Exploring the Chemical Composition of Day vs Nighttime Particulate Matter

Faith Myers[1,2], Emmaline Longnecker[1], Andre Schaum[1], and Paul Ziemann[1]

1. CIRES at CU Boulder 2. New Mexico Institute of Mining and Technology

Background

- Poor air quality was responsible for approximately 8 million premature deaths in 2019[1]
- Fine particulate matter (less than 2.5 microns-PM 2.5) contributes to poor air quality-which in cities can lead to the formation of smog
- PM 2.5 particles are created through atmospheric chemical reactions involving gasses
- PM 2.5 particles are small enough to travel deeper into the lungs and be absorbed into the bloodstream
- The Northern Front Range of Colorado has over 30 days a year where the air quality index (AQI) is over 100- which is unhealthy. Nitrates and nitrated products can significantly contribute to the level and type of pollution in populated areas[2]

Introduction

- This study examined the impacts of air pollution from urban to rural environments in the Colorado Front Range
- We studied the chemical composition of PM 2.5 and used the chemical composition to explore the impacts of air pollution
- Nitrates are typically dominant at night; however, in urban areas, human emissions can cause nitrates to be present in the daytime
- We expected nitrates to be highest in Denver, lower in Boulder and lowest at the Mountain Research Station (MRS)

Particulate Matter Formation

PM 10

PM 10 is formed when larger particles are suspended in the atmosphere

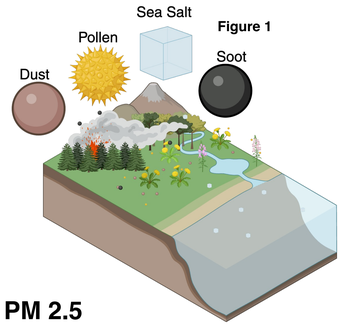
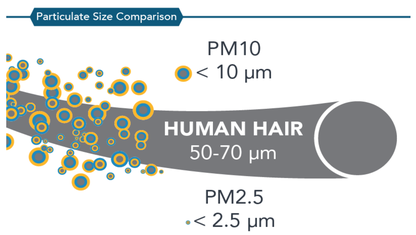


Figure 1



Size Comparison[3]

PM 2.5

PM 2.5 is formed when gases react with each other. With each reaction a gas gains more functional groups, eventually causing the gas to condense onto a particle

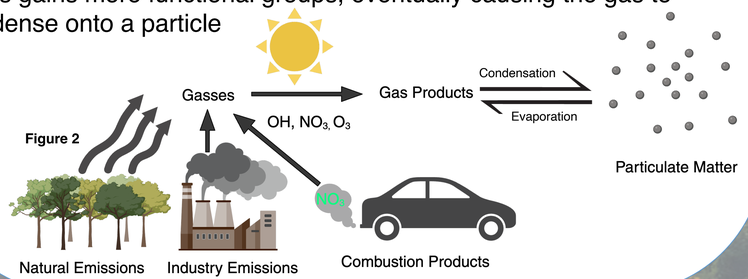
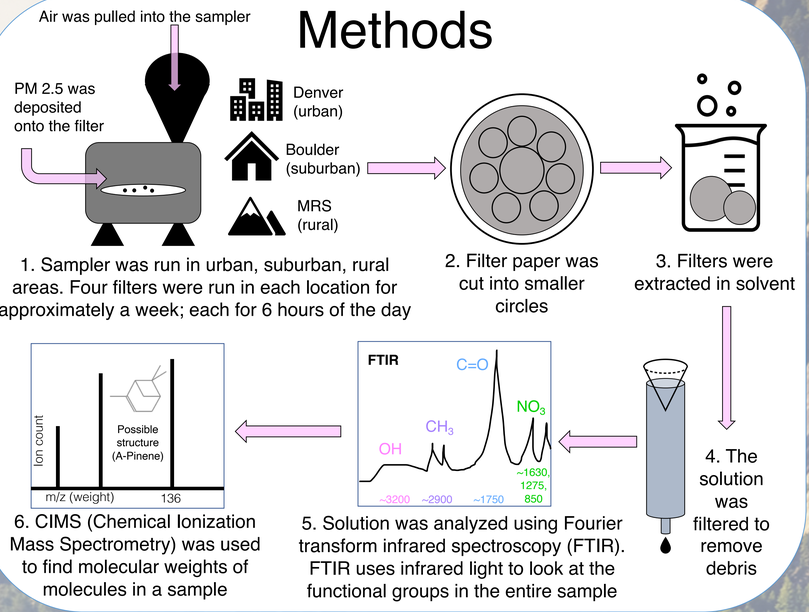


