



KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

College of Petroleum
Engineering & Geosciences

Efficiency of Cerium- modified Palm Oil Fly Ash in Catalytic Ozonation of Phenol

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Geosciences

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6th
**WATER
ARABIA**
Conference & Exhibition



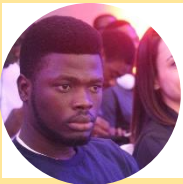
The Research Team



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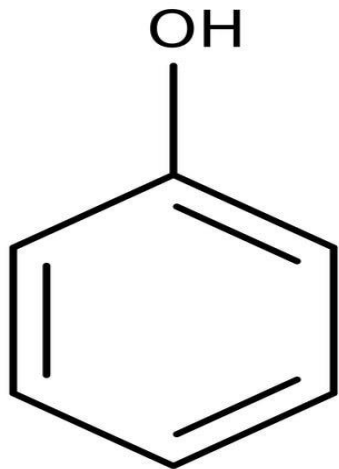
Introduction



- Water and Water Pollution
- KSA and Water Pollution
- Phenol Water Contamination

Phenol Contamination removal

- Adsorption
- Bioremediation
- Ozonation (Ozone-induced oxidation of phenol)
- Catalytic ozonation



Previous Works

| Authors, Year | Methods Used | Remarks |
|---|--|--|
| J.A. Zazo, , A.F. Mohedano, J.J. Rodr´iguez [2006] | Catalytic wet peroxide oxidation of phenol with a Fe/active carbon catalyst | Significant loss of activity of the enzyme due to Fe leaching. |
| A. Tor, Y. Cengeloglu, M.E. Aydin, M. Ersoz, [2006] | Removal of phenol from aqueous phase by using neutralized red mud, J. Colloid. | They used neutralized red mud as adsorbent for phenol removal, but the yield was relatively slow and time consuming |
| Dhatwalia, Vinod K. Nanda, Manisha, 2015 | Biodegradation of Phenol: Mechanisms and Applications | Reiterated that phenol can be broken down by microbes. However, it' time consuming and Microbial growth could be inhibited by High conc. of phenol |
| Mahdi Farzadkia et al, 2014 | Catalytic Ozonation of Phenolic Wastewater: Identification and Toxicity of Intermediates | Ozonation requires high energy consumption. |
| Bassam Tawabini, Tajudeen Oyehan, Eyad S.I, Mustapha B.(2020) | Catalytic ozonation of phenol using cerium impregnated acid treated POFA | ??? |



OBJECTIVES OF THE RESEARCH

Evaluate the efficiency of Cerium modified Palm oil Fly Ash in the catalytic ozonation of Phenol.

Investigate optimum conditions needed for catalytic ozonation using cerium-based APOFA

The background of the slide is a photograph of water taken from an underwater perspective. The water is a deep, vibrant blue, and the surface is visible in the upper right quadrant, showing ripples and light reflections. The overall lighting is dim, creating a serene and somewhat mysterious atmosphere.

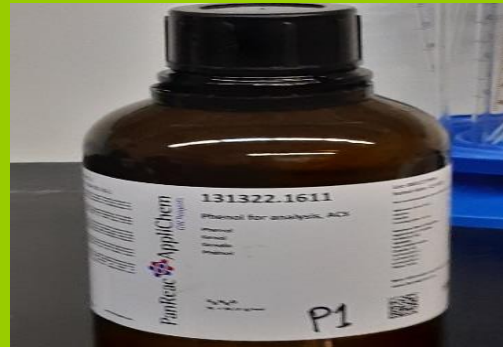
MATERIALS AND METHOD

Materials and Method



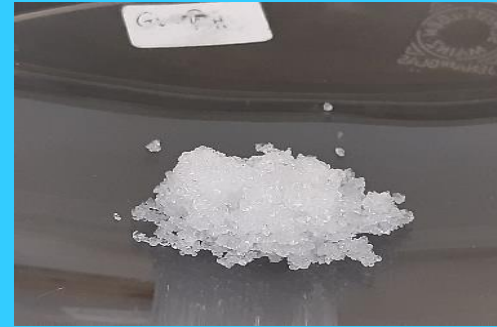
Palm Oil Fly Ash

It was prepared from our lab



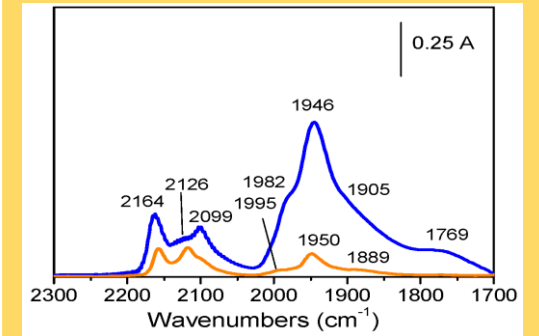
Phenol

Was supplied by Panreac (Germany). Desired concentration was made with serial dilution



