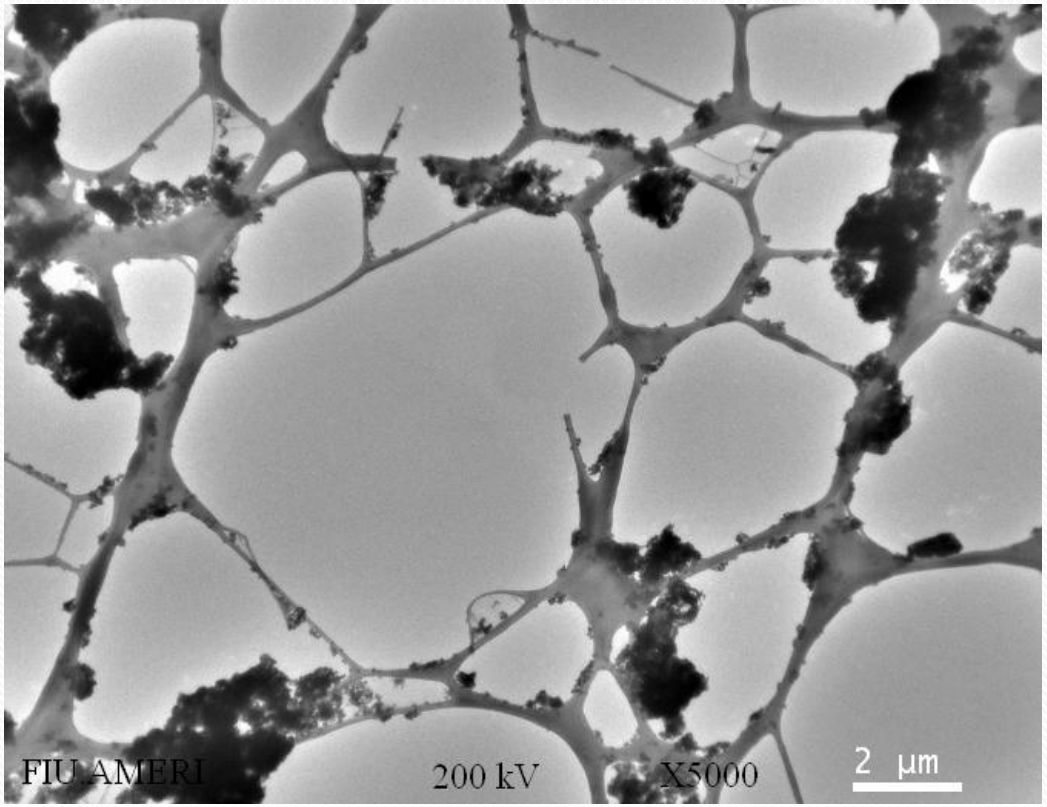
After 24 Hours

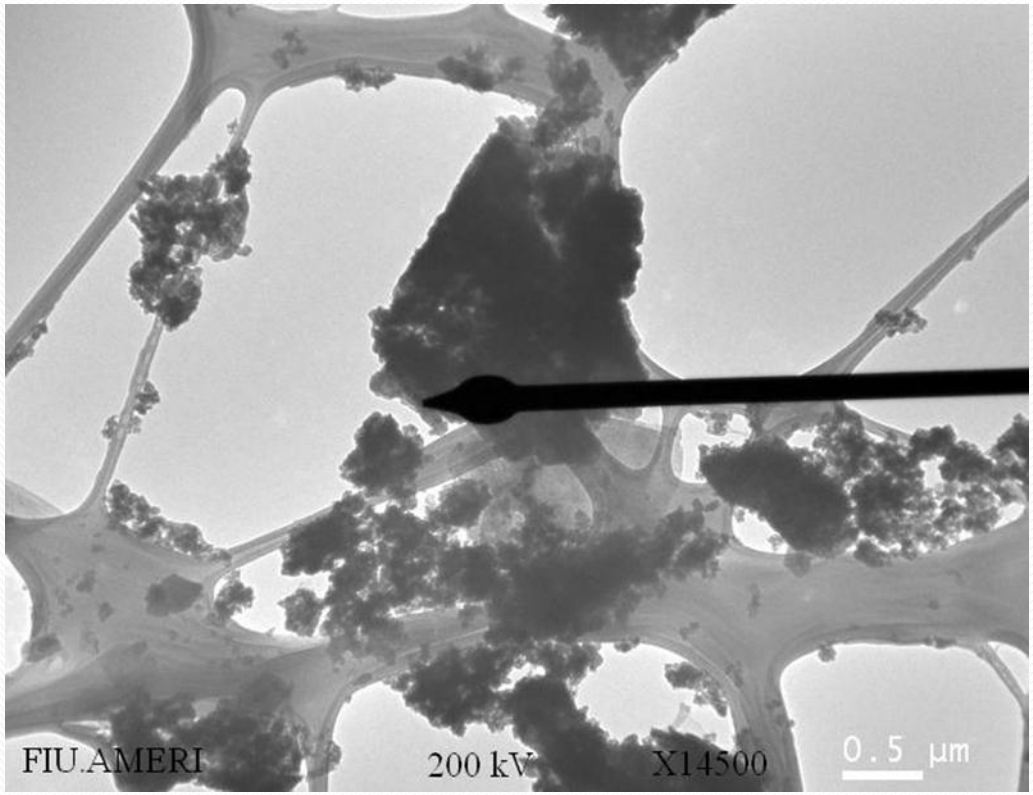


After 24 Hours

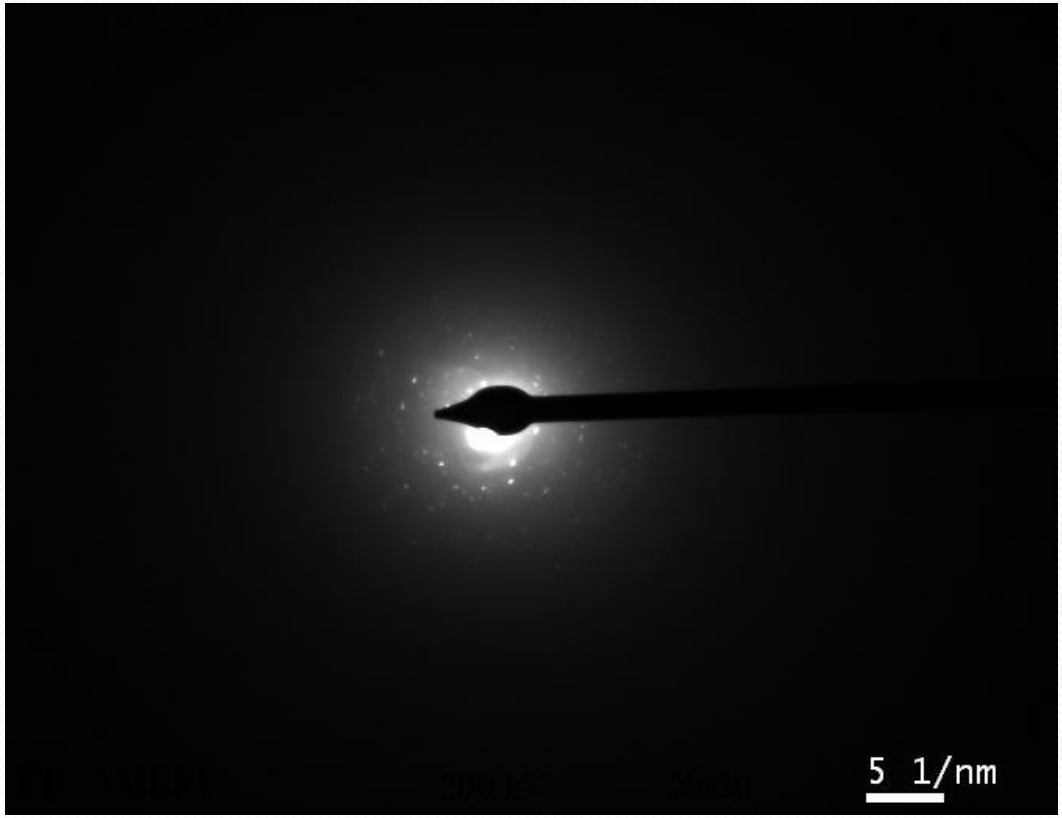


CaO_2 +Fe^{2+} + leachate




FIU.AMERI
200 kV
X14500
0.5 µm

CaO_2 Atoms Spatial Distribution



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Acknowledgements

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- Dr. Anna Bricker
- Ms. Emma Lopez
- Mr. Richard Urban
- Ms. Allison Vo

Thanks to Our Research Team!

Thank You !