Save the Planet!
Alternative Fuel Catalysis

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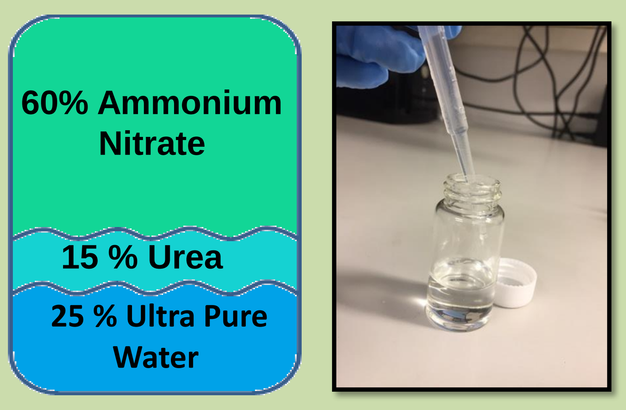
Background

Eighty-five percent of the world's energy originates from fossil fuels[1] which contribute towards global warming. However, an aqueous solution of urea and ammonium nitrate (UAN) can be used as green fuel[2]. Nevertheless, its combustion can produce harmful byproducts such as NO_x, CO and NH_3[3]. Catalytic converters are able to transform these byproducts into harmless gases. Our research goal was to characterize the activity of selected catalysts. The catalysts consisted of γ-Al_2O_3 doped with active metal. Comparison of weight hourly space velocity (WHSV) was performed, describing their catalytic activity.

Experimental

Fuel Solution



Catalyst Characterization

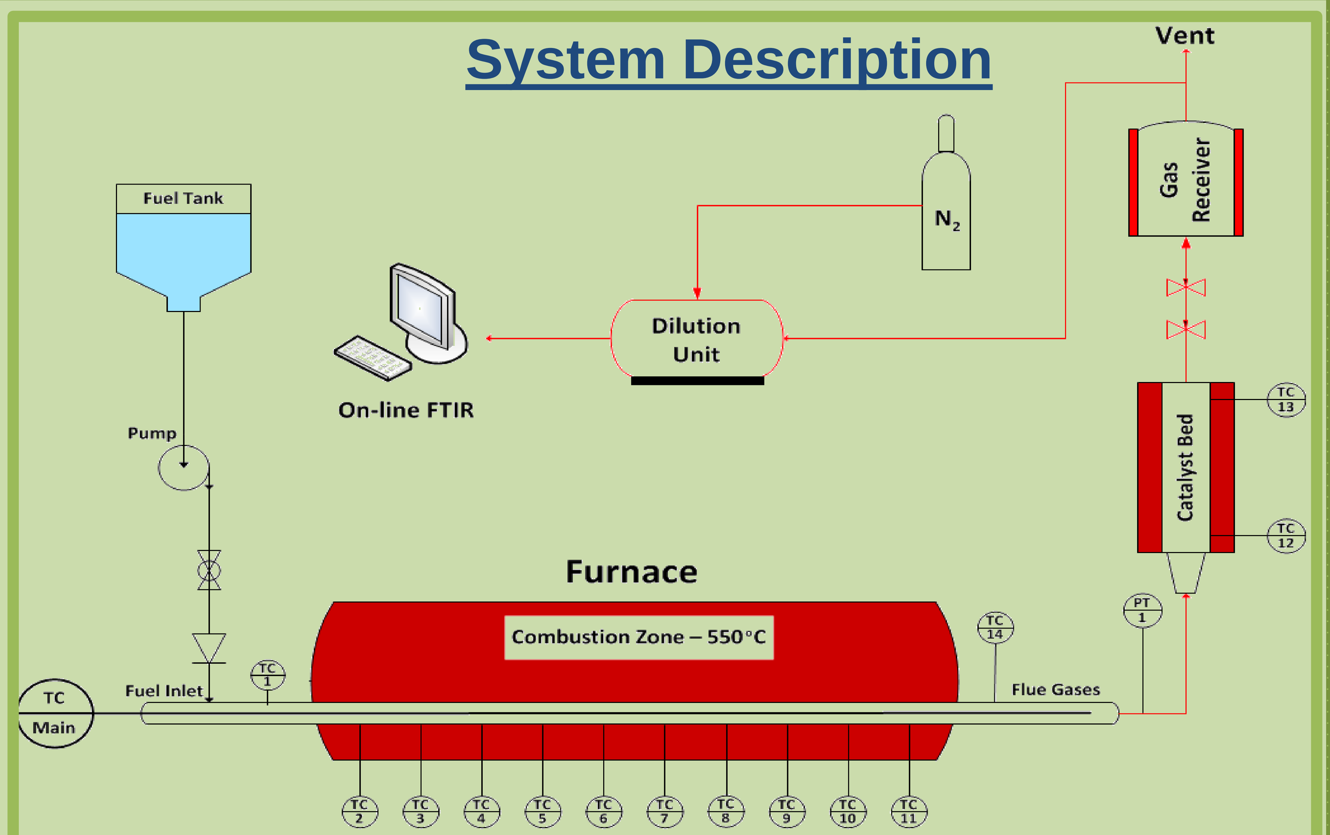
Surface morphology → High Res. Scanning Electron Microscopy → Examination of phases → X-ray diffraction (XRD)