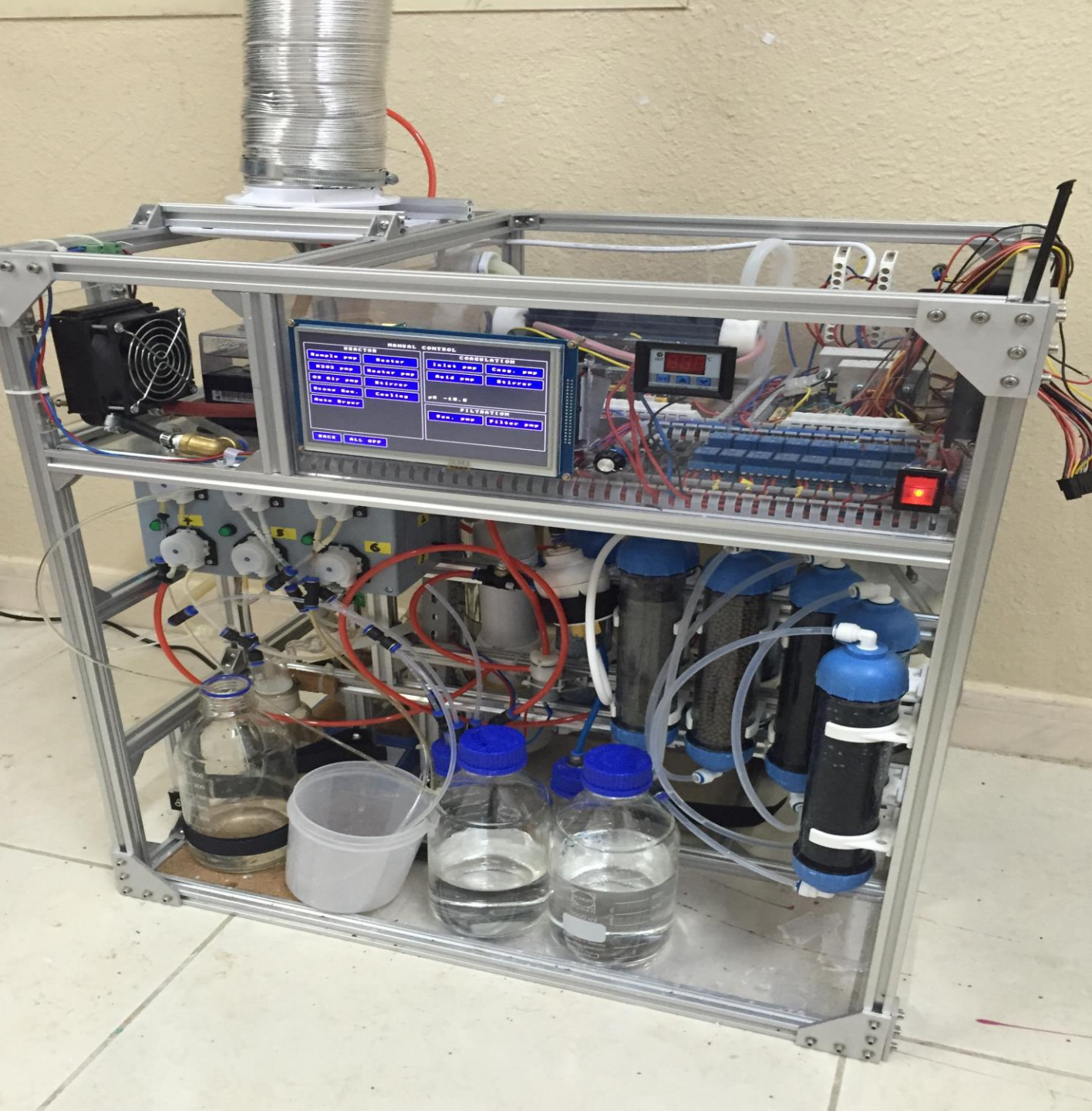
Cerium Oxide

Cerium nitrate ($\text{Ce}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$) was obtained from Sigma-Aldrich. Nitric acid (HNO_3) was supplied by Sigma Aldrich(Germany).



Catalyst Characterization

Particle size analysis
SEM-EDX



Materials and Method

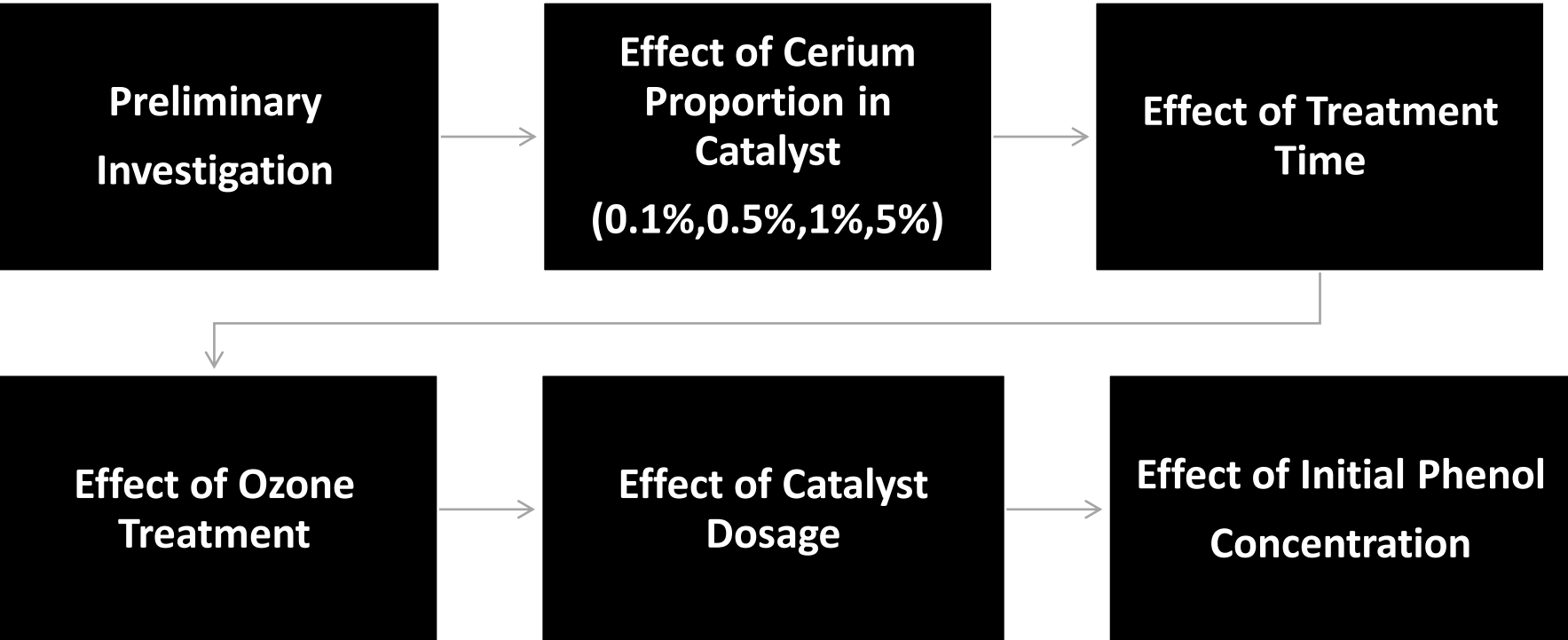
Analytical tools


Lab-assembled Ozone Reactor

TOC Analyzer

Materials and Method

EXPERIMENTAL LAYOUT



The background of the slide is a deep blue, almost black, underwater scene. Light rays from the surface create shimmering, wavy patterns of bright blue and cyan, reflecting off the water's surface and creating a sense of depth and movement. The overall effect is serene and scientific.

