# Characterization of the Physical, Chemical, and Biological Properties of PM Emissions, VOCs, and Carbonyl Groups from Commercial Cooking Operations

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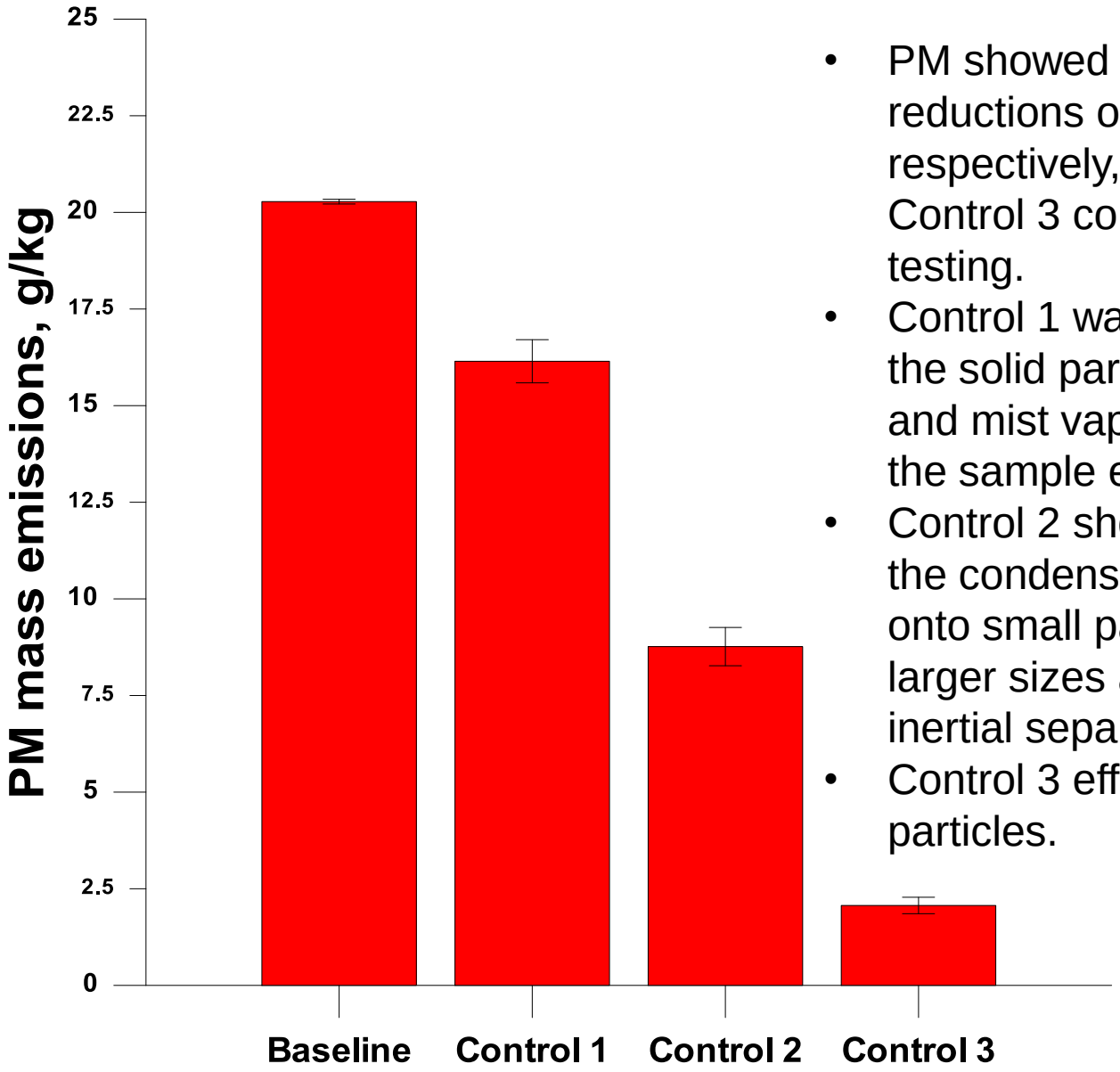
Georgios Karavalakis, Ph.D.