Catalyst Preparation

Acetylacetonate metal precursor Dissolved in chloroform → Overnight vacuum drying at 40ºC →

→ Calcination at 40ºC for 2hrs under air flow → Reduction at 40ºC for 2hrs under H_2 flow →

System Description



System scheme: TC – thermocouple, PT – pressure transducer, FTIR – Fourier transform infrared spectrometer, heated parts highlighted in red

Results

Characterization Results

Metal particles in the fresh (unused) samples were identified only in the ruthenium catalyst. In the spent (used) samples, metal particles were observed in both catalysts, although fewer particles in the rhodium (Fig. 1).

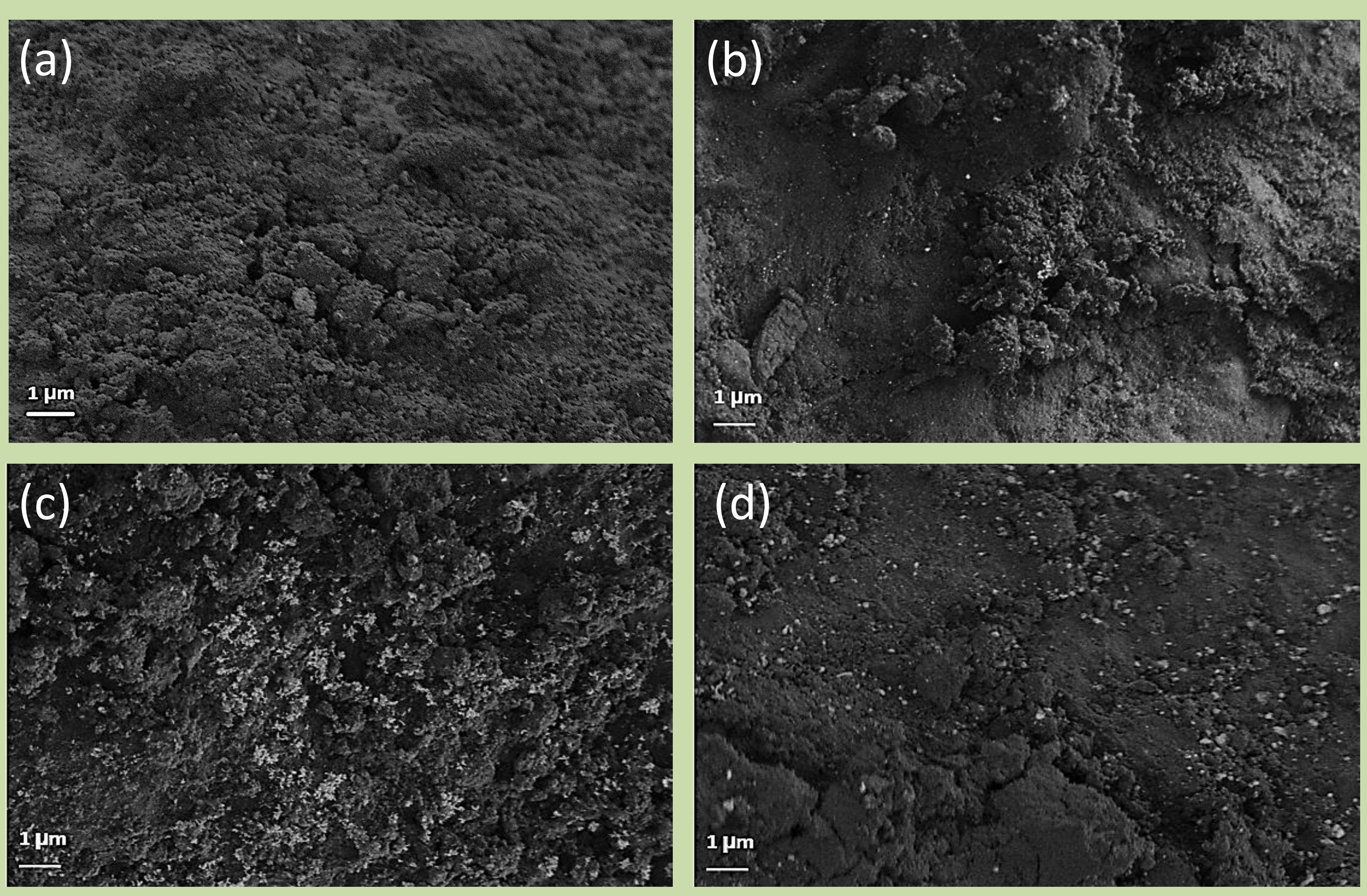


Figure 1 – High Resolution Scanning Electron Microscope (HR-SEM) images of: (a) fresh rhodium, (b) spent rhodium, (c) fresh ruthenium and (d) spent ruthenium

No rhodium phase was detected in the spent sample. However, ruthenium phase was identified (Fig. 2). This implies the same observations from the HR-SEM images.

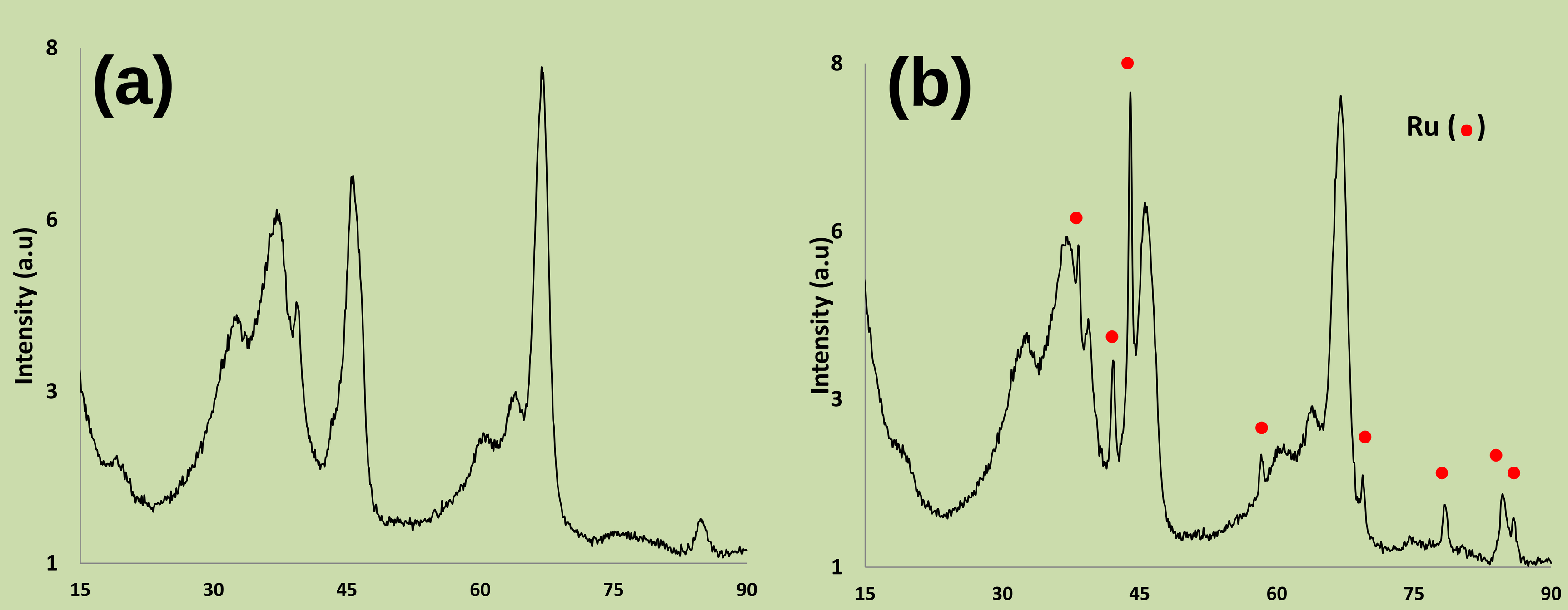


Figure 2 – X-ray Diffraction Patterns of: (a) spent rhodium and (b) spent ruthenium catalysts

WHSV Results

$$WHSV = \frac{Total\ reactant\ mass\ flow\ rate\ (\frac{mg}{hr})}{Catalyst\ weight\ (gr)} \quad (eq.1)$$