RESULTS AND DISCUSSION

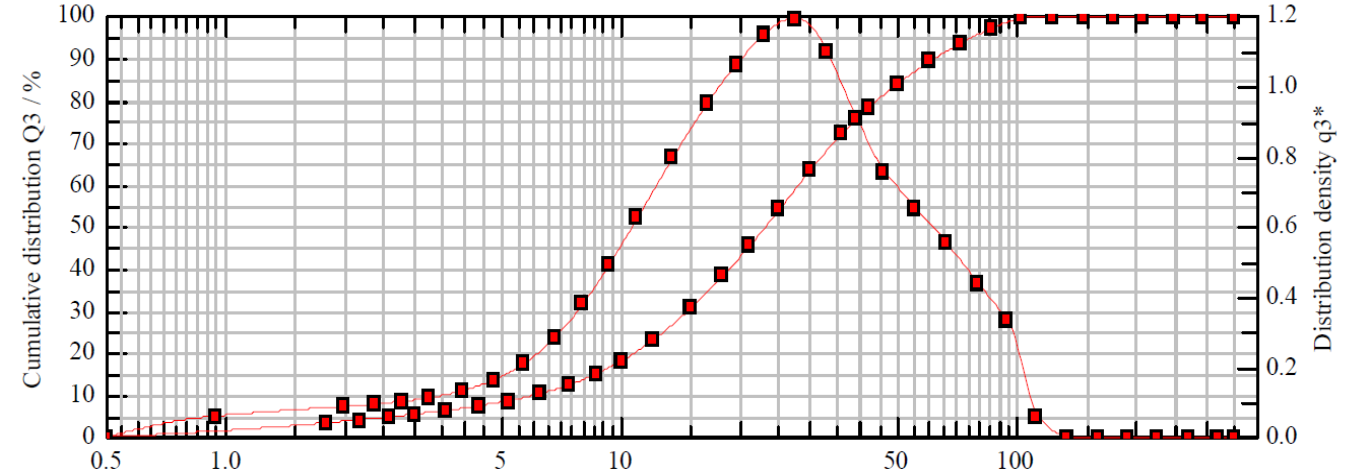
Results and Discussion

Characterization Results: particle size analysis

5% Ce-POFA particle analysis showed that most of the particles are around 15.52

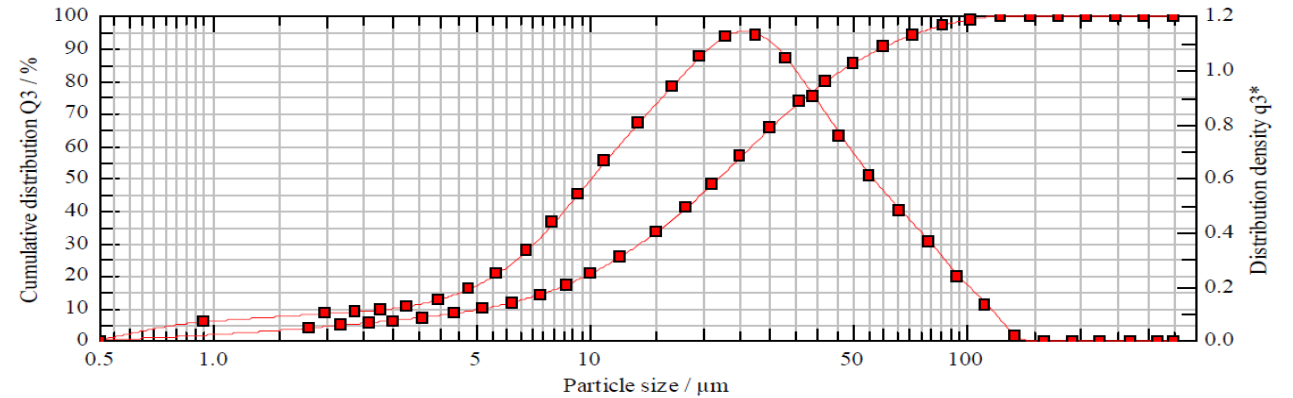
• 0.1 % CE-POFA

| | | | | |
|-----------------------------|------------------------------|------------------------------|--------------------------------------|---------------------------------------|
| $x_{10} = 6.07 \mu\text{m}$ | $x_{50} = 23.08 \mu\text{m}$ | $x_{90} = 61.90 \mu\text{m}$ | $\text{SMD} = 10.89 \mu\text{m}$ | $\text{VMD} = 28.90 \mu\text{m}$ |
| $x_{16} = 9.08 \mu\text{m}$ | $x_{84} = 49.81 \mu\text{m}$ | $x_{99} = 98.51 \mu\text{m}$ | $S_v = 0.55 \text{ m}^3/\text{cm}^3$ | $S_m = 2343.72 \text{ cm}^2/\text{g}$ |



• 0.5 % CE-POFA

| | | | | |
|-----------------------------|------------------------------|-------------------------------|--------------------------------------|---------------------------------------|
| $x_{10} = 5.32 \mu\text{m}$ | $x_{50} = 21.89 \mu\text{m}$ | $x_{90} = 59.06 \mu\text{m}$ | $\text{SMD} = 10.08 \mu\text{m}$ | $\text{VMD} = 27.83 \mu\text{m}$ |
| $x_{16} = 8.16 \mu\text{m}$ | $x_{84} = 47.73 \mu\text{m}$ | $x_{99} = 104.94 \mu\text{m}$ | $S_v = 0.60 \text{ m}^3/\text{cm}^3$ | $S_m = 2533.56 \text{ cm}^2/\text{g}$ |



Characterization Results: particle size analysis

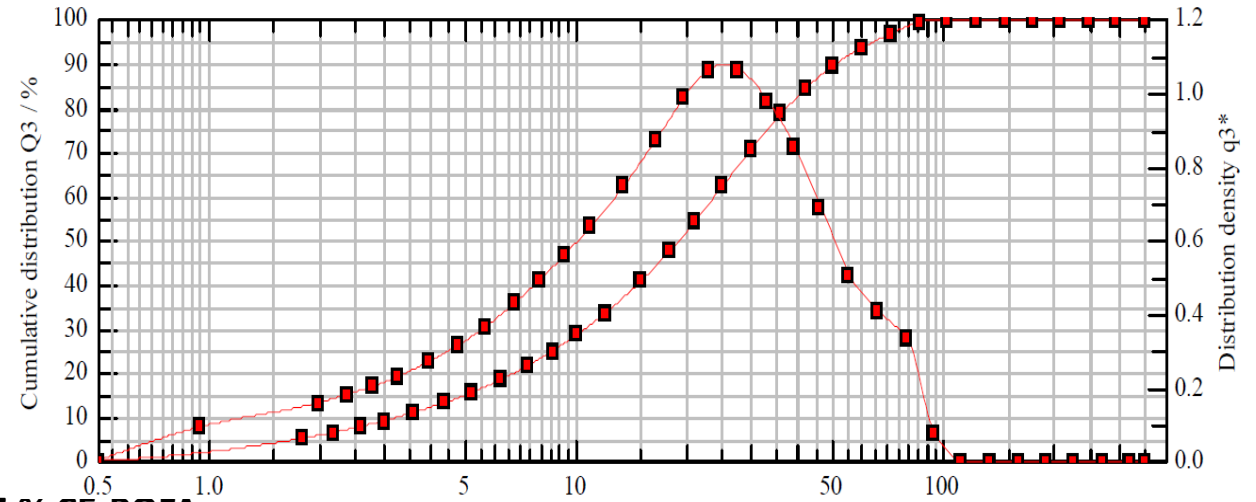
The result shows a clear disparity between the variants of the catalyst which is a manifestation of the lab modifications

| Material | X50(μm) |
|--------------|----------------------|
| 0.1% Ce-POFA | 23.08 |
| 0.5% Ce-POFA | 21.89 |
| 1% Ce-POFA | 18.89 |
| 5% Ce-POFA | 15.52 |

Results and Discussion

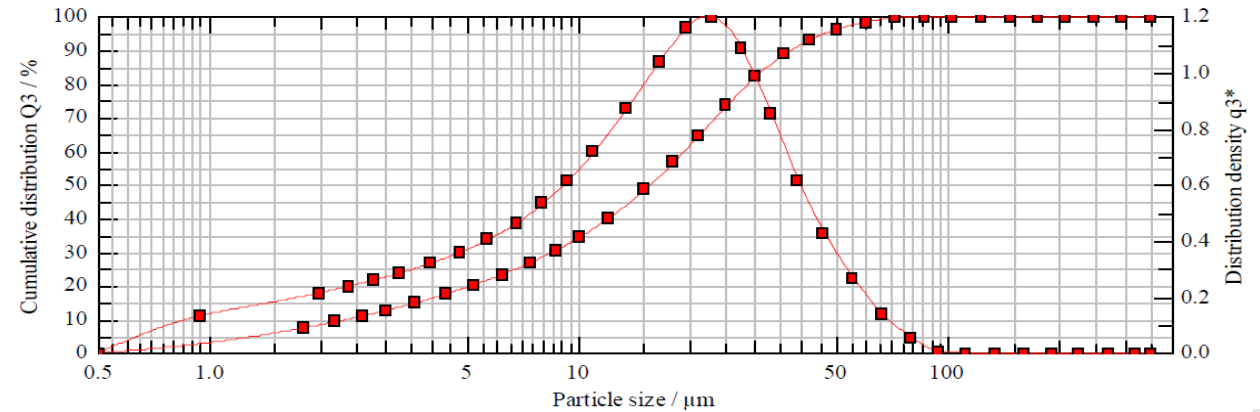
• 1 % CE-POFA

| | | | | |
|-----------------------------|------------------------------|------------------------------|--------------------------------------|---------------------------------------|
| $x_{10} = 3.29 \mu\text{m}$ | $x_{50} = 18.98 \mu\text{m}$ | $x_{90} = 50.96 \mu\text{m}$ | $SMD = 7.92 \mu\text{m}$ | $VMD = 23.64 \mu\text{m}$ |
| $x_{16} = 5.35 \mu\text{m}$ | $x_{84} = 41.60 \mu\text{m}$ | $x_{99} = 83.56 \mu\text{m}$ | $S_V = 0.76 \text{ m}^2/\text{cm}^3$ | $S_m = 3224.31 \text{ cm}^2/\text{g}$ |