# Background

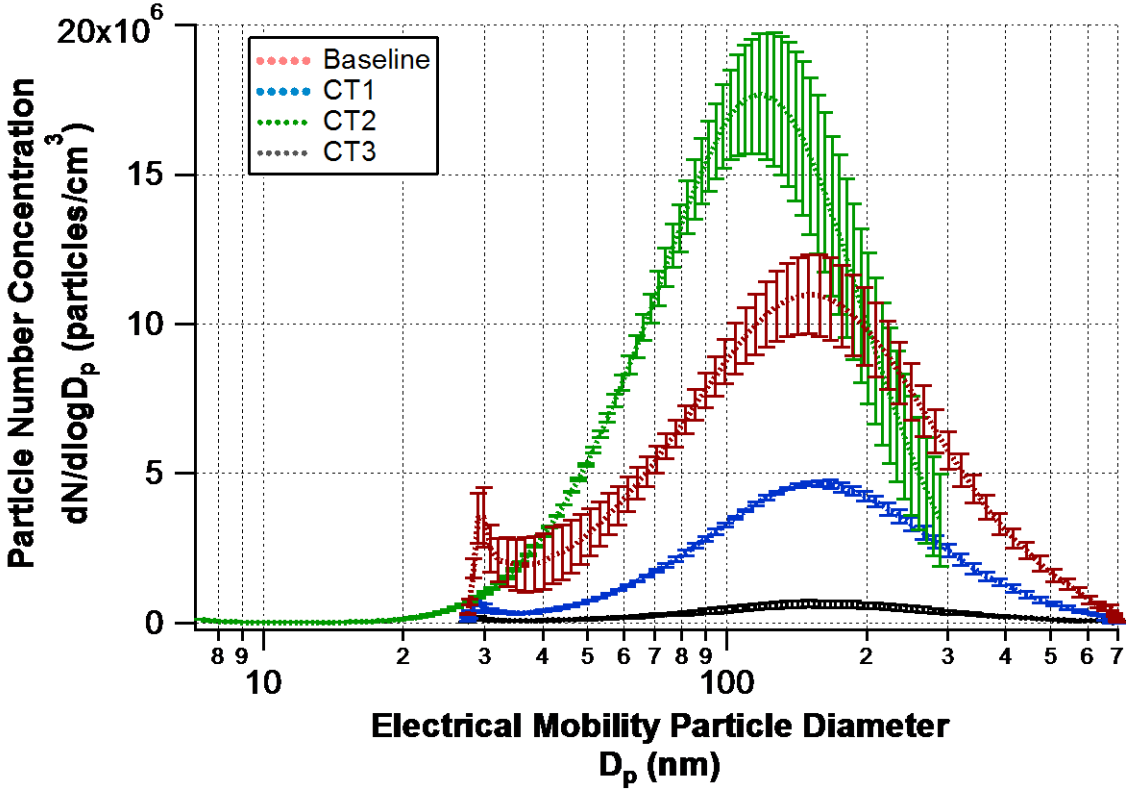
- Testing was conducted in accordance with the SCAQMD Test Protocol for Determining PM Emissions from Under-Fired Charbroilers for 3 technologies and baseline testing:
  - In-hood two stage baffle filters (Control 1)
  - Rooftop exhaust conditioning and inertial separation (Control 2)
  - Electrostatic precipitator/activated carbon cells (Control 3)
- Emissions measurements included:
  - Gaseous toxics (carbonyl compounds, 1,3-butadiene, and BTEX)
  - PM mass, particle number, and particle size distributions
  - Polycyclic aromatic hydrocarbons (PAHs), nitrated-PAHs, metals, inorganic ions, organic acids and other polar compounds, EC/OC fractions, and heterocyclic aromatic amines
- Health assays included:
  - Oxidative and electrophilic properties of PM
  - Inflammatory responses of PM emissions

# PM mass Emissions




- PM showed statistically significant reductions of 20%, 57%, and 90%, respectively, for Control 1, Control 2, and Control 3 compared to the baseline testing.
- Control 1 was more effective in removing the solid particles, but not the gaseous oil and mist vapors, which were abundant in the sample effluent.
- Control 2 showed high efficiency due to the condensation of the hot grease vapor onto small particles, which then grew to larger sizes and subsequently removed by inertial separation.
- Control 3 effectively removes the smaller particles.

