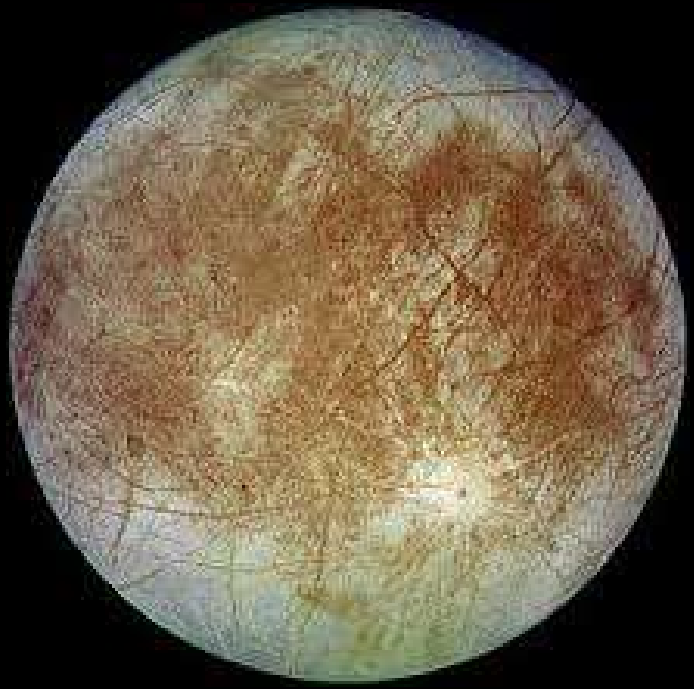
Thermal Reactions in Simulated Astrophysical Environments



