Impact of Green Roofs on SOA Formation and Ozone Removal on HVAC Filters

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Overview

1. Motivation
2. Key Concepts
3. Experiment
4. Results and Analysis
5. Conclusion and Recommendations

Motivation

Indoor lifestyle + indoor air chemistry

Modern urbanite spends 90% of the day indoors

Reference: Klepeis et al. NHAPS: A resource for accessing human exposure to environmental pollutants. 2001.

Indoor lifestyle + indoor air chemistry

Modern urbanite spends 90% of the day indoors

VOCs
SOAs
Ozone

Indoor lifestyle + indoor air chemistry

Modern urbanite spends 90% of the day indoors

SOAs
Ozone

Key concepts

Ozone

- Common pollutant in urban environment
- Potentially harmful to human health
- Strong oxidant--interacts with VOCs → SOAs + *X*

Source: EPA, Google images

Secondary Organic Aerosols (SOA)

- Formed through successive oxidation reactions with parent organic molecule.
- Fine solid phase compounds suspended in air
- Nano-particles suspended in air are able to penetrate deeper into lungs and thus are of particular concern

Source: Google images

Experiment

Green roofs vs white roofs, HVAC filters, ozonolysis

$+ O_3 = ?$

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Source: Google images

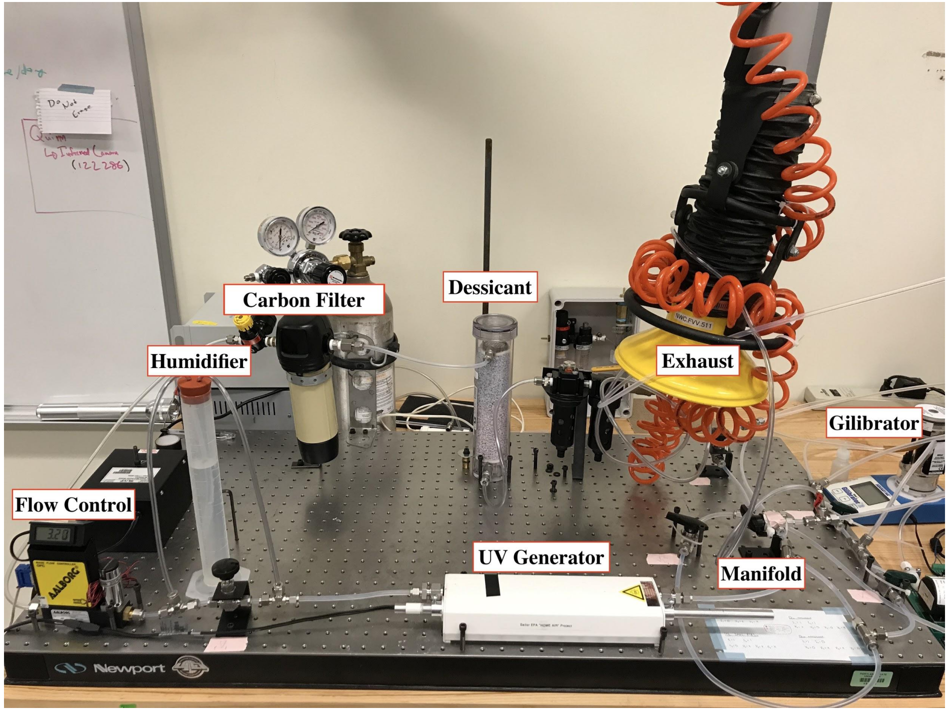


Figure 1: Zero air is controlled by MFC and then can be optionally humidified or photolyzed. Variable flow path at manifold. Gilibrator measures inlet and outlet flow rates.

