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Identification of water-soluble organic gases in 13 real homes

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It is known that volatile organic compounds (VOCs) are elevated indoors compared to outdoors. We hypothesize that OVOCs are elevated indoors as well. However, indoor OVOCs are poorly characterized. OVOCs are more likely to be water-soluble (thus called water-soluble organic gases (WSOG)) and dissolve into liquid water when present. Approximately18-50% of homes in the United States are considered damp (Mendell et al. 2011). Dampness is particularly prevalent in the southeastern U.S. given the high outdoor relative humidities. In damp homes, liquid water is expected to be present on surfaces, skin, and particles. Once dissolved into liquid water, WSOG can undergo chemistry and form products that will stay condensed or volatilize back into the air. Thus, differences in chemistry between dry and damp homes is likely to lead to different OVOC exposures.

The goal of this work is to collect and identify WSOG in real homes. To do this, mist chambers were employed to collect WSOG inside and directly outside (for comparison) 13 real homes. Two chambers sampled inside and two outside for two hours twice consecutively, each with a collection volume of 25 mL of water at 25 L min^{-1}. Samples were analyzed for total organic carbon (TOC) and indoor samples were on average 15 higher indoors than out. Indoor samples were analyzed by ion chromatography for organic acids. In indoor samples, acetic acid accounted for 32 to 43% of TOC, while formic acid accounted for 8 to 14% of TOC. Aqueous hydroxyl radical oxidation of the WSOG mixtures in indoor samples was performed to examine potential reactivity once dissolved in liquid water. Reacted samples were analyzed by QTOF-ESI-MS in the positive mode to identify reactive compounds. Many samples contained over 50 reactive compounds. Some compounds were only present in one home, while others were found in many sampled homes.

Identification of water-soluble organic gases in 13 real homes in New Jersey and North Carolina

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1. Background

- Many volatile organic compounds (VOCs) have been detected and quantified indoors. However, most of these are non-polar.
- It is expected that many VOCs are oxygenated through reactions with ozone and other oxidants indoors which makes them more polar. These compounds are often water-soluble.
- Water-soluble organic gases (WSOG) can partition into liquid water indoors and react altering indoor air chemical makeup and therefore changing exposures.
- Homes that have high relative humidities, such as those in the southeast in the summer, are likely to have liquid water condensation on surfaces.

2. Project aim

Collect and identify water-soluble organic compounds in 13 real homes

Mist chamber devices used in sampling →

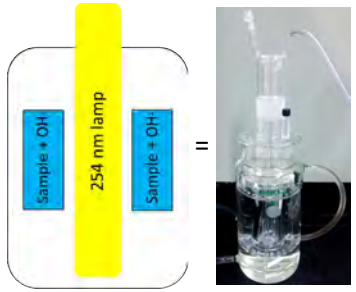
3. Sampling methods

- Sampling locations – Inside main area of homes in 13 samples collected between June and October 2015.
- Four mist chambers in parallel, two sampling inside, two sampling outside for two hours twice consecutively.
- WSOG scrubbed from air in 25 mL of water at a flow rate of 25 L min^{-1}.
- All samples composited and stored frozen until use in experiment-sized volumes.

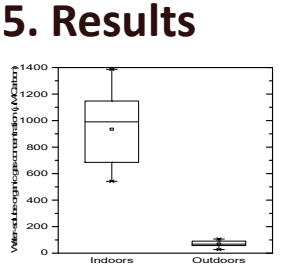
4. Experimental and analysis methods

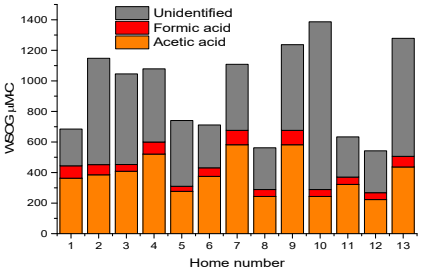
- Indoor and outdoor samples were analyzed for total organic carbon.
- Indoor samples were analyzed were analyzed for acids by ion chromatography.
- Reactive compounds were determined by reacting samples with hydroxyl radicals (OH) over 60 minutes. Samples were oxidized by OH (through photolysis of hydrogen peroxide with a UV lamp) and were analyzed by electrospray ionization mass spectrometry.
- Repeats and controls were completed to ensure reliability and accuracy of results.

Reaction vessel →



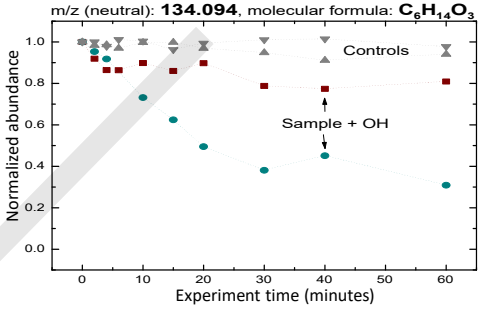
5. Results

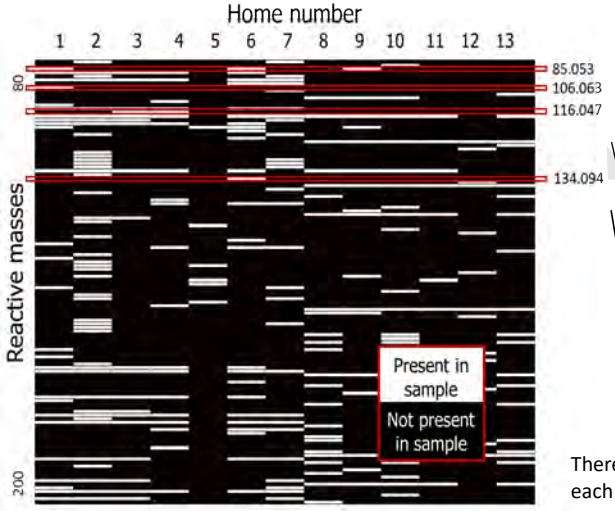




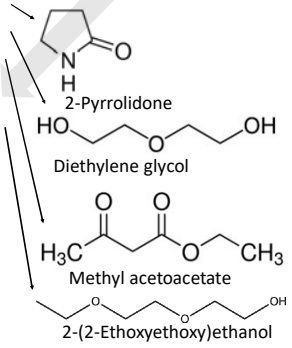
WSOG concentrations on average are 15 times higher indoors than out. A significant portion of the WSOG in each home is acetic acid while some is formic acid. The remainder are still unknown.

An example of a reactive compound. This mass decreases over time in the repeat experiments, but not the controls.





Possible structures of some reactive compounds



There are many reactive compounds in each home.

6. Conclusions

- Acetic acid and formic acid contribute significantly to WSOG.
- Many compounds in each home react with OH in water. Some are unique to each home while others are present in many homes.
- Reactive compounds include amines, alcohols, ethers, and esters.
- MS-MS will be completed to determine molecular structures of compounds.
- Any health effects from exposures are currently unknown, but identification of WSOG indoors is a crucial step in this determination.

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