Mark Loeffler

Northern Arizona University

New Faculty in the Department of Physics and Astronomy

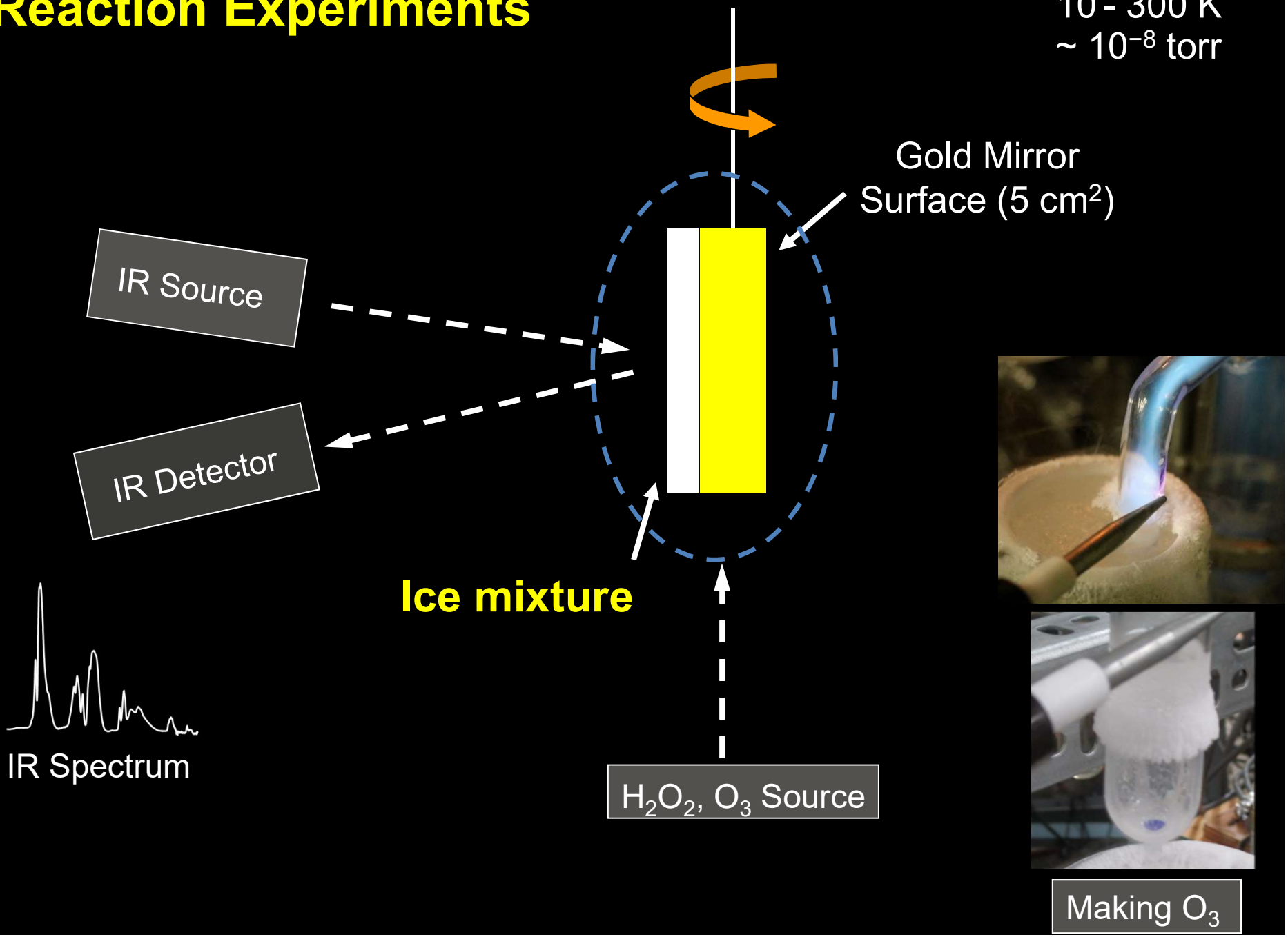
NORTHERN ARIZONA UNIVERSITY

Background

- Composition of planetary surfaces can be altered by radiolysis/photolysis
- Laboratory studies show H_2O_2 and O_3 easily form from radiolysis/photolysis
  - Few detections via remote sensing
- Why the difference?
  - H_2O_2/O_3 react with other compounds in the ice?