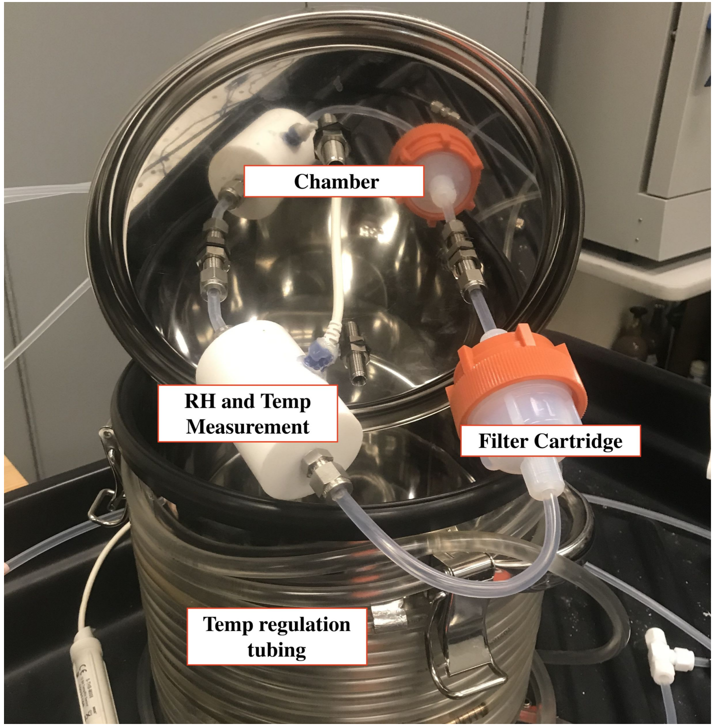
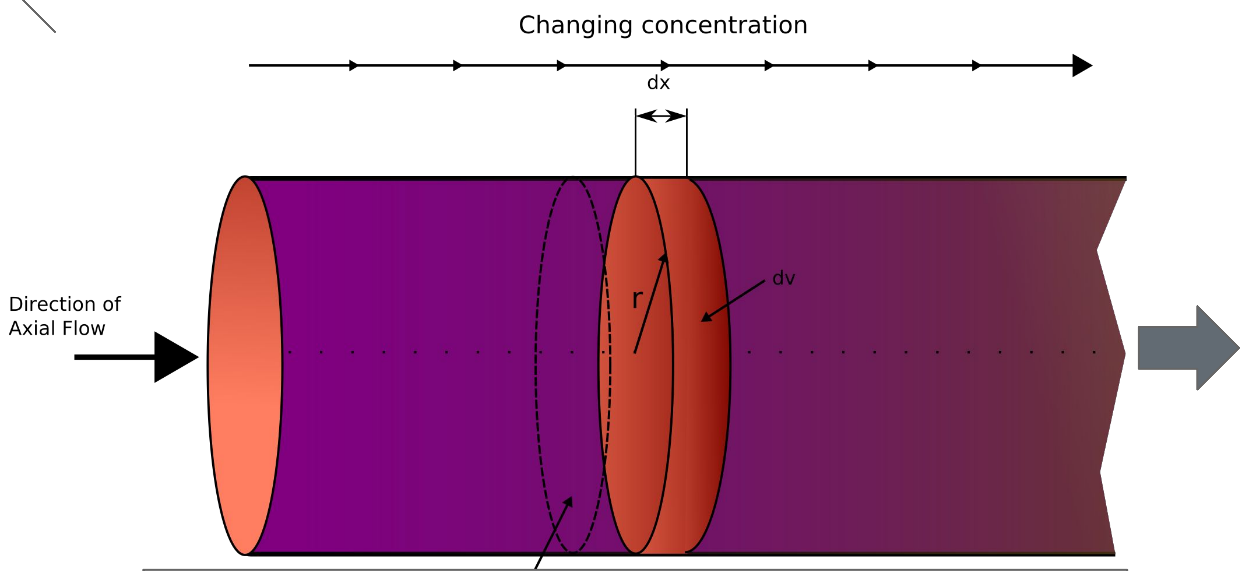


Figure 2: Chamber contains filter, maintains temp, and prevents contamination.

Components of Apparatus--Detectors not pictured.