• 5 % CE-POFA

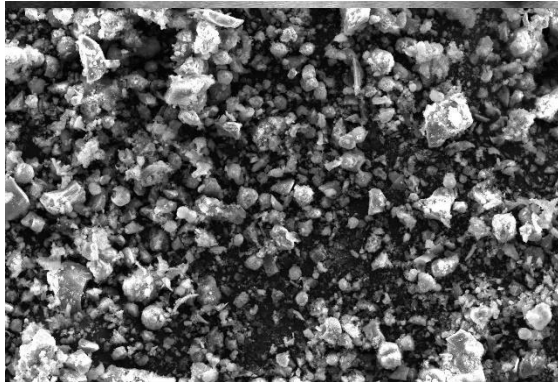
| | | | | |
|-----------------------------|------------------------------|------------------------------|--------------------------------------|---------------------------------------|
| $x_{10} = 2.37 \mu\text{m}$ | $x_{50} = 15.52 \mu\text{m}$ | $x_{90} = 37.49 \mu\text{m}$ | $SMD = 6.36 \mu\text{m}$ | $VMD = 18.25 \mu\text{m}$ |
| $x_{16} = 3.93 \mu\text{m}$ | $x_{84} = 31.59 \mu\text{m}$ | $x_{99} = 65.96 \mu\text{m}$ | $S_V = 0.94 \text{ m}^2/\text{cm}^3$ | $S_m = 4011.76 \text{ cm}^2/\text{g}$ |



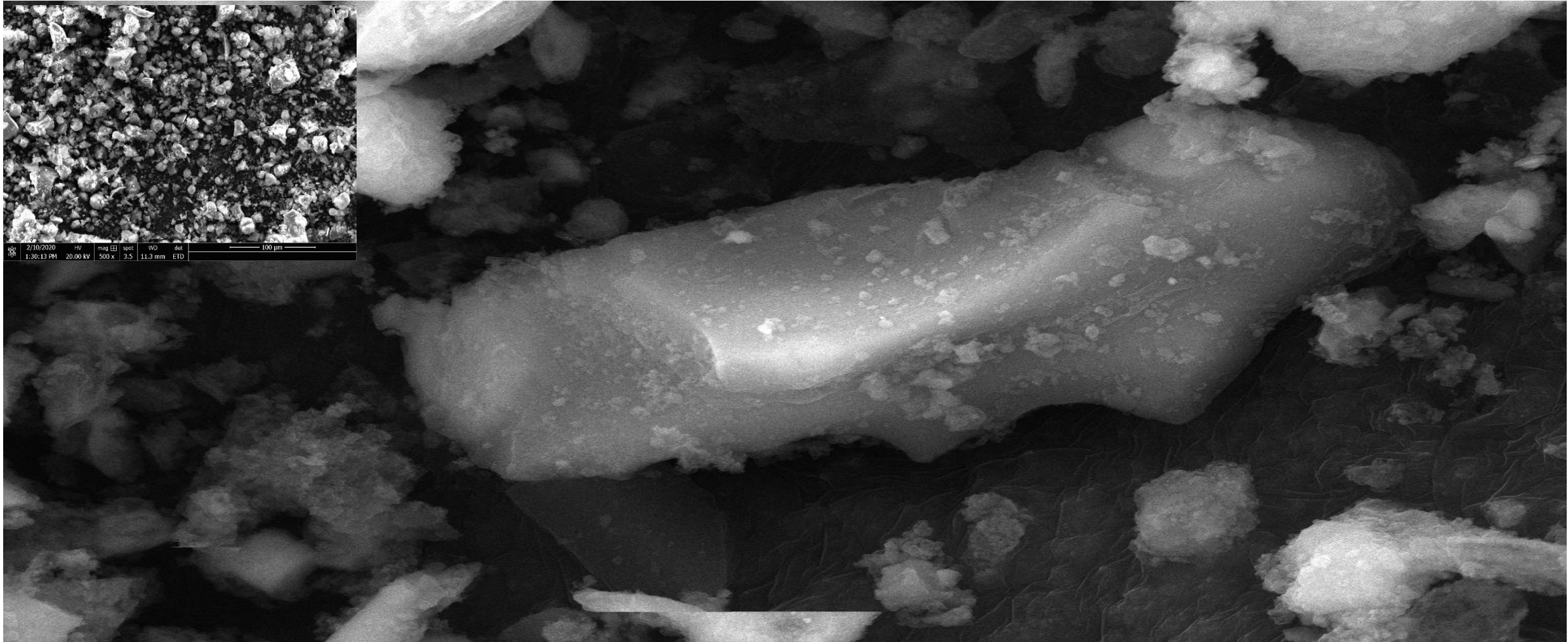
Characterization Results:

SEM, POFA

Results and Discussion



| | | | | | |
|------------|----------|-------|------|---------|-----|
| 2/10/2020 | HV | mag | spot | WD | det |
| 1:30:13 PM | 20.00 kV | 500 x | 3.5 | 11.3 mm | ETD |