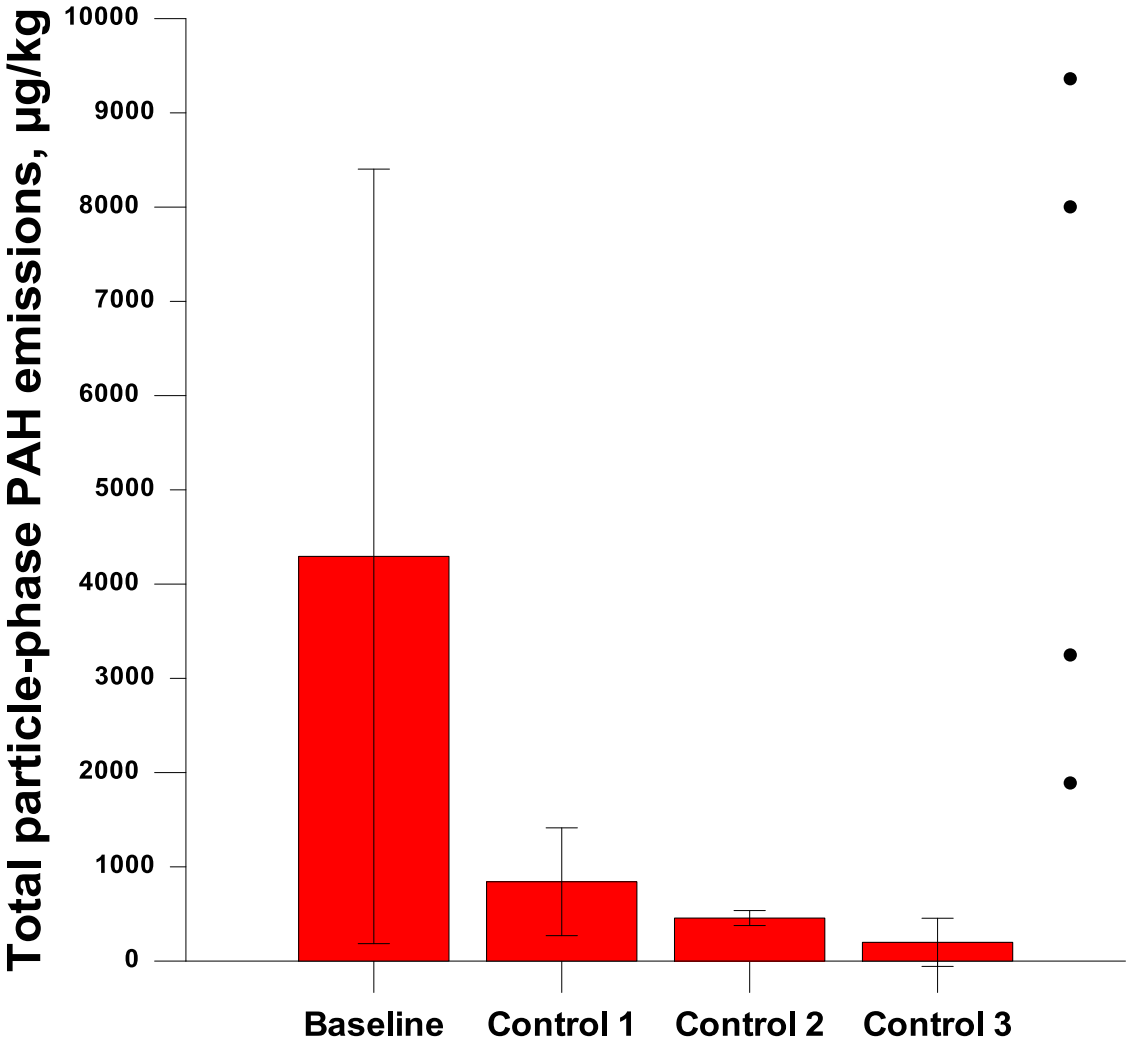
# Particle Size Distributions




Particle size distribution profiles from all experiments were largely unimodal in nature