Results and Analysis

Analytical Model (Heuristic)



$$C(t) = \frac{\alpha}{\lambda}\left(1 - e^{-\lambda t}\right)$$

Figure 3: Heuristic plug-flow reactor model used to fit ozone data.

Source: Wikipedia

Ozone Removal Data

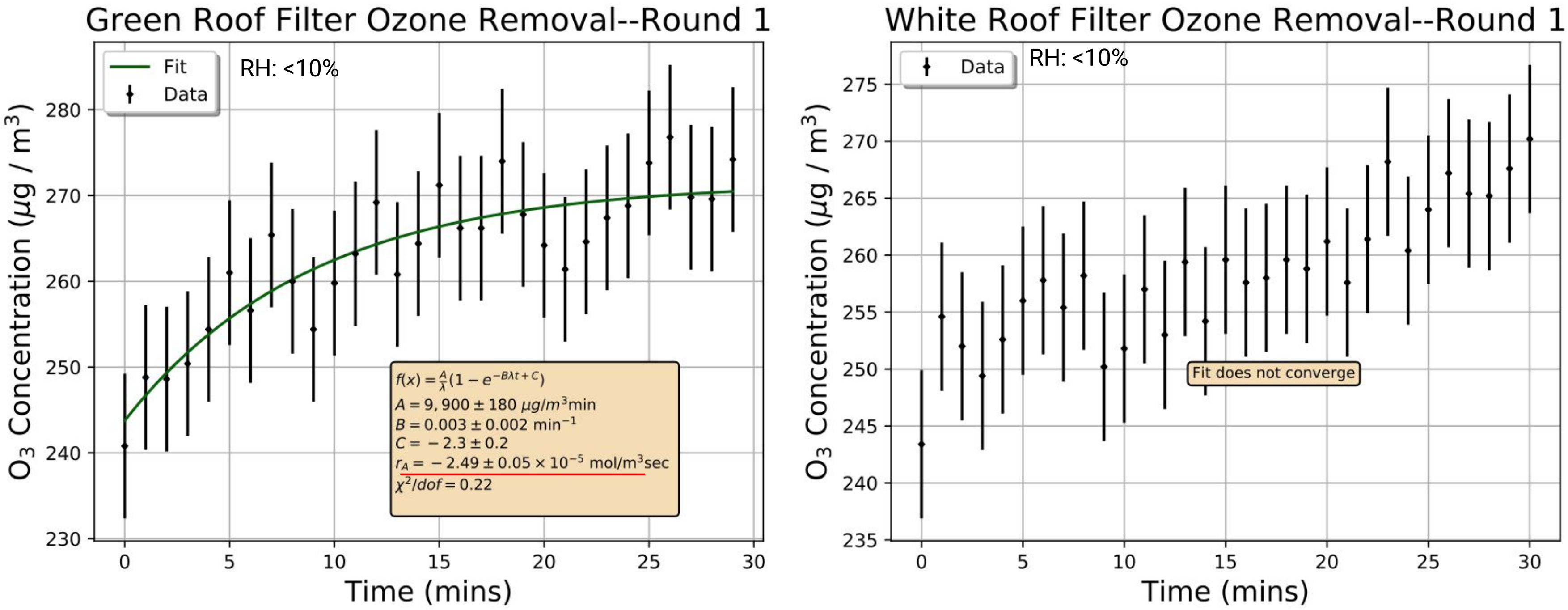
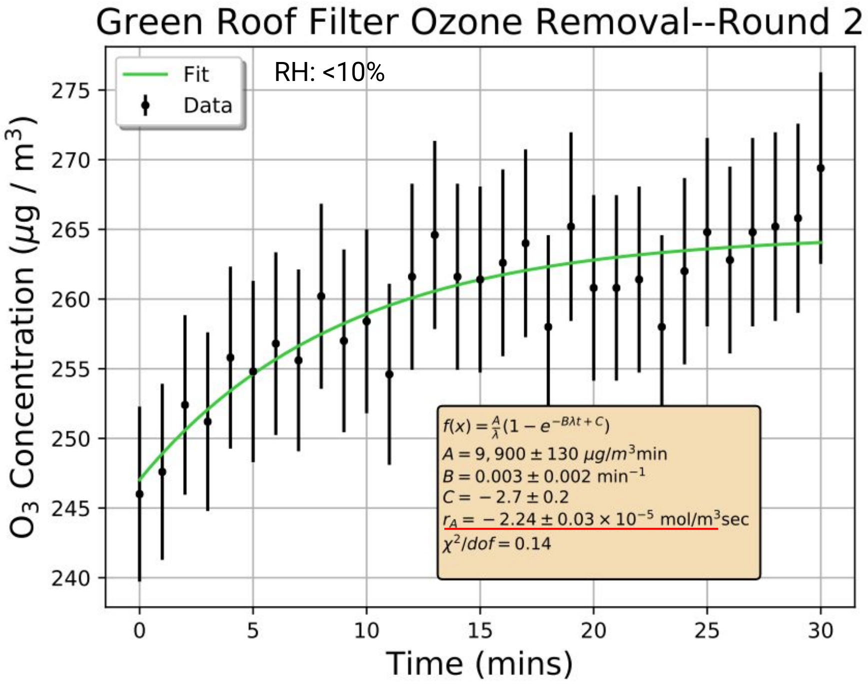


