A Study to Measure the Chemical Characteristics of Particle Emissions from Biomass Burning Stoves

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Direct Emissions of Particulate Matter
Goals of the Study

• **Goal 1:** Measure chemical composition and associated parameters (size distribution and mass) of the particles emitted from wood and corn combustion.

• **Goal 2:** Compare chemical composition, size distribution and mass emissions from various types of fuel combusted:
  – Hard wood: Oak, Birch
  – Soft wood: Pine
  – Corn

• **Goal 3:** Compare emissions characteristics.
It is of interest to characterize sources of particles in the atmosphere

• Aerosol particles are of critical importance in the atmosphere because of their effect on:
  – Human Health
  – Visibility
  – Climate Change

• We need to understand contributions from various emission sources, eg:
  – Anthropogenic, eg: combustion (gasoline, diesel, biomass, etc.)
  – Natural, eg: sea-spray.
Schematic of Our Measurements

Sample directly from chimney

Lopi Wood Stove
St. Croix Corn Stove

Gas emissions (CO₂, CO, O₂, NOₓ)

Particle Size Distribution (SMPS)

Particle Mass Concentration (TEOM)

Particle Chemical Composition (ATOFMS)
Sampling from the Wood Stove
The Corn Stove
Gas Measurements

- Characterize combustion conditions
- Concentrations of: CO$_2$, CO, O$_2$, NO, NO$_2$
- Two gas monitors to determine the dilution ratio
  - Monitor #1 (TSI CA-Calc) measured raw emissions
  - Monitor #2 (ECOM-AC) measured diluted emissions
Particle Mass Concentration

- TEOM: Thermal Electric Oscillating Microbalance
- PM2.5 mass emissions (mg/m³ of exhaust sampled)
- Mass emission is a useful measure when comparing emissions from different sources
Particle Mass Concentration

Oak

mass concentration (ug/m³)

Fire Lit

Door Closed

Reloaded Wood

time

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Particle Mass Concentration

Birch

Mass concentration (ug/m3)

Choked
Fire (vent)
Door Closed
Fire Lit

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Particle Size Distribution

• SMPS: Scanning Mobility Particle Sizer
• Number of particles as a function of particle size
  – 10 – 700 nanometers
    (1 nanometer = 10^{-9} meters)
  – Size distribution measured every 2.5 minutes
• Particle size determines many atmospheric and health effects
Particle Size Distribution

- Pine (avg 11:40-12:45)
- Corn (avg 11:45-12:20)
Particle Size Distribution

- Oak (14:00)
- Oak (14:45 after adding wood)
Particle Chemical Composition

- ATOFMS: Aerosol Time-of-Flight Mass Spectrometer
- Size and chemical composition of individual particles, in real time
  - Ash
  - Soot
  - Organic compounds
TSI 3800: Aerosol Time of Flight Mass Spectrometer - AKA Wallace

- Aerodynamic Lens
- Ellipsoidal Mirrors
- Sizing Lasers (532 nm)
- PMT
- Reflectron
- Microchannel Plate Ion Detectors
- Ionization/Desorption Laser (266 nm)
ATOFMS – Pine (sorted by particle size)

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ATOFMS - Corn

K₂SO₄⁺
K₂HSO₄⁺
K₂Cl₃⁺
K⁺
Results?

- A great deal of good data was acquired
- Data analysis is underway and will require integration of the results from all of the instruments used
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