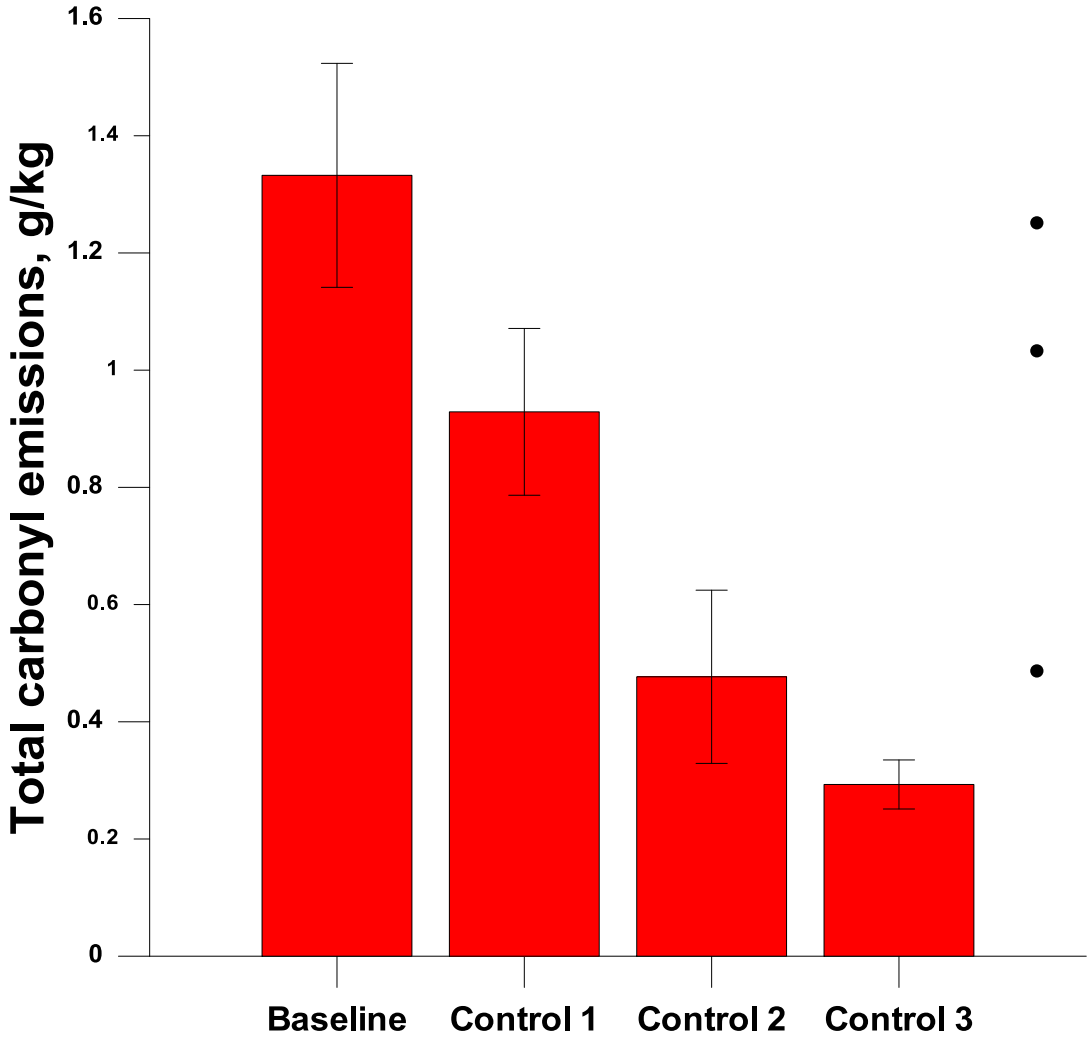
- The peak diameters for baseline, Control 1, and Control 3 were at 150 nm compared to Control 2 at 118 nm.
- Control 2 was more efficient at removing the larger particles.
- Control 3 showed the lowest particle concentrations when compared to the other technologies and the baseline experiment

