Particulate Reactive Oxygen Species: Prevalence and Health Effects

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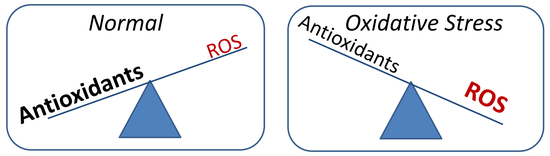
IGERT Indoor Environmental Science and Engineering

Motivation

Reactive oxygen species (ROS) are an important class of secondary air pollutants. ROS are generated from photochemical reactions in air containing VOCs and NO_x. In indoor environments, reactions between ozone (O_3) and unsaturated organic compounds (emitted from building materials, cleaning and personal products) may be an important additional source of ROS. ROS on particles especially can reach deep into the lungs.

High levels of ROS in the body can induce cell injury and cause a variety of deleterious health effects.



On average, we spend nearly 21 hours inside buildings every day, 16 of which are spent at home. Yet, ROS on indoor particles have not been well-characterized.

- **Is there a lot of ROS inside buildings?**
- **What are the health effects of ROS?**

Method

Sample $PM_{2.5}$ for 3 hrs with personal environmental monitors (PEM). Place 2 inside and 2 outside each sampled building. Measure air quality parameters simultaneously.

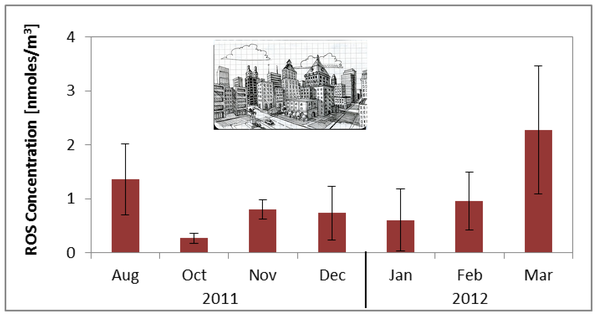
Remove filter from PEM and sonicate in buffer for 10 mins.

Add (i) 2',7'-Dichlorofluorescin (DCFH) that has undergone deacetylation by base-catalysis, and (ii) Horseradish Peroxidase .

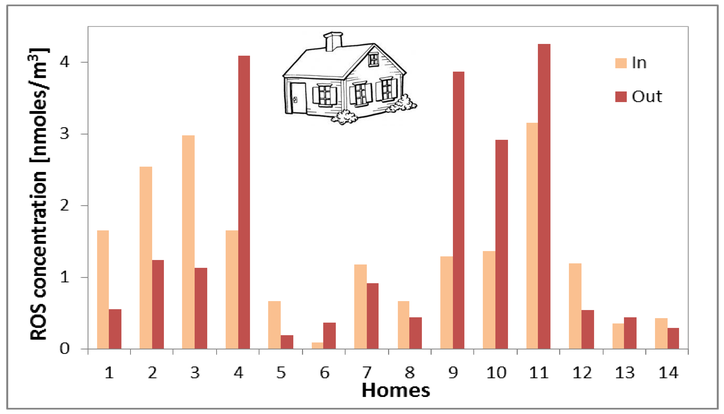
Incubate at 37°C for 15 mins.

Read fluorescence emission at 530 nm with excitation at 485 nm.

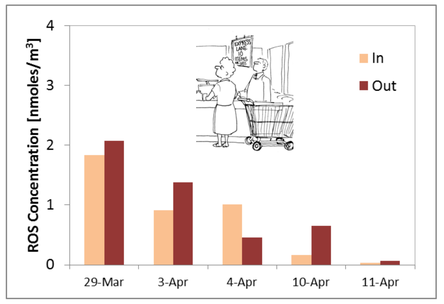
Indoor and Outdoor levels of ROS



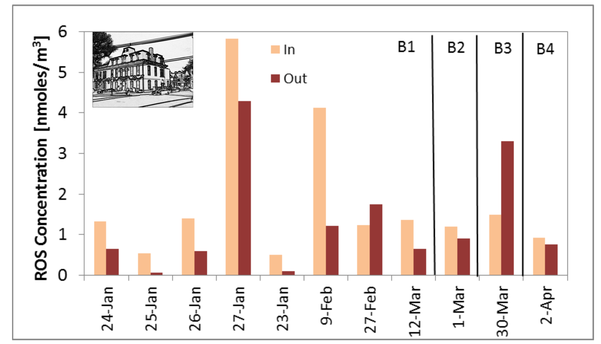
- **Urban outdoor** ROS were measured at a fixed location in Austin on 5 days in each month.
- Outdoor ROS were higher in warmer months and lower in colder months.