Reaction Experiments

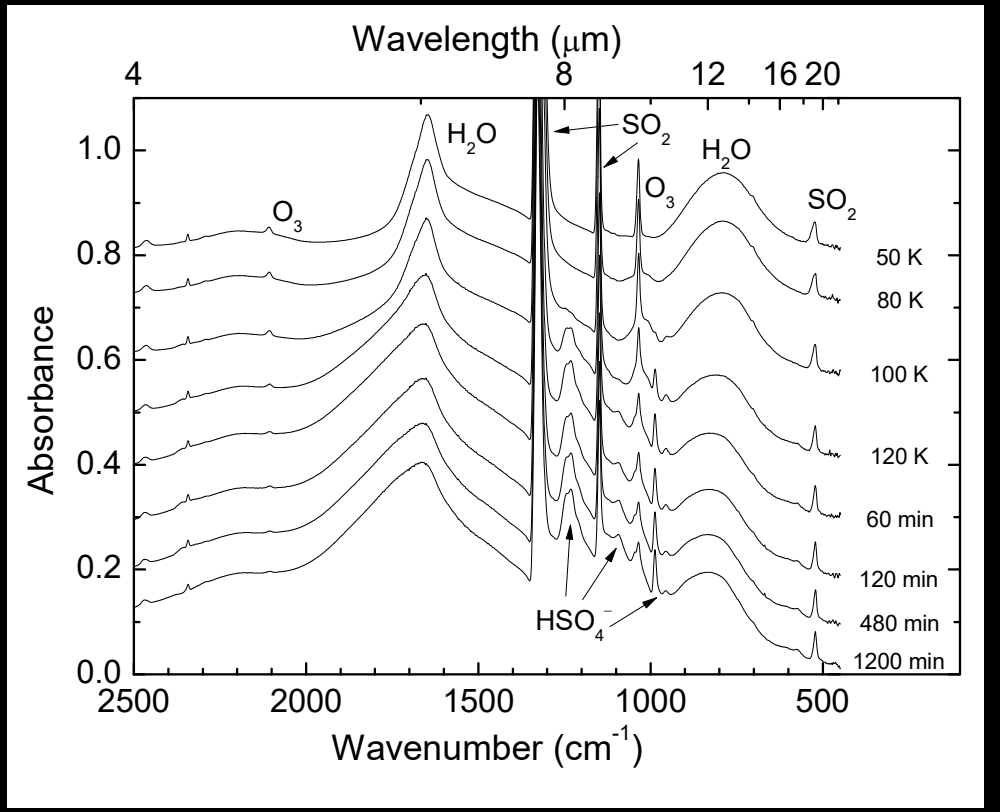
10 - 300 K
~ 10^{-8} torr



Making O_3

Recent Lab Findings

- Grow mixtures of H_2O+SO_2 with oxidant
  - H_2O_2 and O_3 react
- Main products:
  - HSO_3^- (80 – 100 K)
  - $S_2O_5^{2-}$ (80 – 100 K)
  - HSO_4^- (> 100 K) – O_3
  - SO_4^{2-} (> 100 K) – H_2O_2
- Important for Jovian icy satellites
- What about other molecules?
  - H_2S?
  - CO?
  - NH_3?

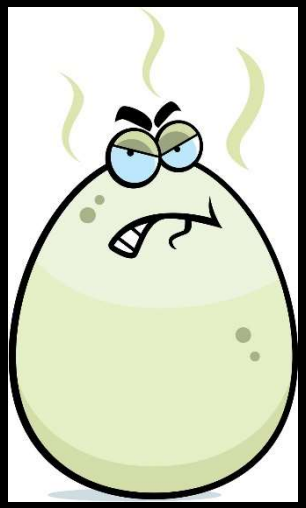


Can some trends be established?

Can some trends be established?

Hydrogen sulfide

Smells like…



React? Yes

Can some trends be established?

	Hydrogen sulfide	Methanethiol Methyl mercaptan
		
Smells like…		
React?	Yes	Yes

Can some trends be established?

	Hydrogen sulfide	Methanethiol Methyl mercaptan	Methylthiomethane Dimethyl sulfide
			
Smells like…			
React?	Yes	Yes	??

