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Extracting Rare Earth Elements From Catalytic Converters

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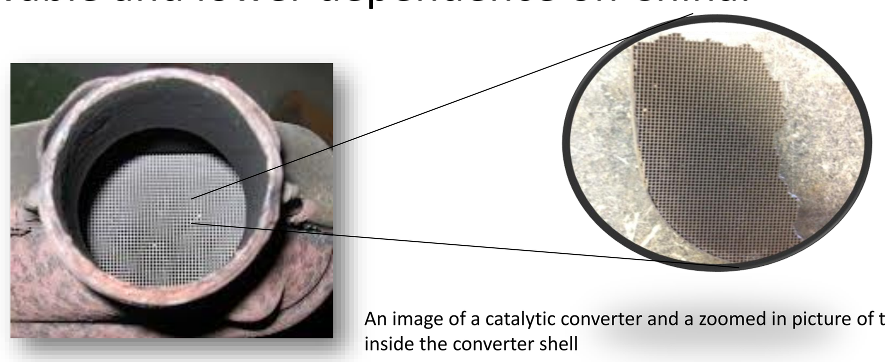
Introduction

The objective of this SURF project was to design a method to extract rare earth elements from the monolith of a catalytic converter. The monolith is coated with different metals to clean emissions. Rare earth metals like Cerium, Yttrium and Lanthanum are all part of the monolith, Cerium having the highest concentration. Catalytic converters are recycled for the Platinum Group Elements (Platinum, Palladium and Rhodium) because of their price. Rare Earths are not currently recycled but they are not renewable and China is responsible for mining 95% of them. Finding a way to extract them from converters would increase supply, make the technology more renewable and lower dependence on China.

