Determinants of Isoprene SOA Yields from Recent Comprehensive Chamber Studies

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20 October 2016
Motivation

~535 Tg y\(^{-1}\)

25-50% of annual global secondary organic material production

Guenther et al., 1995, 2012
Henze et al., 2006
Hoyle et al., 2007
Heald et al., 2008
Lin et al., 2012
Motivation

~50% is “low-NO”
Motivation
The Low-NO pathway

Surratt et al., PNAS, 2010
IEPOX SOA

Hu et al., ACPD, 2015
The Low-NO pathway II

LVOC (dihydroxy-dihydroperoxide, carboxyl/epoxyl-tetrol...)

<10%

Krechmer et al., ES&T, 2015
Low-NO Isoprene SOA Yields

• Broad range (0.01 – 0.2)
• Parameterizations focused on IEPOX
• Many contributing factors: LWC/RH, T, H⁺, SO₄²⁻, NH₄⁺, particle area, organic coating...

Carlton et al., ACP, 2009; Gaston et al., ES&T, 2014
Methods

1. Humidify
2. Inject isoprene
3. Inject NO, NO\textsubscript{2}, CH\textsubscript{3}ONO, t-BuOOH
4. Inject seed salt
5. Wait for wall loss & coagulation
6. Irradiate

**Environmental Chamber (21 m\textsuperscript{3})**

- uv lights ($\lambda_{\text{max}} = 350$ nm)

**Analytical Instruments**

- AMS
- DMA
- CIMS
- GC
- RH/T
Experiments

Systematically and comprehensively varying:

- temperature
- particle acidity (atomizing solution → AIOMFAC)
- humidity (→ LWC)
- particle surface area
- [NO] and [NO₂]
- organic coatings
- seed salt composition
Results

Yields are calculated from DMA & GC, and are:

- shown at end of photooxidation (stable)
- corrected for particle wall loss
- corrected for coagulation
- NOT corrected for vapor wall loss

... so consider them tentative
Low-NO: pH, RH, and T

![Graph showing the relationship between pH, RH, and mass yield at different temperatures (17 °C, 25 °C, 32 °C).]
Low-NO: $f_{82}$ and $f_{91}$
Low-NO: IEPOX-SOA and pH

IEPOX

LVOC

AMS $f_{82}$ vs pH

AMS $f_{91}$ vs pH

Legend:
- 17 °C
- 25 °C
- 32 °C

RH (%)
Low-NO: LVOC-SOA and T

IEPOX

LVOC

AMS $f_{82}$

AMS $f_{91}$

temp (C)

16 19 22 25 28 31 34

10 $\times 10^{-3}$

pH

-3 -2 -1 0 1 2 3 4 5

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Low-NO: AMS signatures

IEPOX

LVOC

17 °C
25 °C
32 °C
High-NO: Nitrate Pathway

Diagram showing a chemical pathway involving molecules such as NO, NO$_2$, and HO. The pathway is represented with chemical structures and reactions.

Graph showing the relationship between seed surface area (µm$^2$ cm$^{-3}$) and mass yield at different temperatures (°C). The graph includes data points and a color scale for temperature.
High-NO: MPAN Pathway
Conclusions

Low NO: AMS is useful in differentiating between IEPOX and LVOC pathways, yields from which depend on pH/RH and T respectively.

High NO: \([\text{NO}]/[\text{NO}_2]\) ratio determines relative importance of nitrate (low yield, T dependent) and MPAN (high yield, nucleation) pathways.