# Total Particle-Phase PAH Emissions



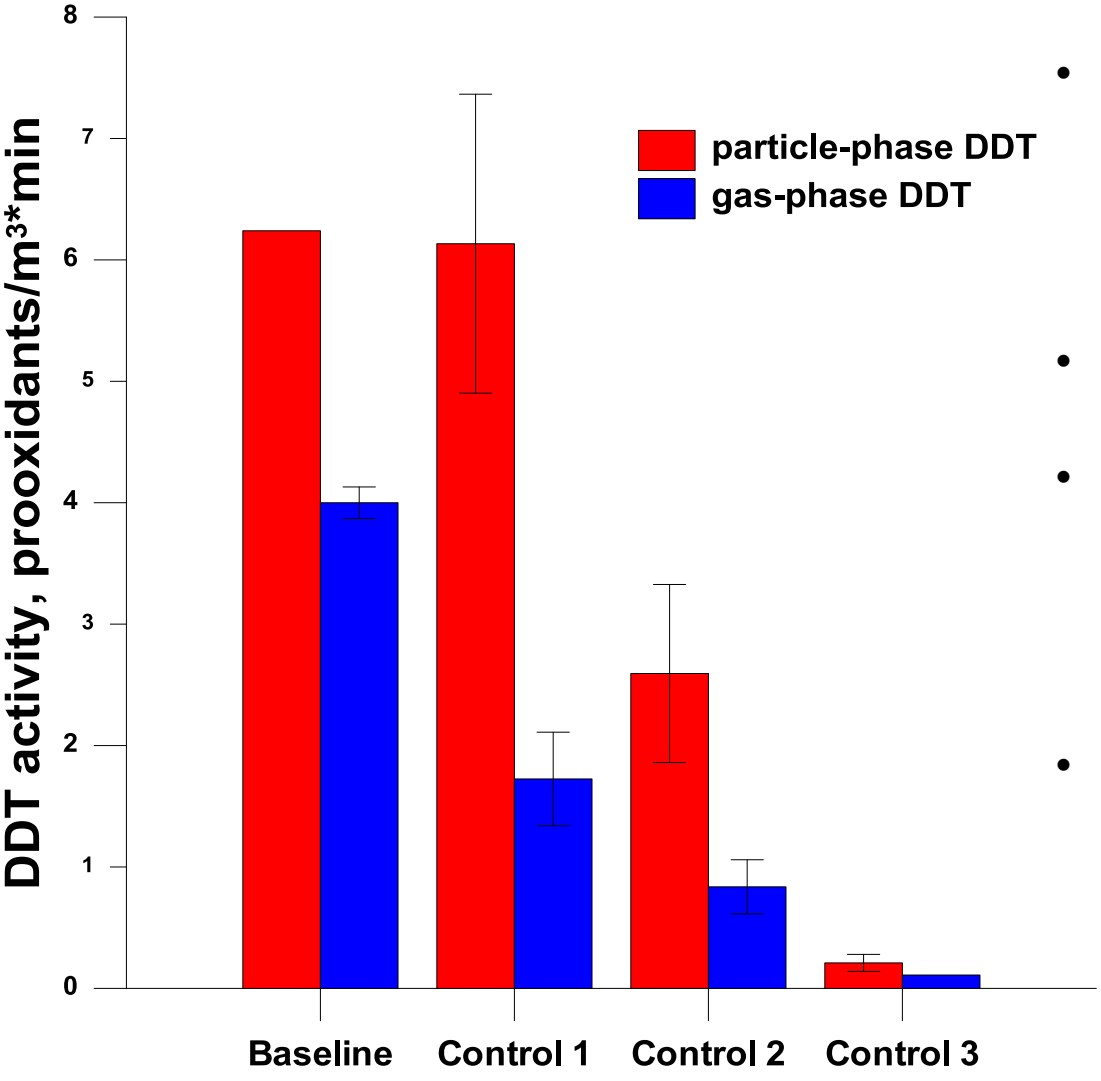

- PAHs are not present in the chemical structure of beef.
- PAHs were formed due to the direct access of lipids and fats onto the natural gas open hot flame, which were pyrolyzed and subsequently volatilized and partly re-deposited on the meat surface.
- Large reductions in PAHs with control technologies.
- Heavier PAH compounds (more carcinogenic) showed reductions with control technologies.

# Total Carbonyl Emissions




- Charbroiling is an important source for carbonyl emissions.
- Formaldehyde and acetaldehyde, the dominant aldehydes for this study, are products of lipid oxidation and also classified as carcinogens.
- Important reductions in carbonyl emissions with the use of control technologies.

# PM Oxidative Activity




- This assay measures the prooxidant content of the sample based on its ability to transfer electrons from dithiothreitol (DTT) to oxygen.
- Reductions in particle-phase redox activity for the control technologies.
- Gas-phase redox activity lower that particle-phase, suggesting that emissions contain more redox-active constituents in the particle-phase of PM.
- Lower gas-phase prooxidants for the control technologies.

# Summary & Conclusions

- Under-fired charbroiler particle emissions:
  - primarily < 1 micron
  - dominated by organic carbon (OC), elemental carbon (EC) small fraction
  - contain toxics (PAHs, nitrated-PAHs)
- Control technologies can:
  - significantly reduce PM mass emissions (% reductions vary by control)
  - reduce exposure to gaseous toxics, such as carbonyls
  - reduce particle- and gas-phase PAHs and nitrated PAHs
- Overall, toxicity of PM emissions reduced by controls.

# Possible Future Studies

- Additional characterization of cooking aerosol for its impact on allergic airway diseases and the cardiovascular system.
- Investigating the impact of charbroiled cooking operations on secondary organic aerosol formation and subsequently on urban air quality.