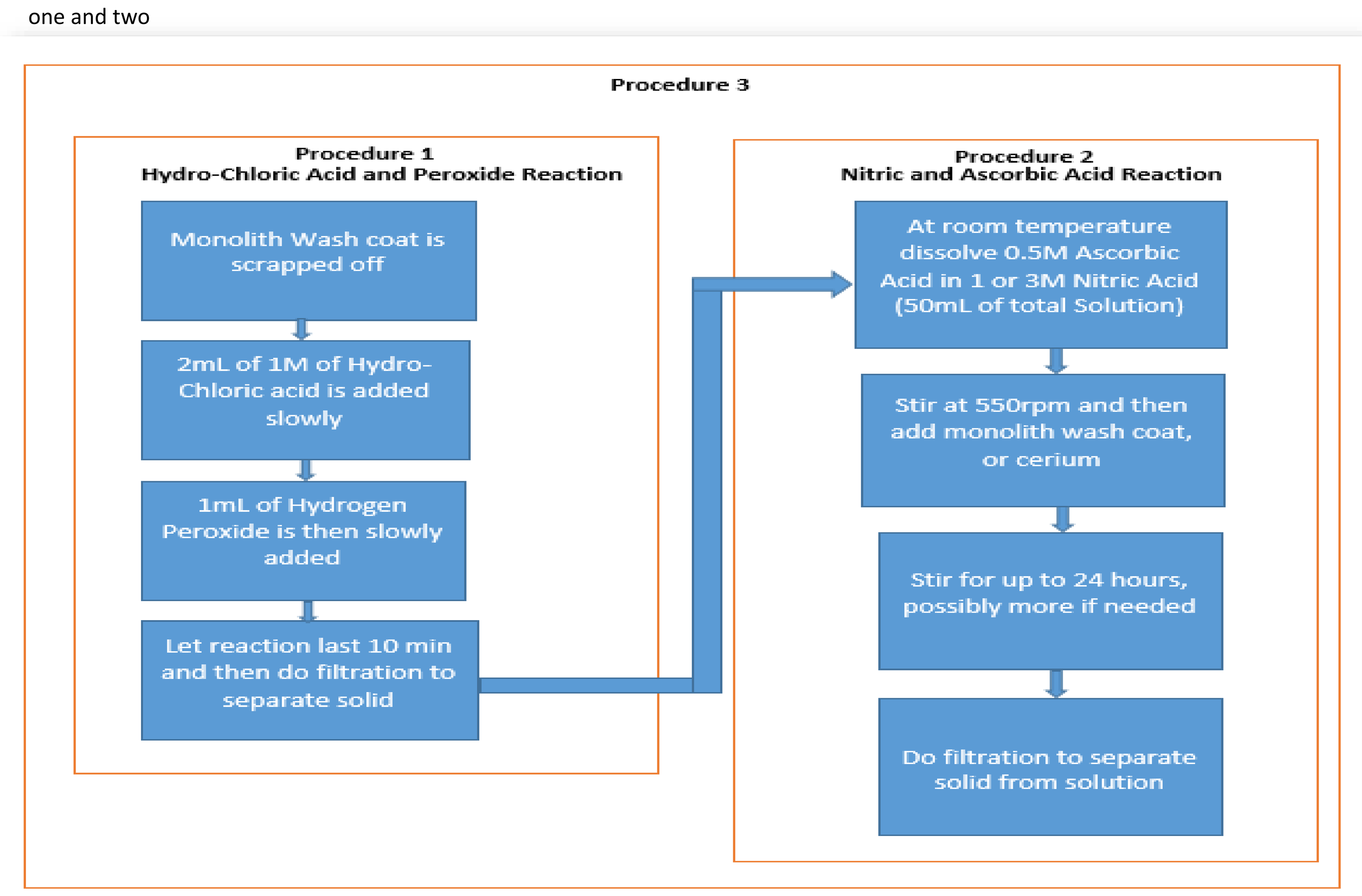


An image of a catalytic converter and a zoomed in picture of the monolith, located inside the converter shell

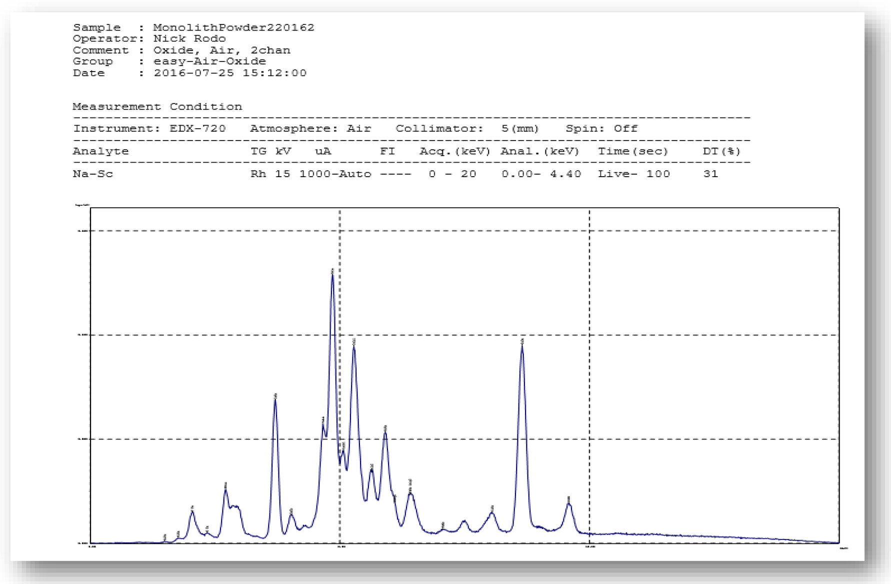
Materials and Methods

In procedure one, the wash coat was scraped from the monolith. It was placed in a 100 mL beaker and then 1M, 1mL Hydro-Chloric Acid was added. Then one molar of Hydrochloric acid was added slowly to the beaker. Procedure two requires 1 or 3 molar Nitric Acid and 0.5 molar Ascorbic acid. The Nitric acid was not one molar so it needed to be diluted and then added to the 50 mL flask. To get 1M Nitric Acid, 3.14 mL solution was added. Then 4.4g (0.5M) ascorbic acid was added slowly to control the reaction. They were stirred together to dissolve the ascorbic acid. Then the solid material was added to the solution and it was stirred at 550rpm for 20-24hours.