Figure 2

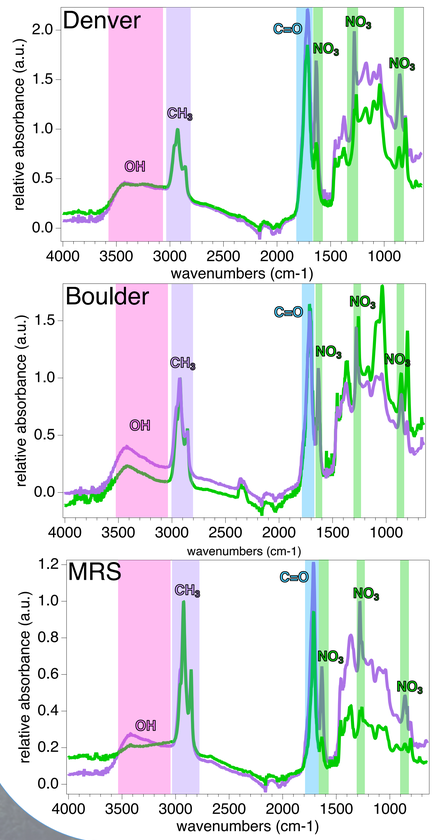
Methods



FTIR Results

Daytime/Nighttime FTIR

Day 10am-4pm **Night** 10pm-4am



Nitrate/Carbonyl Ratio

	Day	Night	Change
Denver	0.465	0.765	160%
Boulder	0.524	0.687	130%
MRS	0.274	0.537	200%

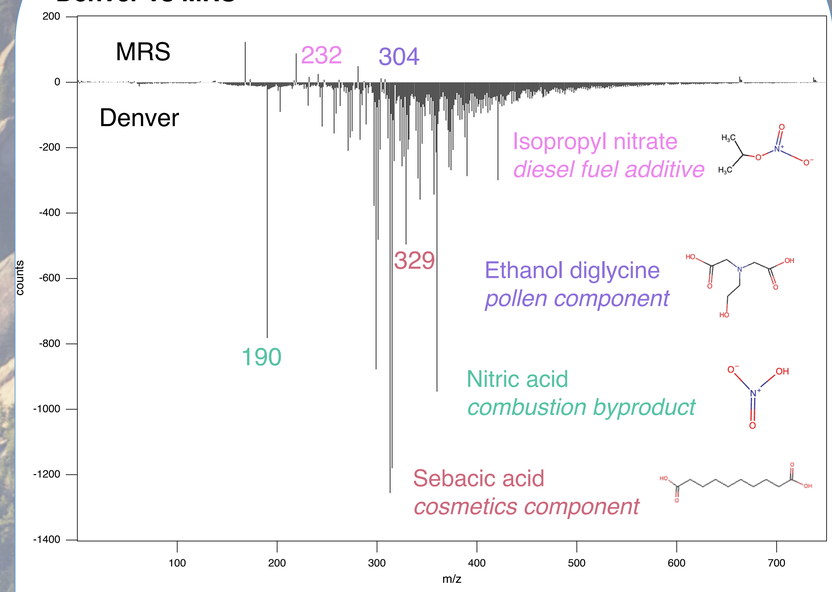
- A nitrate (NO_3)/carbonyl (C=O) ratio helps determine relative abundance of nitrates. A higher number means more nitrates were present

General Findings

- Nitrates were more abundant at night
- Products were more functionalized in higher populated areas
- Higher functionality in Denver and Boulder indicates a higher concentration of reactive gasses and OH, NO_3, and O_3 relative to MRS

CIMS Results

Denver vs MRS



General Findings

- Isopropyl nitrate and ethanol diglycine were largely unique to the MRS
- Most products were less than 500 m/z which is consistent with semi-volatile molecules typically found in PM

Conclusion

- Chemical functionality increased as the population increased
- More nitrated products were found in nighttime samples
- CIMS data indicates that the MRS had unique products that were not present in Denver
- Future work could potentially focus on differences in PM composition seasonally; and including quantitative analysis of functional groups to gain a better understanding of pollution composition
- Future work could also look into the impacts of wildfires on particulate matter formation; particularly in urban areas

References

1. Lelieveld, J., Haines, A., Burnett, R., Tonne, C., Klingmüller, K., Münzel, T., & Pozzer, A. (2023, November). Air pollution deaths attributable to fossil fuels: Observational and Modelling Study. *BMJ (Clinical research ed.)*. U.S. National Library of Medicine. https://pubmed.ncbi.nlm.nih.gov/38030155/. Accessed 24 July 2024

2. Wertz, J. (2024, February 26). Climate change is erasing decades of air quality improvements. it's also making Colorado's Air Worse. *Colorado Public Radio*. Colorado Public Radio. https://www.cpr.org/2024/02/26/climate-change-erasing-decades-of-air-quality-improvements-making-colorado-air-worse/. Accessed 19 July 2024

3. California Air Resources Board. (n.d.). *Inhalable Particulate Matter and Health (PM2.5 and PM10) | California Air Resources Board.* https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health#:~:text=on%20particle%20size.-,PM2.,tissue%20damage%2C%20and%20lung%20inflammation. Accessed 7 July 2024

4. Figures 1 and 2 created with Biorender.com

5. Funded by NSF grant 1757930

Contact- faithmyers001@gmail.com