Rh WHSV = $\frac{89832.5}{4.5900}$ = **19571.4** $\frac{mg}{hr * gr_{cat}}$

Ru WHSV = $\frac{95051.7}{6.1096}$ = **15557.8** $\frac{mg}{hr * gr_{cat}}$

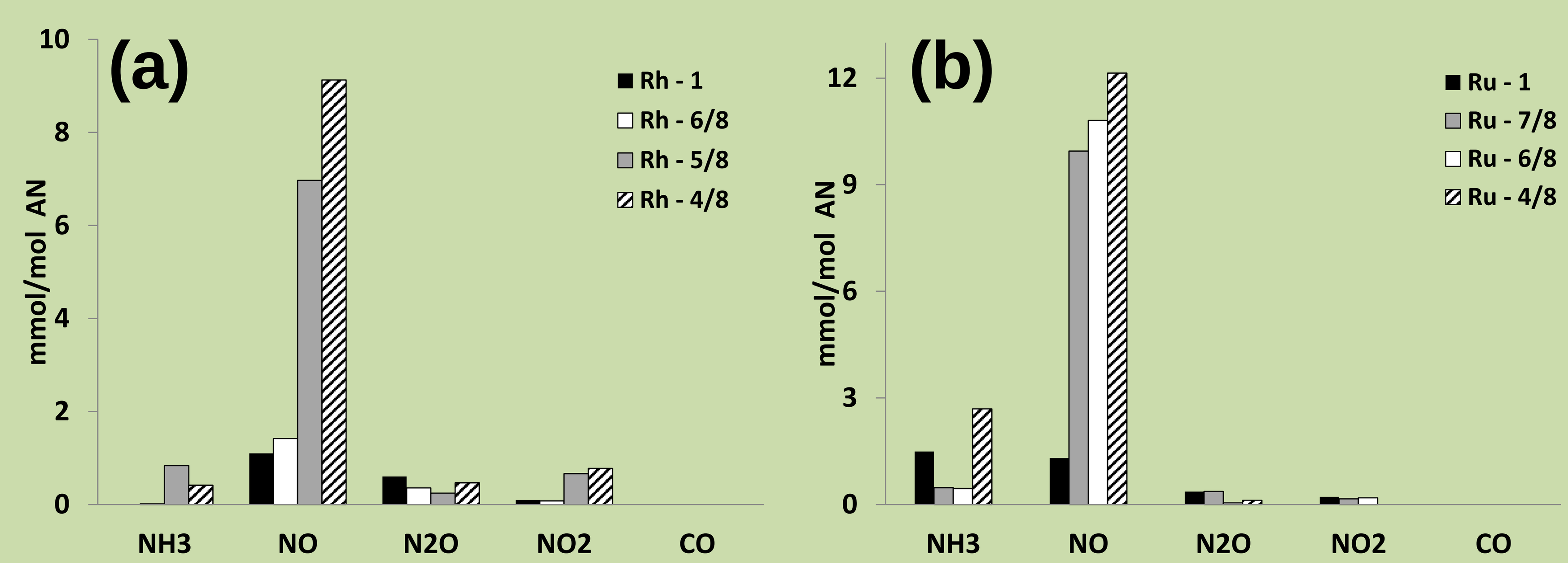


Figure 3 - Effluent pollutants concentration for different catalyst weight: (a) rhodium catalyst, (b) ruthenium catalyst

Catalyst Surface Area

Catalyst / Status	Fresh	Spent
Rhodium $[\frac{m^2}{gr}]$	212.3	138.8
Ruthenium $[\frac{m^2}{gr}]$	190.8	140.5

Table 1 – B.E.T. Surface area of different catalysts

Conclusions

- The results determined that rhodium performed as the optimal catalyst as it demonstrated the highest WHSV.
- In the tested conditions, rhodium exhibited better conversion of ammonia than ruthenium.
- Rhodium based catalyst displayed smaller noble metal grain sizes compared to ruthenium based catalyst.

Acknowledgments

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[1] – World Energy Council, Resources Summary Report, 2016 (ISBN: 978-0-946121-62-5)
[2] - Elishav, O., Tvil, G., Mosevitzky, B., Lewin, D., Shter, G.E. and Grader, G.S., 2017. The Nitrogen Economy: The Feasibility of Using Nitrogen-Based Alternative Fuels. *Energy Procedia*, *135*, pp.3-13.
[3] - Dana, A.G., Shter, G.E. and Grader, G.S., 2014. Thermal analysis of aqueous urea ammonium nitrate alternative fuel. *RSC Advances*, *4*(66), pp.34836-34848.=

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