The following is the three procedures that were used. Procedure 3 is a combination of one and two



Materials Characterization



The graph on the left represents all the elements that the XRF (right) found in the sample being tested. The higher the peak, the more energy needed to remove an electron.

The following diagrams represent the results from the X-Ray Florence for a catalytic converter. On the right, each peak represents a different element. In this graph, Cerium is the two highest peaks because the energy required to remove an electron is so substantial. The device on the left is the XRF machine used to find the elements weight percent.

Results

The table above represent the weight compositions of each metal inside the monolith. This is before the converter was scrapped, meaning all elements above are part of a converter. Notice Cerium is 5.1 wt%.

Catalytic Converter Initial Data

Compound	Wt%
ZrO_2	22.82
Al_2O_3	15.78
SiO_2	15.15
SrO	12.13
PdO	10.1
CeO_2	5.1
ZnO	4.52
La_2O_3	4.04
Fe_2O_3	3.08
P_2O_5	2.12
MnO	2.06
Y_2O_3	1.88
V_2O_5	1.06
CuO	0.2

The table includes the weight percent's of all the elements located in a catalytic converter monolith. The main focus is Cerium, Lanthanum, and Yttrium.

The table on the left is the wt% of each element in solution after procedure 1. The table on the right represents the elements in the powder after procedure 3 was conducted. Notice the increase in all three rare earth elements/

Solution After Filtration and HCl and Peroxide addition Table 3

Compound	Wt%
SiO_2	77.09
CaO	9.47
SrO	5.35
CuO	4.34
ZrO_2	3.77

Final Powder (After Procedure 1 and 2)

Compound	Wt%
ZrO_2	45.62
CeO_2	19.46
P_2O_5	15.2
ZnO	4.68
La_2O_3	4.62
Y_2O_3	3.64
SrO	2.92
MnO	2.23
HfO_2	0.85
PdO	0.8

After running the powder through Procedure 3 (Hydro-Chloric Acid and Peroxide then Nitric Acid and Ascorbic Acid), the results showed that Cerium, Lanthanum and Yttrium did not dissolve.

Their weight percent's increased, Cerium 19.4%, Lanthanum 4.6% and Yttrium 3.6%, and Cerium increasing 4X the original amount. The solution contained base metals such as Silicon, Strontium and Zirconium. If all base metals were to dissolve, it would leave PGM's and rare earths making separation easier.

Conclusion

The separation of rare earth elements from catalytic converters proved to be more difficult than anticipated. The results showed that Ceria does dissolve in Nitric and Ascorbic acid however, the Cerium and other rare earths did not dissolve from the monolith. Instead, the Ascorbic Acid dissolved base metals like Strontium, Silicon, and Zirconium increasing the concentration of the Cerium. The results indicated that other metals could be separated and the rare metals would be left in solid form. If this was accomplished then the overall process would be more efficient. According to the data this is the most promising direction to move this project. Other metals are easier to dissolve and separate therefore, removing these base metals should be the main objective. Rare mineral separation from catalytic converters could be the way of the future and it would increase supply which lowers our dependence on China.

Recommendation

- Investigate other processes that could dissolve rare earth elements
- Increase time or molarity of solutions to see if higher concentrations of base metals are dissolved

References

- Beaudoux, Xavier. *Vitamin C Boosts Ceria- Based Catalysts Recycling*. April 2016.
- Stefan Steinlechner, Jurgen Antrekowitsch. *PGM Recycling From Catalysts In a Closed Hydrometallurgical Loop With An Optional Cerium Recovery*. Leoben, 2016

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