- ROS were measured at 14 **homes** during Jan-Apr 2012.
- Avg. indoor:outdoor ROS ratio = 1.53 (±1.04 SD).



- ROS were measured at a **retail store** on 5 separate days.
- Avg. indoor:out door ROS ratio = 0.91 (±0.78SD).



- ROS were measured at 4 **institutional buildings**, B1-4. B1 sampled on 8 days.
- Avg.indoor:outdoor ROS ratio = 2.58 (±2.29 SD).

Outdoor ROS increase with outdoor ozone, TVOC, and temperature.

Outdoor ROS decreases with increasing distance from a busy motorway.

Indoor ROS increase with indoor $PM_{2.5}$, TVOC, and temperature, as well as outdoor ROS.

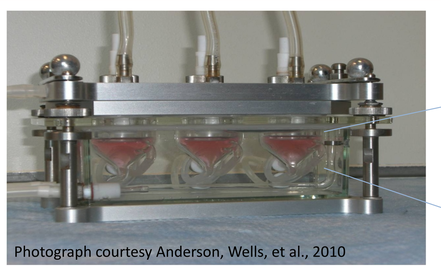
1.78x

Indoor ROS were higher than outdoor ROS in 60% of the samples taken. On average, indoor ROS concentrations were 1.78 times higher than outdoor ROS concentrations.

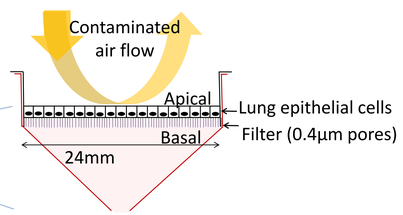
How to ↓ ROS?

- Indoor ROS concentrations are directly correlated with indoor $PM_{2.5}$ concentrations. Reducing activities which generate $PM_{2.5}$ (e.g. cooking, using scenting agents and cleaning products) can reduce indoor ROS.
- Increasing ventilation can lower indoor ROS concentrations, but not necessarily near busy roadways.

Health Effects of ROS



Photograph courtesy Anderson, Wells, et al., 2010

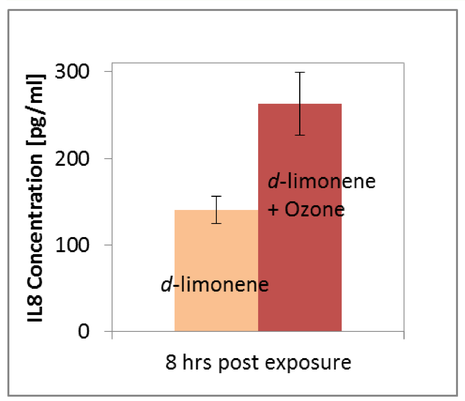


Reactions between pollutants, such as VOCs and O_3, can be an important pathway for ROS. In collaboration with researchers at NIOSH, I exposed human lung epithelial (A549) cells to a mixture of *d*-limonene & O_3 in an *in vitro* exposure module (above).

Methodology

- Lung cells grown on Transwell inserts. Basal side touches culture media which is maintained at 37°C. Pollutant flows over apical surface.
- 3 replicates for each condition.
- 4-hr exposure period.
- Culture media extracted 8 hours after exposure; ELISA used to assess inflammatory proteins (such as IL-8).

Results



↑ ROS

↑ inflammation

Exposure to a mixture of *d*-limonene and O_3 leads to a greater inflammatory response in lung cells than exposure to either *d*-limonene or O_3 alone.