Figure 4: Ozone concentration at the outlet of the filter as a function of time for green roof and white roof samples--first round of data collection

Ozone Removal Data



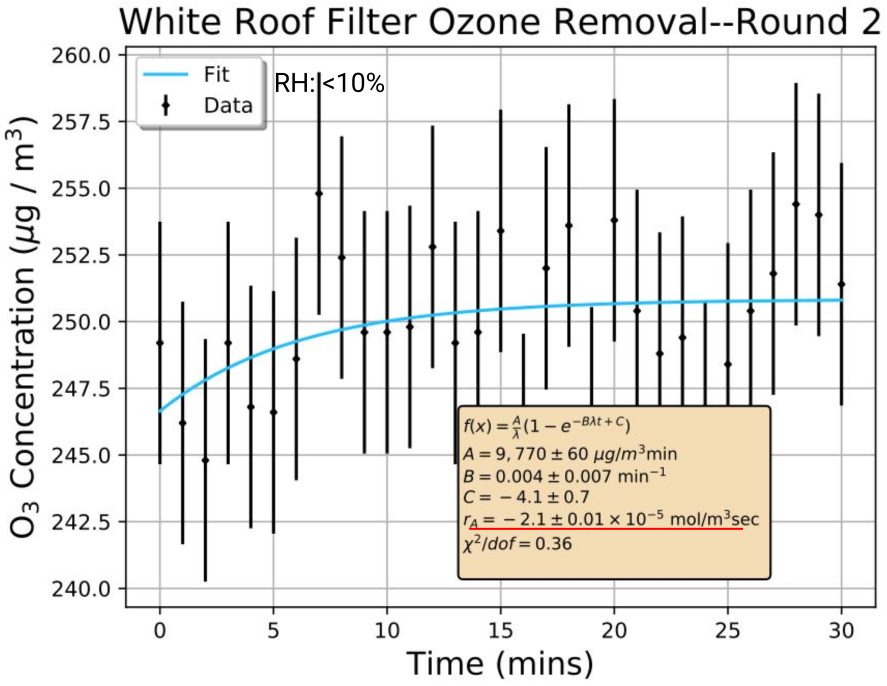


Figure 5: Ozone concentration at the outlet of the filter as a function of time for green roof and white roof samples--second round of data collection

Ozone Removal Data

<u>Interpreting the data:</u>

- Our green roof sample exhibited a higher ozone removal efficiency and higher reaction rates. Implies greater by-product formation.
- Our white roof sample did not exhibit the expected trend in ozone removal.
- Conflicts with literature. Working hypothesis: humidity dependence.

