Atmospheric Monitoring of Ultrafine Particles

Philip M. Fine, Ph.D.
South Coast Air Quality Management District

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Outline

• What do we monitor?
  • Mass, upper size cut, total number, non-volatile number
• Where do we monitor for Ultrafines?
  • Siting criteria
  • Local or regional influences
  • Number of locations
• How do we monitor for Ultrafines?
  • Instrumentation
  • Averaging times/maxima – daily/annual
• Does a monitoring network for Ultrafines even make sense?
  • Criteria pollutant vs. air toxic
What Characteristics of Ultrafines Do We Measure?

• Mass
  • PM mass measurements similar to PM10 or PM2.5 methods
    • Time-integrated filter-based methods
    • Continuous methods (TEOM, BAM)
  • Size-selective inlet to remove larger particles
    • Ultrafine size-cut leads to higher pressure drops across inlet device
      • Still feasible down to 150-180 nm
        • Demonstrated for 150 nm inlet on BAM (Chakrabarti et al., AS&T 38(S1), 2004)
  • What is the upper size cut?
    • 50 nm, 100 nm, 150 nm, 180 nm, 250 nm
Size Cut (Aged Aerosol)

Average Size Distribution - Riverside May 2001
(6AM-10AM)

Number/cc

Mass/cc

Particle diameter (nm)

Number

Mass

100 nm  150 nm  180 nm  250 nm
Size Cut (Source Aerosol)

Size Distribution - Long Beach Morning - October, 2002

Particle diameter (nm)

Number/cc

Mass/cc

Number

Mass

100 nm  150 nm  180 nm  250 nm
For the previous size distributions and upper size cuts, **80% of the measured particle mass** would be found in the following size ranges, thus biasing measurements towards the upper end of the measured ranges.

<table>
<thead>
<tr>
<th>Riverside</th>
<th>Upper Size Cut</th>
<th>80% of Mass Is Within</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 nm</td>
<td>61-100 nm</td>
<td></td>
</tr>
<tr>
<td>150 nm</td>
<td>94-150 nm</td>
<td></td>
</tr>
<tr>
<td>180 nm</td>
<td>109-180 nm</td>
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<tr>
<td>250 nm</td>
<td>141-250 nm</td>
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<td>100 nm</td>
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<td>150 nm</td>
<td>73-150 nm</td>
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<tr>
<td>180 nm</td>
<td>82-180 nm</td>
<td></td>
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<tr>
<td>250 nm</td>
<td>98-250 nm</td>
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</table>
Little or no correlation between PM number and mass

Riverside, Rubidoux, and Claremont, California. (February 2001 - March 2002)
(Fine et al, AS&T, 38 (S1), 2004)
What Characteristics of Ultrafines Do We Measure?

• Particle Number
  • Relatively easy continuous measurements with CPCs
• Total Particles
  • Total or upper size cut?
    • Aged aerosol can have a mode at 100 nm or larger
  • Lower size cut of the type and model of CPC
    • Ranges from 5 nm to 20 nm
    • Potential composition effects
  • Accuracy of single counting vs. photometric modes
• Non-Volatile Particles Only
  • Adapt PMP Protocol to ambient measurements
    • Thermal denuder or heater upstream
    • Possibly more consistent measurements
What Characteristics of Ultrafines Do We Measure?

• The Ultrafine characteristics measured by any ambient monitoring program should reflect the latest health effects data
  • More Volatile vs. Solid Particles
  • Mass vs. Number
  • Primary vs. Secondary
• Evidence exists for adverse health effects for all of the above.
Where do we monitor for Ultrafines?

- More challenging than more spatially homogeneous pollutants such as ozone and PM$_{2.5}$
- Local sources (traffic) can dominate Ultrafine Number concentrations at any given location

![Graph showing Ultrafine Number concentrations in Glendora and Upland, 1 hour lag, 13 miles apart](b)

Sardar et al. JAWMA 54, 2004
Where do we monitor for Ultrafines?

• Siting criteria
  • Distances from roadways and local sources
• Local vs. more regional influences
• Number of locations
  • Only 13 miles apart can give very different results
  • Good spatial coverage needed
  • Representative of human exposure
    • Most of daily exposure occurs during driving, not at home
• Can particle number levels be interpolated or modeled, and what data do the models need?
How do we monitor for Ultrafines?

• Instrumentation
  • Condensation Particle Counters ($12K-$25K)
    • Particle number only
  • Scanning Mobility Particle Sizers (up to $70K)
    • Full size distributions
    • Number and mass (with assumptions)
  • Filter-based techniques with inlet ($5K-$25K)
    • Mass only, speciation possible
    • Time-integrated or continuous
  • New, cheaper, smaller techniques are being developed
    • Number, size and mass
How do we monitor for Ultrafines?

- **Averaging Times**
  - An ambient standard could be based on:
    - Hourly, daily or annual averages
    - Maximum or percentile ranks of any of the above
  - Choice should be based on emerging health effects data
  - Acute effects: short-term events
  - Chronic effects: long-term exposure

December 2005, Van Nuys

Particle Number/cc

Time, 1-minute data for one full month
Does a monitoring network for Ultrafines make sense?

• Criteria Pollutants
  • National Ambient Air Quality Standards
  • Regulation driven by ambient levels measured at Air Monitoring Stations
  • Source controls implemented to meet the Standards

• Hazardous Air Pollutants (Air Toxics)
  • Regulation at source only
    • No Net Increase
    • Best Available Control Technologies
  • Monitoring only for special studies or assessment programs
Does a monitoring network for Ultrafines make sense?

• Which approach should regulation of UF take?

• Criteria Pollutant Approach
  • Criteria Pollutants are generally regional or urban scale, while Ultrafines are more localized (exception: CO)
  • Monitoring issues more complex for Ultrafines than current criteria pollutants
    • more sites, more expensive equipment, complex atmospheric behavior (unlike CO)

• HAPs approach
  • Many HAPS are dominated by local industrial emissions
  • Most ultrafines are also local, but mostly from mobile sources
  • Control of mobile source emissions would not account for particle formation in the atmosphere
Conclusions

• If a decision is made to regulate Ultrafine Particles, the next step is to decide whether to regulate sources alone or also ambient levels
• If ambient monitoring is desired, the UF metric should be based on emerging health effects data
• The design of a monitoring network for Ultrafine particles needs to consider
  • Representation of population exposure
  • Local, regional and secondary particle sources
  • Cost
• Modeling estimates (i.e. distance to roadways, traffic density) should also be considered