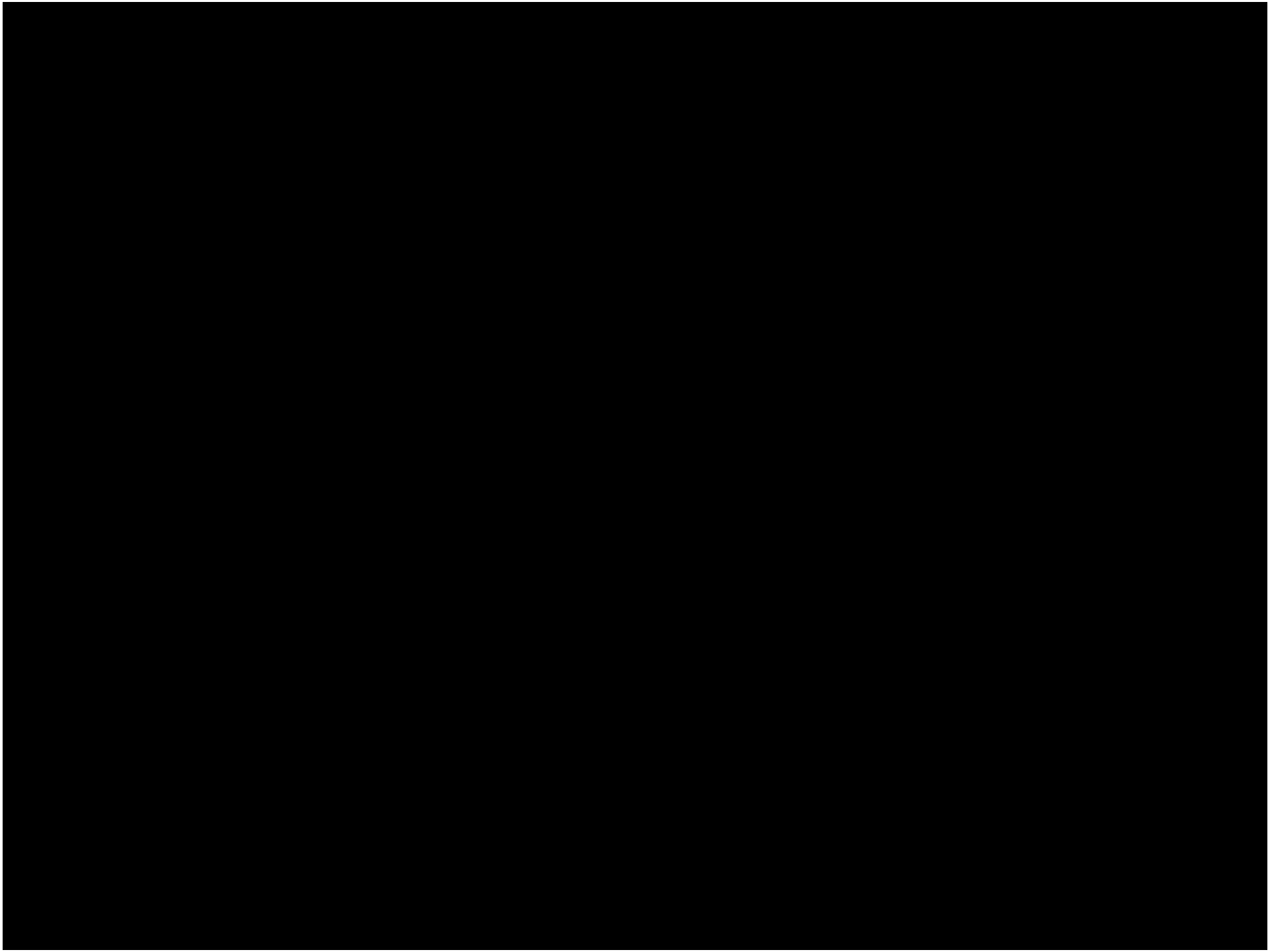
Summary

- Thermal reactions important for Jovian icy satellites
- Reactions also observed with more complicated organosulfur compounds
  - May be relevant to other surfaces
- Future work will test reactions for other ices