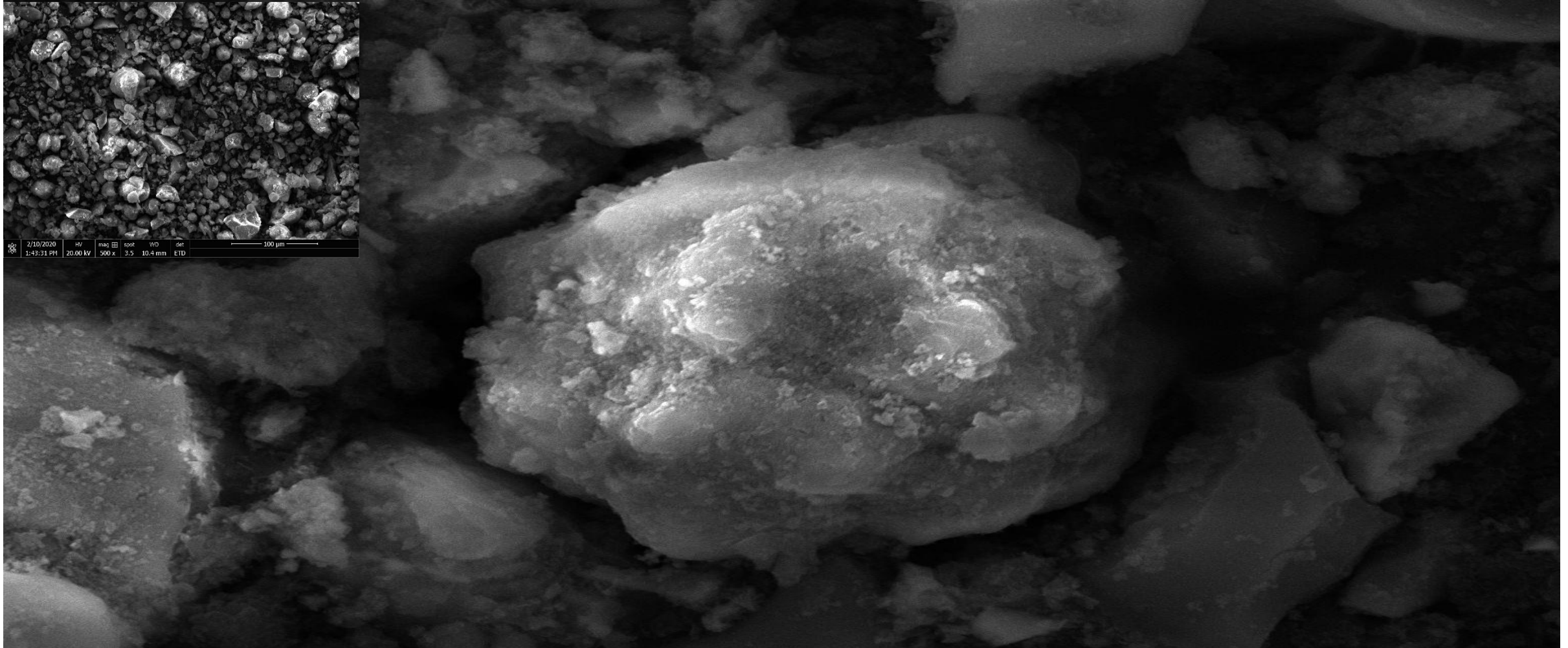
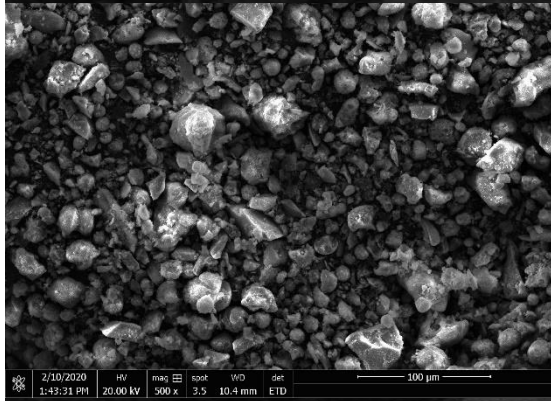


| | | | | | | | |
|--|-------------------------|----------------|--|-------------|---------------|------------|-------|
|  | 2/10/2020 1:26:37 PM | HV 20.00 kV | mag  5 000 x | spot 3.5 | WD 11.3 mm | det ETD | 10 μm |
|--|-------------------------|----------------|--|-------------|---------------|------------|-------|

Characterization Results:

SEM, 1% Ce-POFA

Results and Discussion

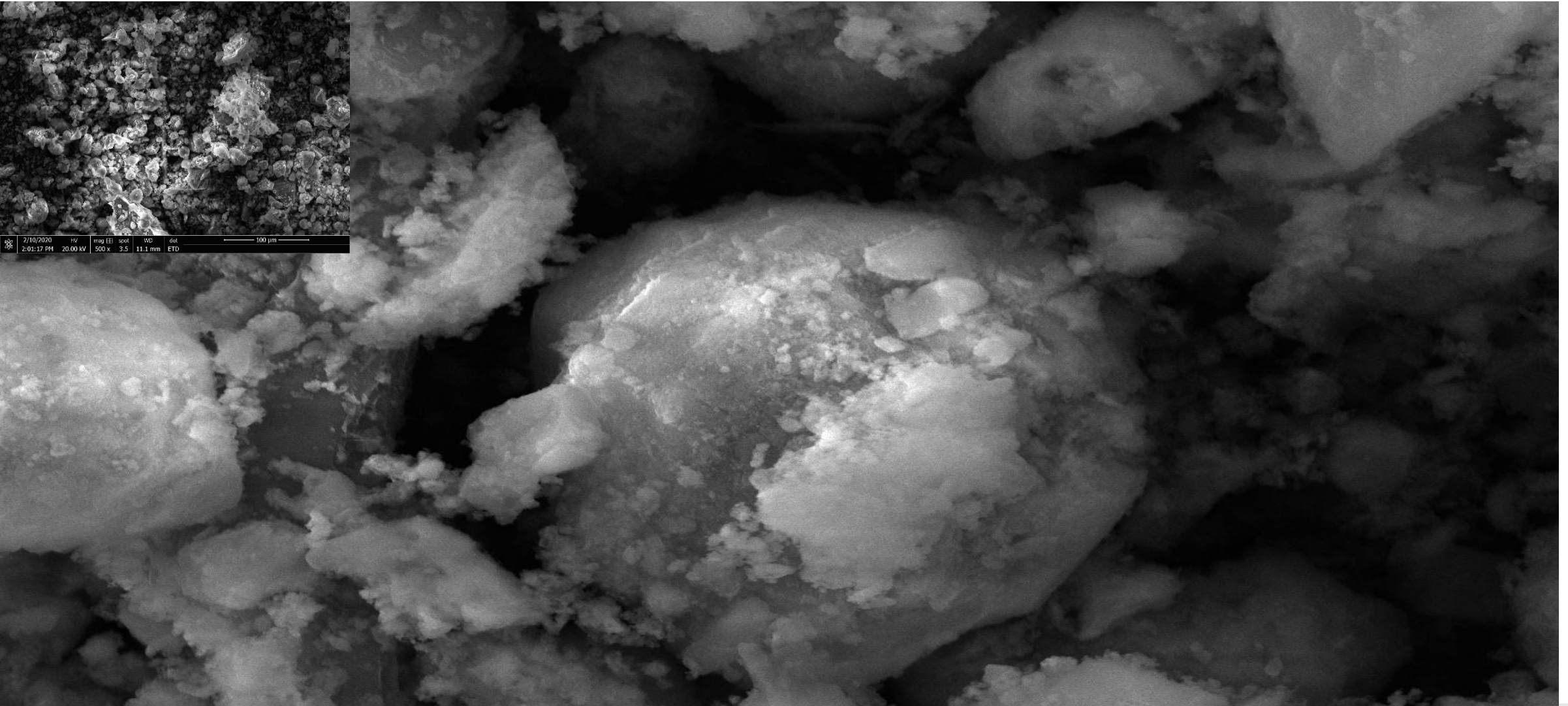
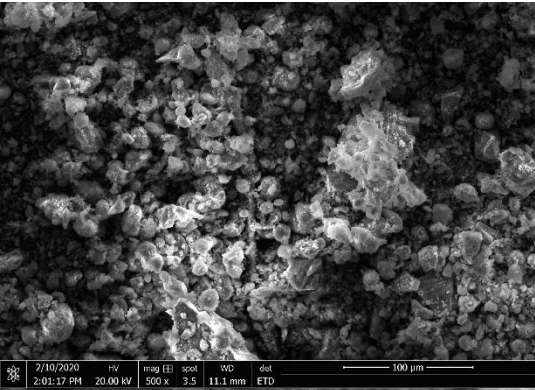


| | | | | | | | |
|--|------------|----------|---|------|---------|-----|-------|
|  | 2/10/2020 | HV | mag  | spot | WD | det | 10 μm |
| | 1:47:00 PM | 20.00 kV | 5 000 x | 3.5 | 10.4 mm | ETD | |

Characterization Results:

SEM, 5% Ce-POFA

Results and Discussion

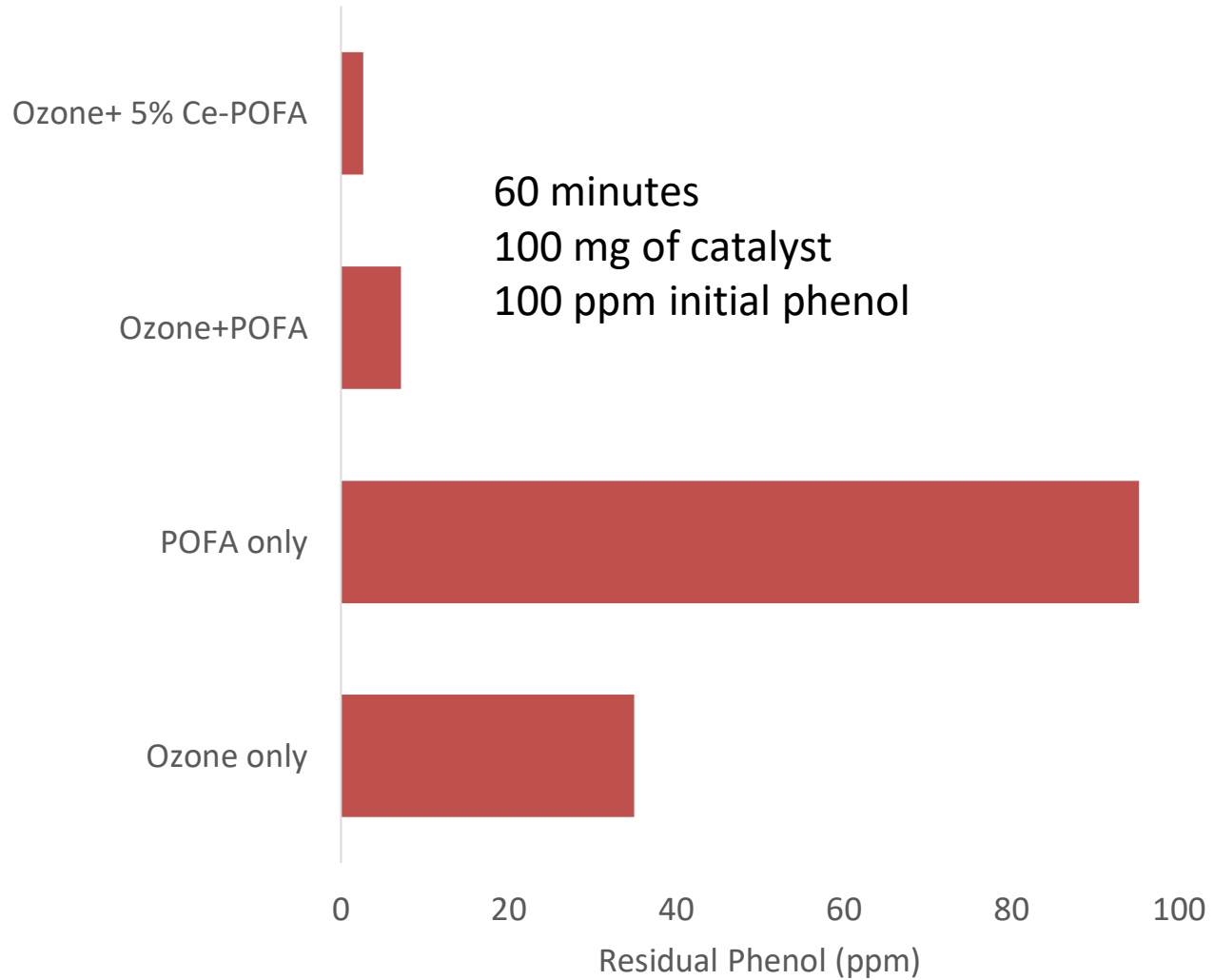


| | | | | | | | |
|--|-------------------------|----------------|----------------|-------------|---------------|------------|-----------|
| | 2/10/2020 2:02:32 PM | HV 20.00 kV | mag 5 000 x | spot 3.5 | WD 11.1 mm | det ETD | 10 μm |
|--|-------------------------|----------------|----------------|-------------|---------------|------------|-----------|

Characterization Results: EDEX

| Column1 | POFA | 1% | 5% |
|---------|---------------|------|-----|
| Oxide | % composition | | |
| Si | 89.8 | 18.7 | 19 |
| Al | 3.5 | 1.4 | 0.6 |
| K | 3.2 | 0.8 | 0.6 |
| Fe | 2 | 2.7 | 0.6 |
| Mg | 0.8 | 0.3 | 0.2 |
| Ti | 0.6 | 0.3 | 0 |
| Ce | nil | 0.4 | 2 |

Results and Discussion



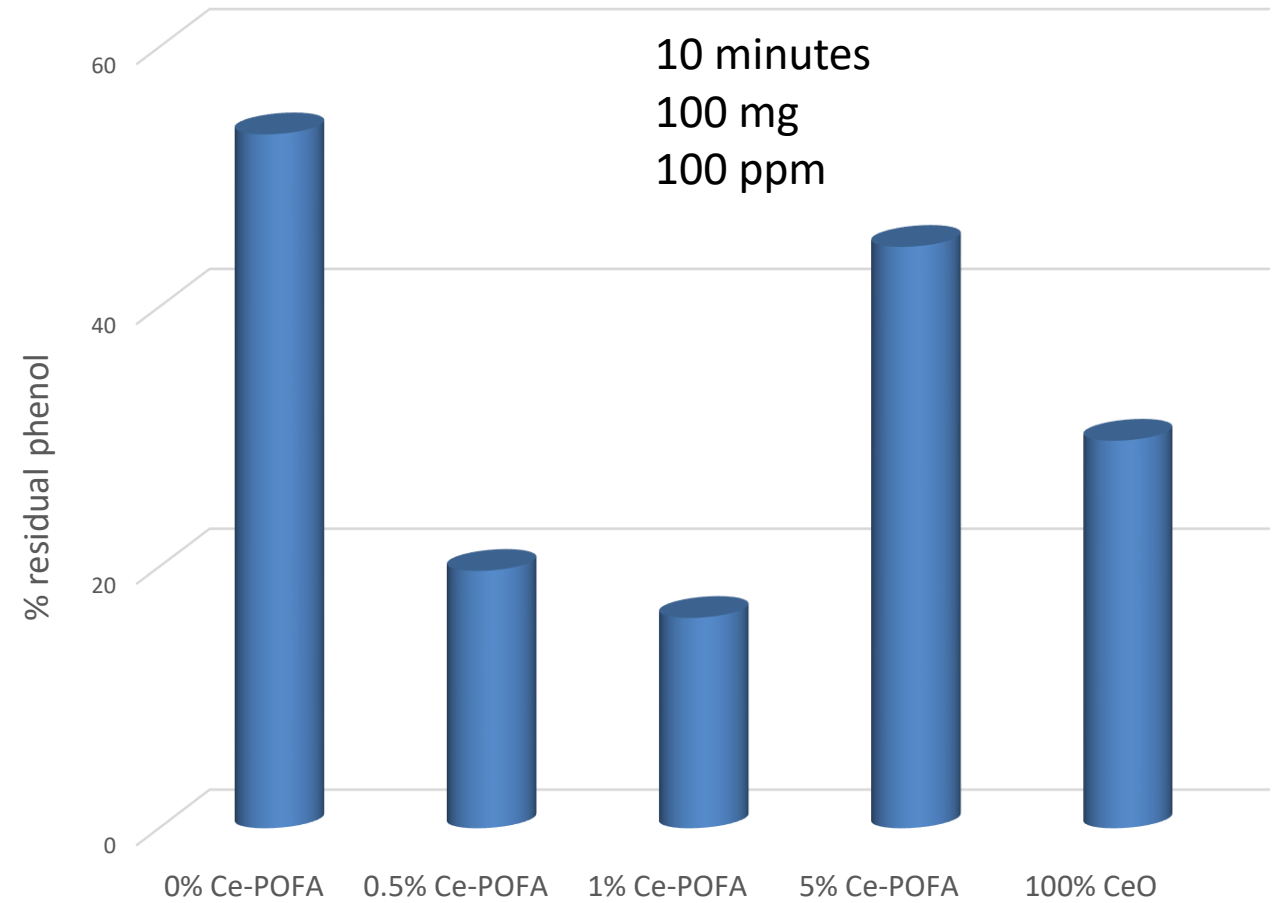
Preliminary investigations

Baseline comparison of removal efficiency of ozone only, POFA only, ozone + POFA, Ozone + cerium-POFA Revealed that the use of the catalyst with ozone has good prospects