Ultrafine Particle Emissions Data

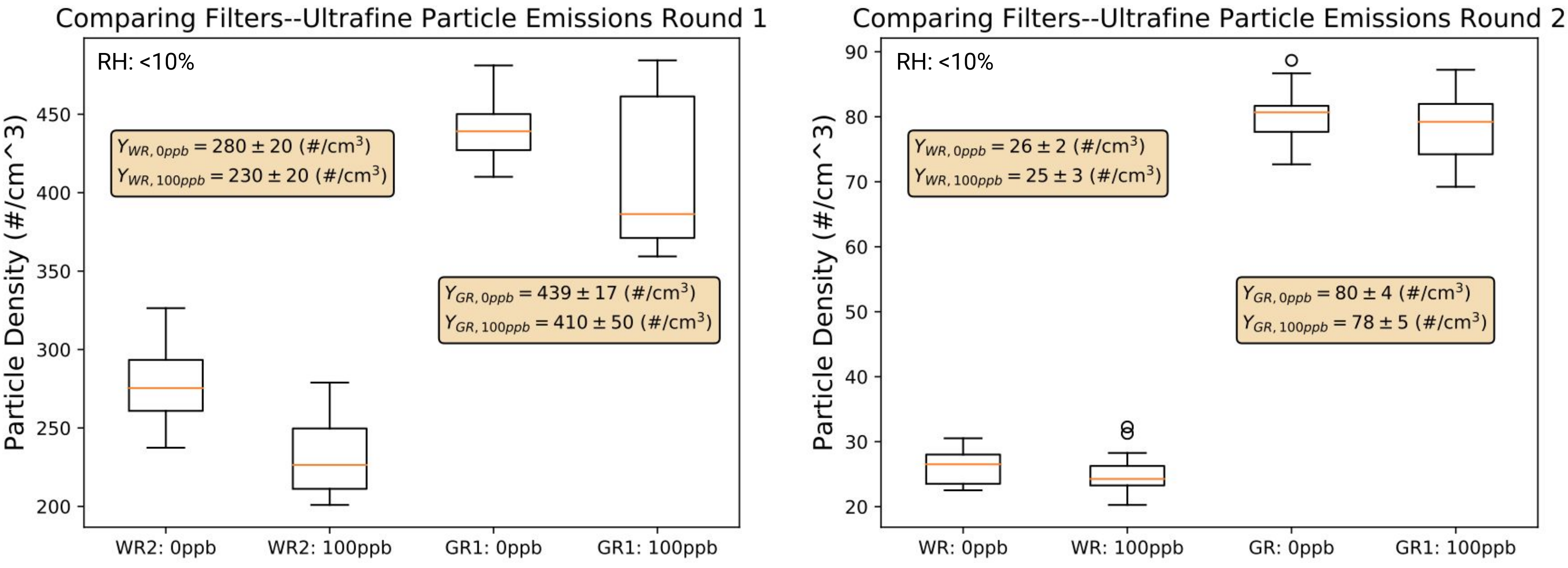


Figure 6: Boxplots comparing ultrafine particle emissions for white and green roof filter samples across two rounds of data collection

Ultrafine Particle Emissions Data

<u>Interpreting the data:</u>

- Our green roof sample exhibited higher rates of ultrafine particle emission, but not due to ozonolysis. Implies mechanism other than ozonolysis
- Average emission rates for white roof samples agreed within error. Again suggesting no influence of ozonolysis

Summary of Conclusions

- The green roof sample exhibited higher ozone removal efficiency and reaction rates. Quality of fit and data necessitate further experimentation and repeat trials.
- The green roof sample emitted higher rates of ultrafine particles, but not necessarily due to oxidation by ozone (as literature would have suggested). Humidity could be key here.

Recommendations For future work

- Repeat experiments on replicate field samples
- Include prepared sample trials in addition to field samples
- Increase duration of data collection for all trials
- Introduce variable humidity to experimental matrix
- Refine analytical model for ozone analysis to better reflect apparatus and reduce fit parameters.

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