Source Signatures of Organic Compounds and Particle Growth in Bakersfield, CA

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Main Questions to be Addressed

• What sources contribute to the organic aerosol mass in Bakersfield?

• What fractions of the organic aerosol mass are HOA and OOA?

• What processes control particle number concentration?

• What vapors contribute to condensational growth during the frequently observed growth events?
Particle Measurements at Bakersfield

- **FTIR: organic functional groups**
  - OM$_1$: 3-6 hour filter samples, 5 samples a day
  - OM$_{2.5}$: 23 hour filter sample, 1 sample a day

- **HR-AMS: non-refractory organics, sulfate, nitrate, ammonium, and chloride**
  - online measurement with 2 min resolution

- **SMPS: particle number size distribution**
  - online measurement with 10 min resolution

- **XRF: elemental concentration**
  - XRF measurements were conducted on PM$_1$ and PM$_{2.5}$ filters
Chemical Composition of Submicron Particles

- Organics (55%)
- Sulfate (11%)
- Ammonium (8%)
- Dust (12%)
- Chloride (0%)
- Nitrate (9%)
- EC (5%)

80% of OM$_{2.5}$ is OM$_1$

Elemental carbon from CARB
Time series of organic functional group concentrations
FTIR and AMS factors from PMF

O/C = 0.7
(Sulfate)

O/C = 0.8
(Sulfate)

Petroleum
Drilling
Operations (V)

Organonitrate (ON)
OA (NO_x EC)

Vegetative
Detritus (Si, Ca)

m/z 43
high43-OOA

m/z 44
high44-OOA

m/z 44
Petroleum
Drilling
Operations

m/z 57
HOA

20 40 60 80 100
Both show 65% of OM is OOA and 11-14% of OM is HOA.
Comparison of HOA and OOA Factors from FTIR and AMS PMF analyses

(a) Sum of AMS high O/C factors
(b) AMS HOA factor

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(a) Sum of AMS high O/C factors
(b) AMS HOA factor
Growth of 10-20 nm diameter particles up to 40-100 nm occurred on most days.

The growth could be followed from early morning to at least 7pm on 31 of the 46 days – regional events over horizontal scales of at least 100 km.
Average diurnal variations in particle number size distribution

The growth was in general linear with time until around 1pm but decreased in rate during afternoon and evening.

The average growth rate was 7.3 nm hr$^{-1}$ with a standard deviation of 2.6 nm hr$^{-1}$ (within the range of what has been observed in for instance Atlanta, Mexico City and Leipzig).
Chemical compounds contributing to ultrafine ($D_p<100\text{nm}$) mass and particle growth

Ultrafine mass distribution

- Organics (83 %)
- Sulfate (14 %)
- Ammonium (3 %)

![Graph showing particle distribution and mass over time](image-url)
Median diurnal cycles of mass and number concentrations

Data provided by CARB

**Ultrafine organic mass**

**Particle number concentration**

Number concentration increases from ~10,000 to ~20,000 cm$^{-3}$ between 10am and 2pm as a result of new particle formation.

- **EC**
- **m/z 57 (POA tracer)**
- **m/z 44 (SOA tracer)**

Rush hour

Photochemical production
How does the ultrafine mass during growth events correlate with other parameters?

- The correlation between ultrafine mass and \( \text{OH} \) concentration (\( R=0.56 \)) was better than the corresponding correlation with \( \text{ozone} \) (\( R=0.29 \)) during the growth events.

- Some correlation also with \( \text{UV radiation} \) (\( R=0.52 \)).

- No clear correlation between ultrafine mass and \( \text{SO}_2 \) (\( R=0.16 \)) or biogenic VOCs such as \( \text{isoprene} \) (\( R=-0.03 \)) and \( \text{alpha-pinene} \) (\( R=0.08 \)) during the events.

- The best correlations were found for gas-phase formaldehyde (\( R=0.80 \)), \( \text{oxalic acid} \) (\( R=0.70 \)), \( \text{formic acid} \) (\( R=0.68 \)), glyoxal (\( R=0.61 \)).

\( \text{SO}_2 \), \( \text{oxalic acid} \) and \( \text{formic acid} \) from Jennifer Murphy’s group  \( \text{OH data from William Brune’s group} \)
Main conclusions

• Traffic emissions, petroleum operations and vegetative detritus contribute to organic mass at Bakersfield.

• FTIR and AMS measurements agree that the OOA fraction of OM$_1$ is 55-63 %.

• New particle formation was the dominating source of particle number at the site.

• Ultrafine particles grew primarily through condensation of organic vapors.
Acknowledgement

- We would like to thank Jennifer Murphy and her group at University of Toronto for providing data of SO$_2$, formic acid and oxalic acid, William Brune’s group at Pennsylvania State University for OH-data and CARB for providing data of elemental carbon.