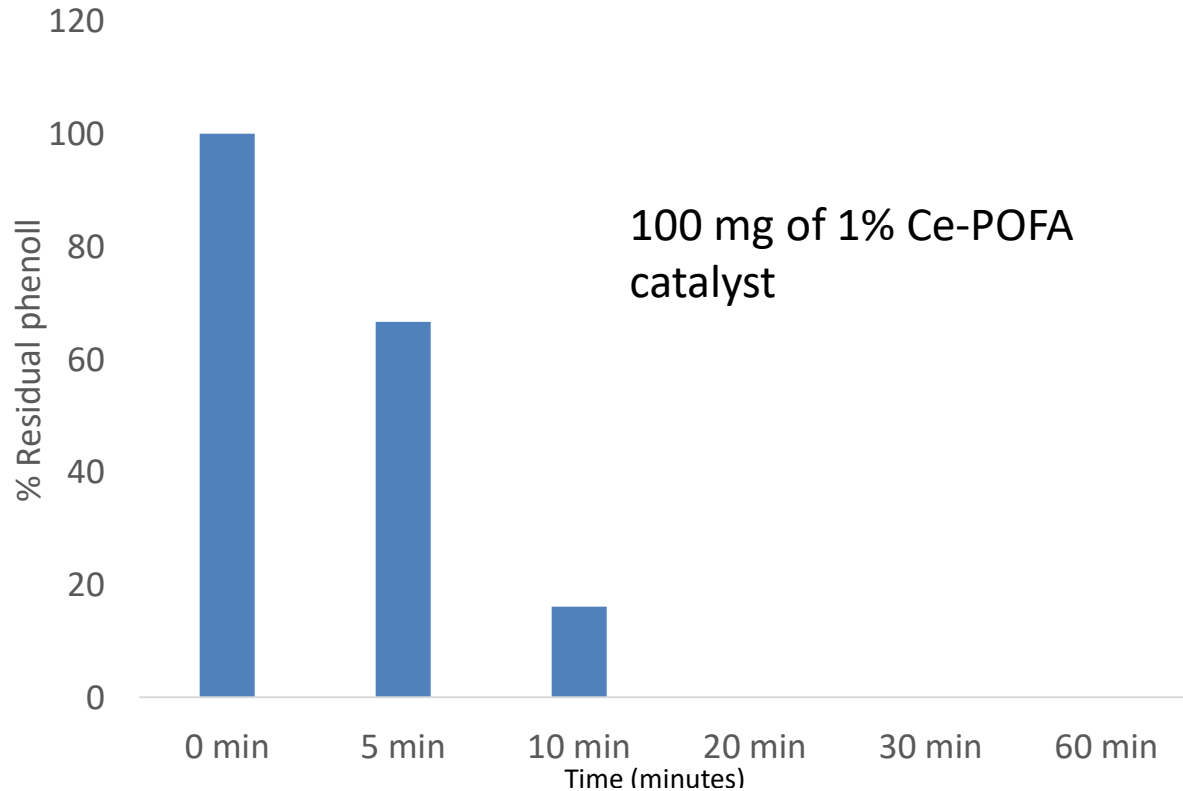
Results and Discussion

Effects of Cerium Proportion in Catalyst

1% Cerium-POFA Combination gave the best removal effect.



