Updates on Aerodyne PAM Oxidation Flow Reactor

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Potential Aerosol Mass (PAM) Oxidation Flow Reactor

- Developed by Bill Brune, improved and manufactured by Aerodyne
- Flow-through reactor, precursors exposed to O$_3$, OH, NO$_3$; HO$_2$, NO$_x$

Characterization: Kang et al., 2007; Lambe et al., 2011, 2015; Bruns et al., 2015
Modeling: Chen et al., 2013; Li et al., 2015; Peng et al., 2015, 2016
SOA formation from multi-generation oxidation of precursors

OVERVIEW

Lambe et al., 2012
Chen et al., 2013
Tkacik et al., 2014
Ortega et al., 2016
Palm et al., 2016
## Deliveries

<table>
<thead>
<tr>
<th>Serial #</th>
<th>Delivery</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>Dec 2016</td>
<td>Washington University in St. Louis</td>
</tr>
<tr>
<td>002</td>
<td>Feb 2016</td>
<td>Pacific Northwest National Laboratory</td>
</tr>
<tr>
<td>003</td>
<td>Feb 2016</td>
<td>Desert Research Institute</td>
</tr>
<tr>
<td>004</td>
<td>Mar 2016</td>
<td>Aerodyne</td>
</tr>
<tr>
<td>005</td>
<td>Jun 2016</td>
<td>Chinese Academy of Sciences</td>
</tr>
<tr>
<td>006</td>
<td>Apr 2016</td>
<td>Ohio State University</td>
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<td>007</td>
<td>Jul 2016</td>
<td>Hankuk University</td>
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<td>008</td>
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<td>009</td>
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<td>Peking University</td>
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<td>010</td>
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<td>Finnish Meteorological Institute</td>
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<td>Laboratorie des Sciences du Climat et de l’Environnement</td>
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<td>012</td>
<td>Nov 2016</td>
<td>National University of Singapore</td>
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<tr>
<td>013</td>
<td>Dec 2016</td>
<td>University of California – San Diego</td>
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System Components

- Oxidation flow reactor with “OFR185” and “OFR254” capability
- O₃ chamber, Humidifier
- Autovalve, RH/T, Photodiode, User I/O Box, Flow Controllers
- E-box with ballasts and control board
- PAMControls software

- FIELD DEPLOYABLE
Unattended field operation in Mar 2016
Gif-sur-Yvette, France
<table>
<thead>
<tr>
<th>Dimming Voltage</th>
<th>O₃ / ppm</th>
<th>RSD (%)</th>
<th>Irradiance / uW cm⁻²</th>
<th>RSD (%)</th>
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</thead>
<tbody>
<tr>
<td>1 VDC</td>
<td>3.6 ± 0.5</td>
<td>12.8</td>
<td>4.2 ± 1.0</td>
<td>24.2</td>
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<tr>
<td>3 VDC</td>
<td>20.3 ± 1.4</td>
<td>6.8</td>
<td>40.0 ± 0.4</td>
<td>0.9</td>
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<td>10 VDC</td>
<td>56.6 ± 3.8</td>
<td>6.7</td>
<td>138.5 ± 4.5</td>
<td>3.3</td>
</tr>
</tbody>
</table>

OVERVIEW
CMMCh Harvard Photochemical Chamber chamber vs PAM

- Teflonbag, with side 2.4 m
- 180 UVA 340nm lamps

Hilkka Timonen, 4th PAM Users Meeting
Increase in BC

Hilkka Timonen, 4th PAM Users Meeting
OH oxidation with NO$_x$

\[
O_3 + h\nu_{254} \rightarrow O(^1D) + O_2 \\
O(^1D) + H_2O \rightarrow 2OH \\
O(^1D) + N_2O \rightarrow 2NO \\
N_2O + h\nu_{185} \rightarrow O(^1D) + N_2
\]

Lambe et al., in prep
Peng et al., in prep
Transition from $\text{RO}_2 + \text{HO}_2$ to $\text{RO}_2 + \text{NO}$-dominant conditions: isoprene

![Graph showing transition from RO₂ + HO₂ to RO₂ + NO-dominant conditions](image)

Lambe et al., in prep
Transition from RO$_2$+HO$_2$ to RO$_2$+NO-dominant conditions: $\alpha$-pinene

Lambe et al., in prep

NEW TECHNIQUES
NO$_3$ radical generation

$$O_3 + NO_2 \rightarrow NO_3 + O_2$$

$$NO_3 + NO_2 \rightarrow N_2O_5$$

$$N_2O_5 \rightarrow NO_3 + NO_2$$
\( \alpha \)-pinene + NO\(_3\) products detected with I-CIMS

(Clustered with \( \bar{I} \))

- \( C_{10}H_{15}NO_5 \)
- \( C_{10}H_{15}NO_4 \)
- \( C_{10}H_{16}O_4 \)
- \( C_{7}H_{9}NO_5 \)
- \( C_{7}H_{11}NO_5 \)
- \( C_{10}H_{15}NO_6 \)
- \( C_{10}H_{15}NO_7 \)
- \( C_{10}H_{15}NO_8 \)

NEW TECHNIQUES
SOA from limonene + NO3, detected with L-ToF-AMS
Outlook

- ~10 deliveries per year
- NO$_3$ radical to supplement OH radical (+ NO$_{x}$)
- Minor tweaks to hardware and software
- Synergistic applications with mass spectrometers

https://sites.google.com/site/pamwiki/home