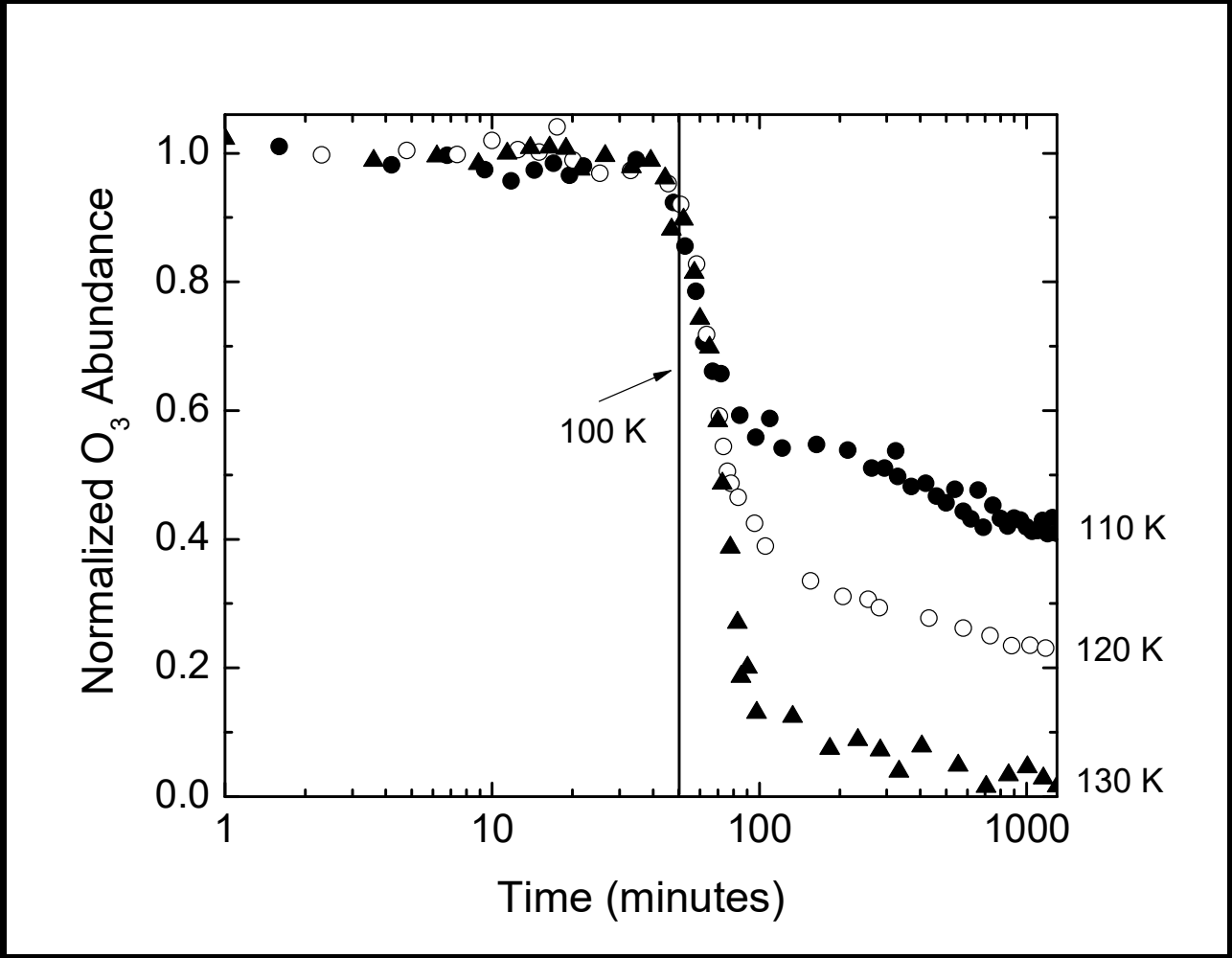
Acknowledgments/Shameless Plug

- Financial support from NASA programs
  - NASA Solar System Workings
  - Outer Planets Research
  - NASA Astrobiology Institute

- Laboratory will be at NAU (Bldg 19 Rm 313)
  - Thermal reactions described here
  - Radiolysis of ices and non-icy surfaces (asteroid analogs, etc.)
  - Characterization/optical properties of astrophysically relevant materials
- Email: mark.loeffler@nau.edu