Results and Discussion

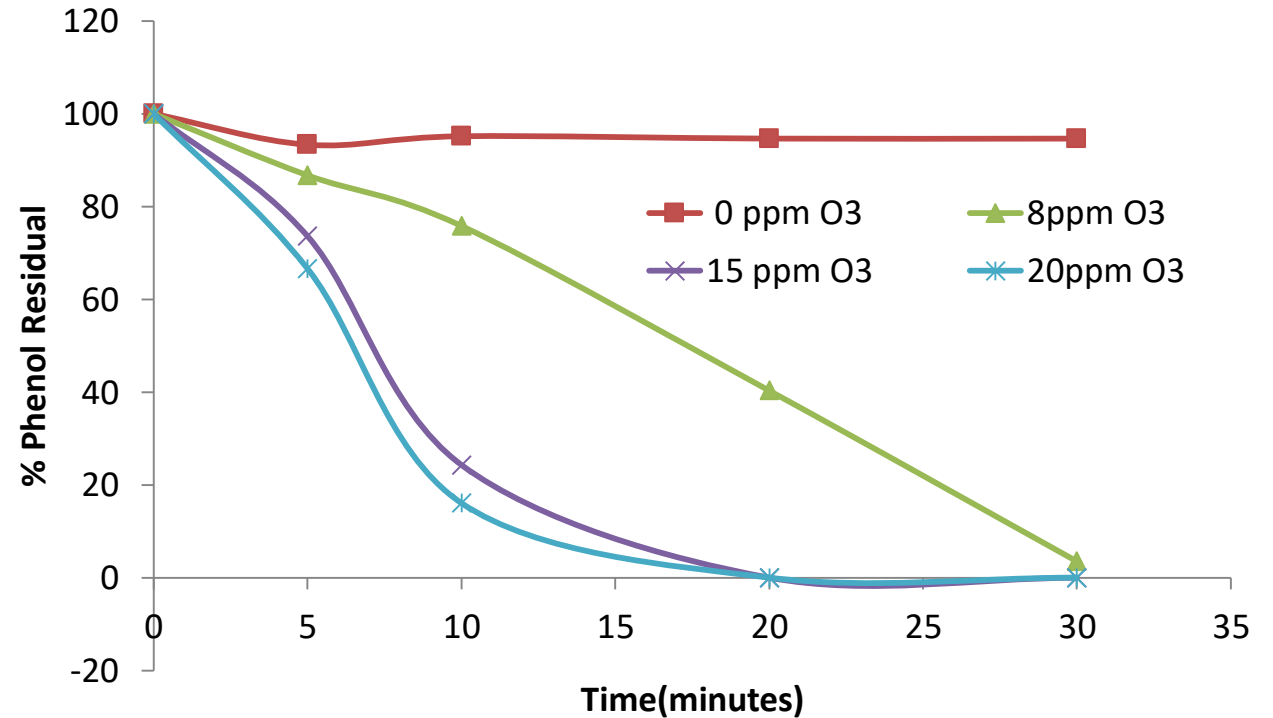


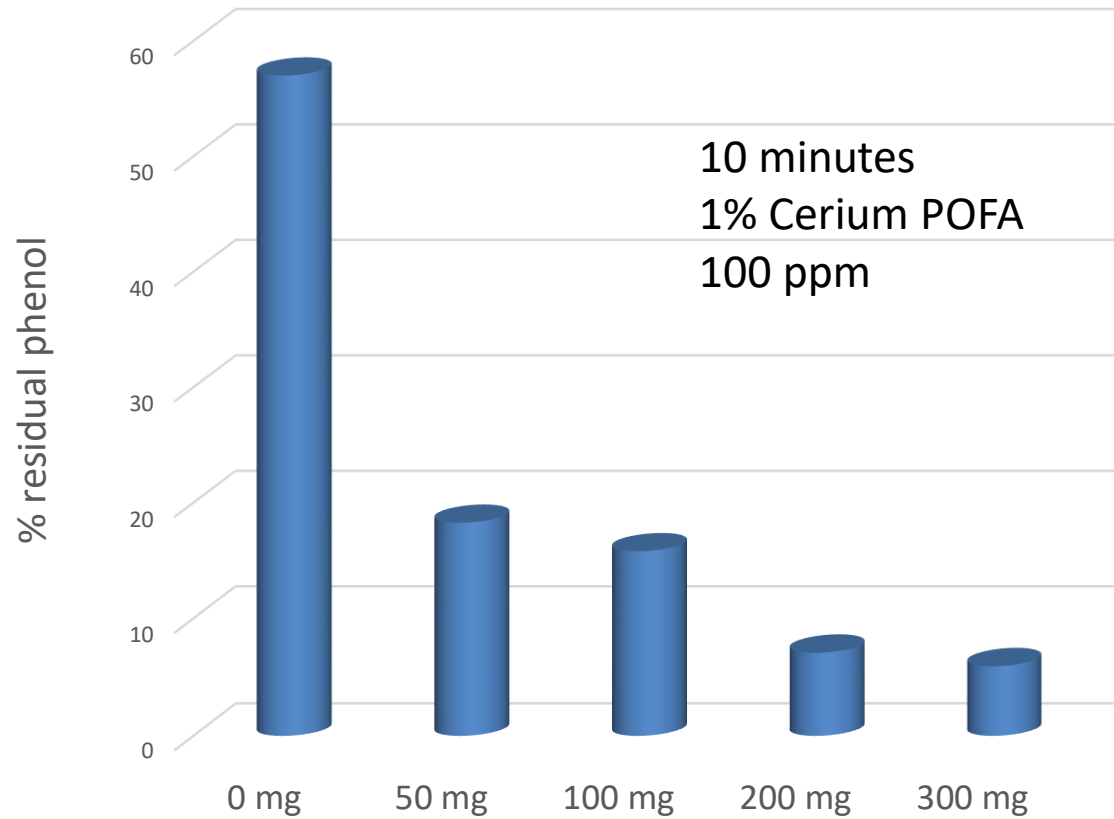
Effect of Treatment Time

We varied time while keeping other conditions (100mg of 1% Ce-POFA , 100ppm of phenol). Result showed that optimum time for phenol removal under this condition is 20 minutes.

Effects of varying Ozone Conc. with Constant Optimal catalyst:

- 0 ppm showed insignificant removal
- 8 ppm gave average removal
- 15 ppm (level 2) and 20 ppm (max) produced almost same efficiency.
- 15 ppm (level 2) is recommended since it requires less energy and produces similar optimal effect as max level



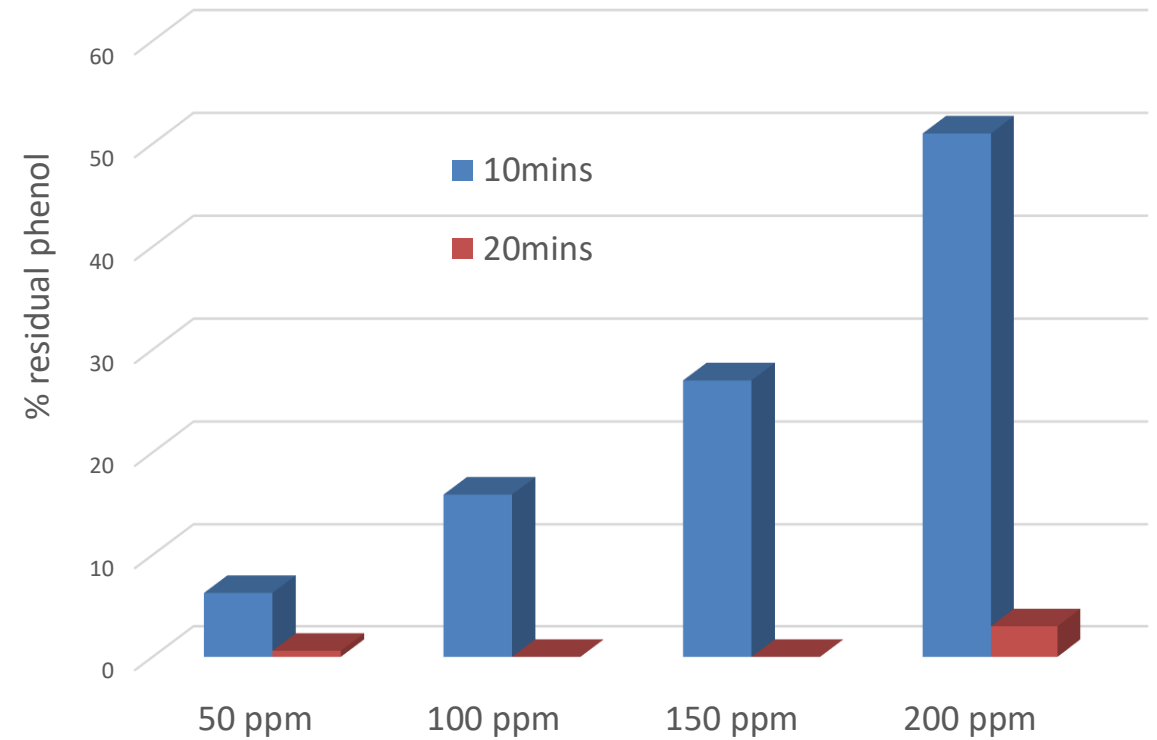


Effect Of Catalyst Dosage

- **Regardless of dose used, almost 100% removed after 20 minutes**
- **For 300mg and 200mg dosages, almost everything was removed within 10minute**
- **Considering Cost and Performance, between 50mg to 100mg is optimum**

Effects of Initial Phenol Concentration

After varying initial phenol concentration, we realized the capacity of our catalyst can go beyond 100ppm. Although additional 10 minutes may be required for the removal.



Conclusion

- In this research, we synthesized a cerium-based POFA as catalyst and optimized its conditions for treatment of phenol-polluted water.
- Addition of the catalyst to ozonation works and that optimal conditions are 100mg 1% Ce-POFA can remove 100ppm of phenol within 10 minutes
- This is exciting as the materials used to produce the catalyst is proven to be cheap and almost free, hence we have a material that is cheap, well efficient, as well as highly environmentally friendly to use as catalyst in phenol removal with ozone

The background is a deep blue, monochromatic image of water. It features a gradient from a dark, almost black blue at the bottom to a lighter, vibrant cyan at the top. The upper portion of the image is filled with intricate, shimmering patterns of light reflecting off the water's surface, creating a sense of depth and movement. The overall texture is soft and fluid, typical of an underwater scene.

THANK YOU