Reaction of O_3 in $H_2O+SO_2+O_3$ ice

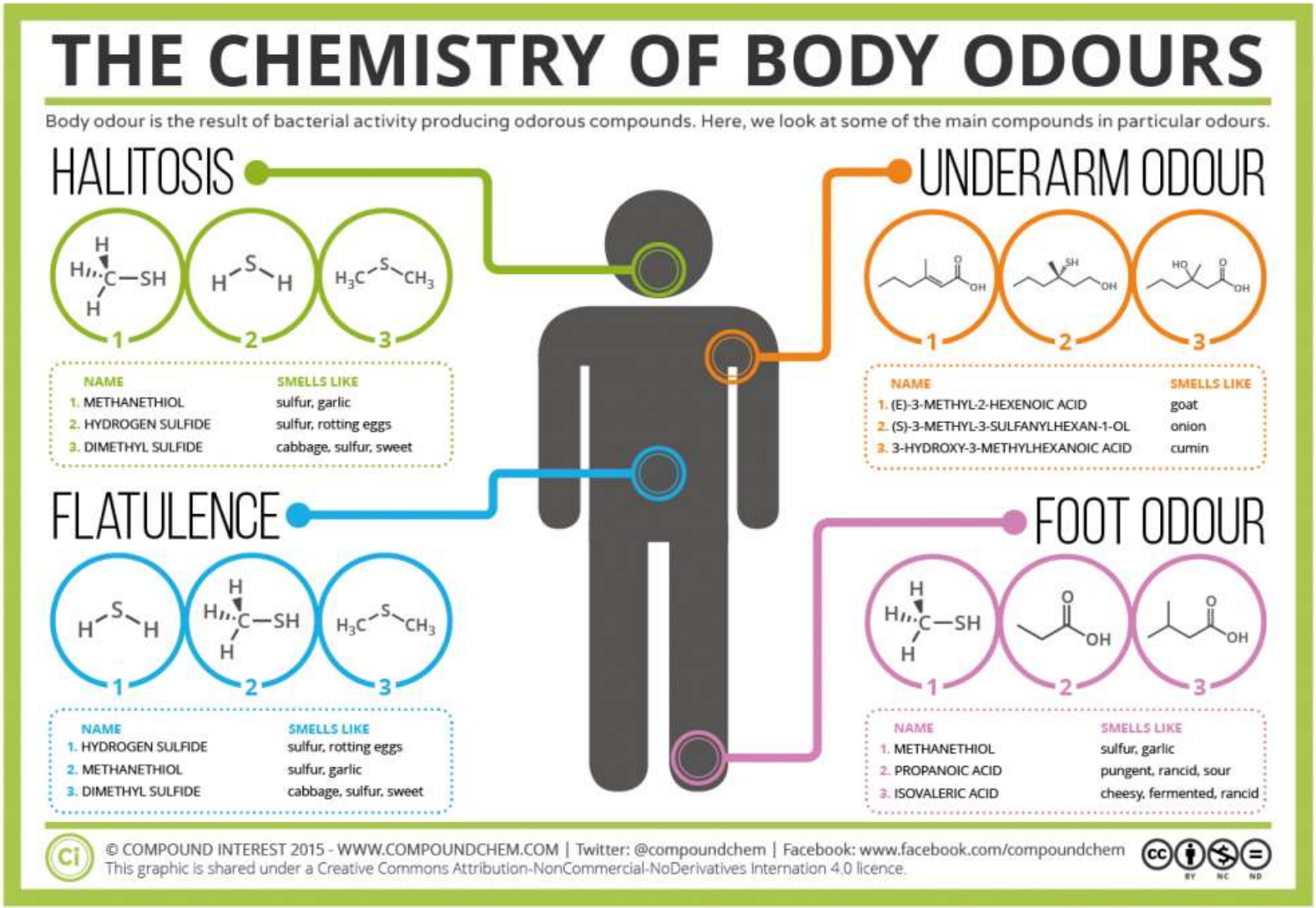


Reaction Pathway

$$2\,H_2O + SO_2 \rightarrow HSO_3^- + H_3O^+$$

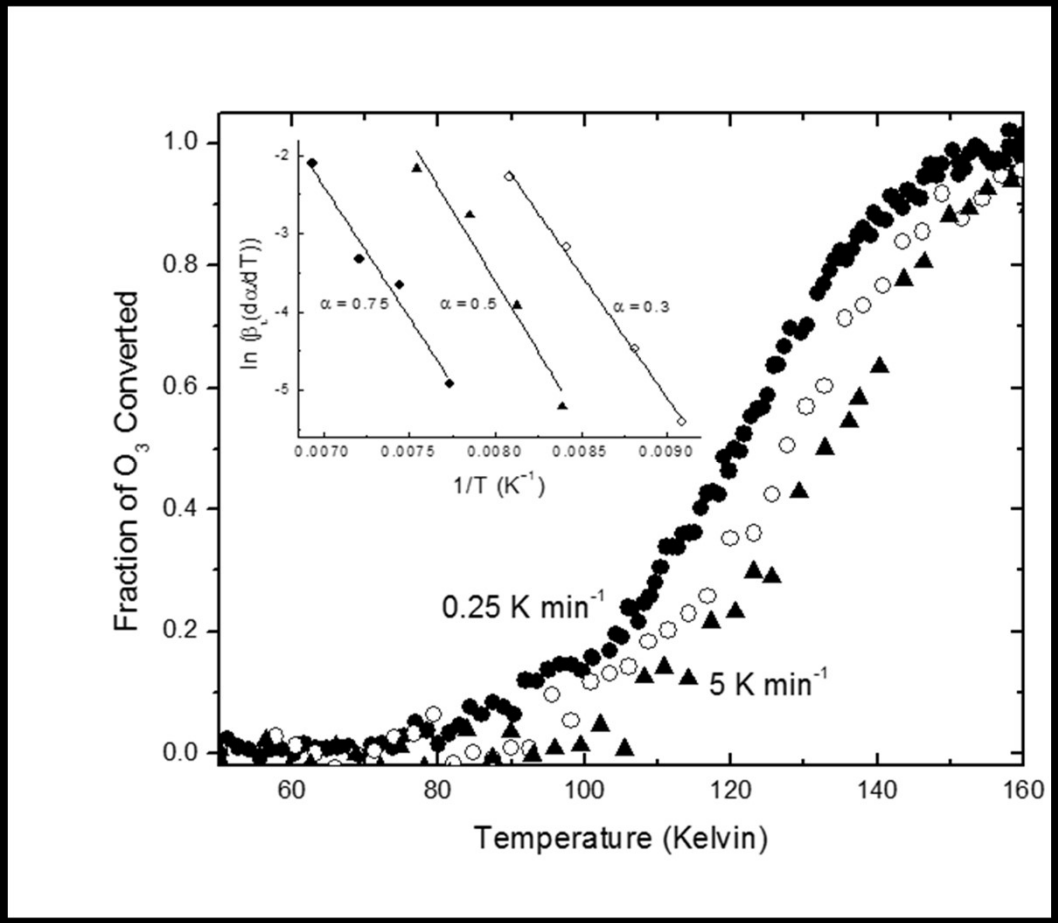
$$O_3 + HSO_3^- \rightarrow HSO_4^- + O_2$$

Seriously?


THE CHEMISTRY OF BODY ODOURS
Body odour is the result of bacterial activity producing odorous compounds. Here, we look at some of the main compounds in particular odours.
HALITOSIS
1
2
3
NAME
SMELLS LIKE
1. METHANETHIOL
sulfur, garlic
2. HYDROGEN SULFIDE
sulfur, rotting eggs
3. DIMETHYL SULFIDE
cabbage, sulfur, sweet
UNDERARM ODOUR
1
2
3
NAME
SMELLS LIKE
1. (E)-3-METHYL-2-HEXENOIC ACID
goat
2. (S)-3-METHYL-3-SULFANYLHEXAN-1-OL
onion
3. 3-HYDROXY-3-METHYLHEXANOIC ACID
cumin
FLATULENCE
1
2
3
NAME
SMELLS LIKE
1. HYDROGEN SULFIDE
sulfur, rotting eggs
2. METHANETHIOL
sulfur, garlic
3. DIMETHYL SULFIDE
cabbage, sulfur, sweet
FOOT ODOUR
1
2
3
NAME
SMELLS LIKE
1. METHANETHIOL
sulfur, garlic
2. PROPANOIC ACID
pungent, rancid, sour
3. ISOVALERIC ACID
cheesy, fermented, rancid
© COMPOUND INTEREST 2015 - WWW.COMPOUNDCHEM.COM | Twitter: @compoundchem | Facebook: www.facebook.com/compoundchem
This graphic is shared under a Creative Commons Attribution-NonCommercial-NoDerivatives Internation 4.0 licence.

Calculation of Activation Energy

- Isoconversional method
  - Heat samples at different rates
- Activation energy of 32 kJ / mole



Isoconversional Method

- $\frac{d\alpha}{dt} = k(T)f(\alpha)$
- $\frac{d\alpha}{dT} = \left(\frac{A}{\beta}\right)e^{-E/RT}f(\alpha)$
- $\ln[\beta_i \left(\frac{d\alpha}{dT}\right)_{\alpha,i}] = \ln[A_\alpha f(\alpha)] - E_\alpha/RT_{\alpha,i}$