Cloud Nucleating Activity of Non-Spherical Particles: Application of Wet CCN Measurement to Iodine Oxides

Madeline Camp, CMMAP Intern Kreidenweis Group

Mentors: Dr. Shunsuke Nakao

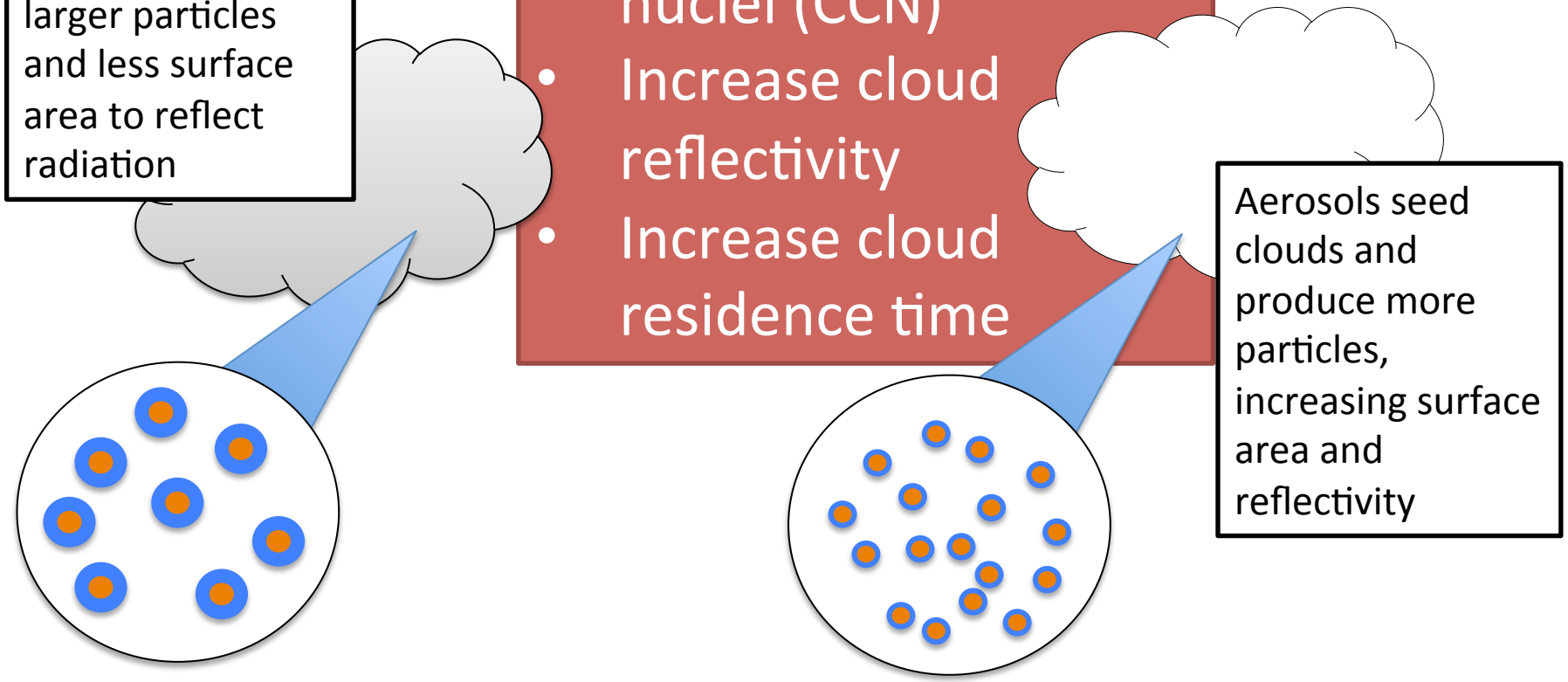
& Dr. Sonia Kreidenweis

Aerosols, Cloud Formation, and Climate

- Aerosols function as cloud condensation nuclei (CCN)
- Increase cloud reflectivity
- Increase cloud residence time

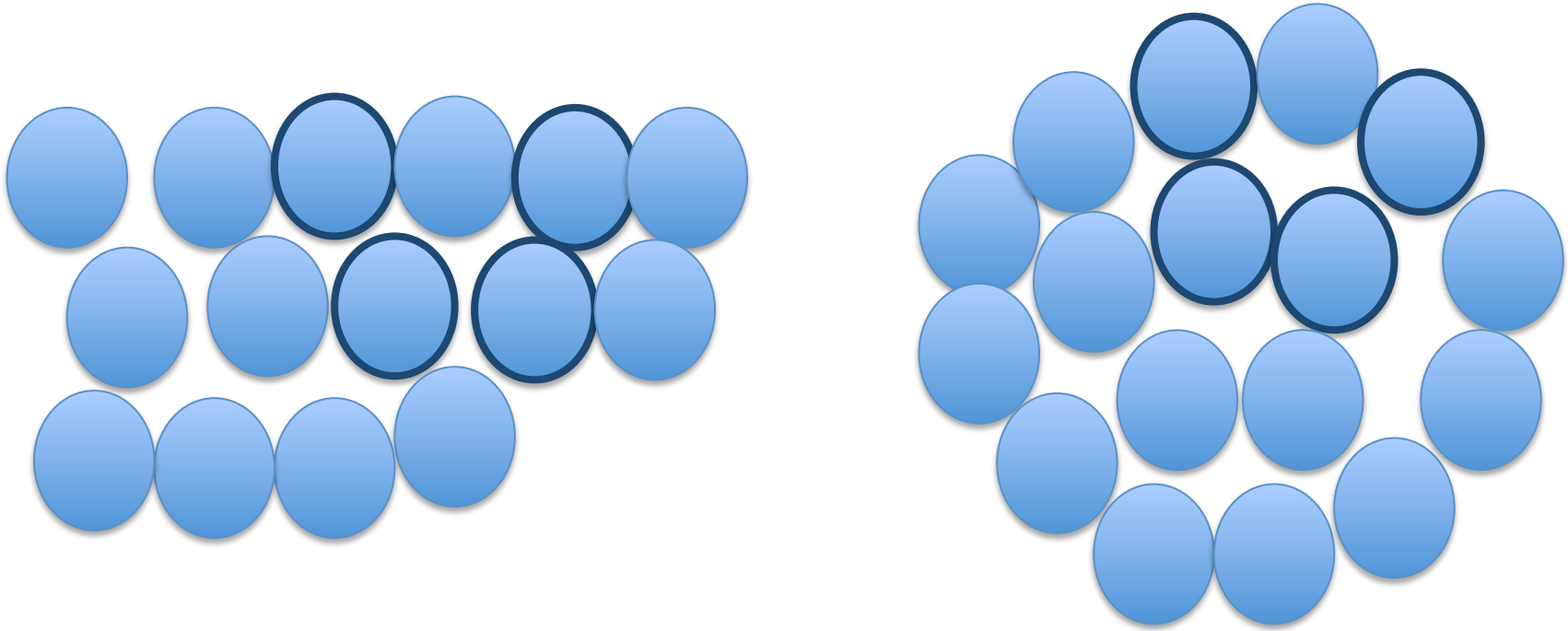
Clouds with fewer aerosols have larger particles and less surface area to reflect radiation

Aerosols seed clouds and produce more particles, increasing surface area and reflectivity



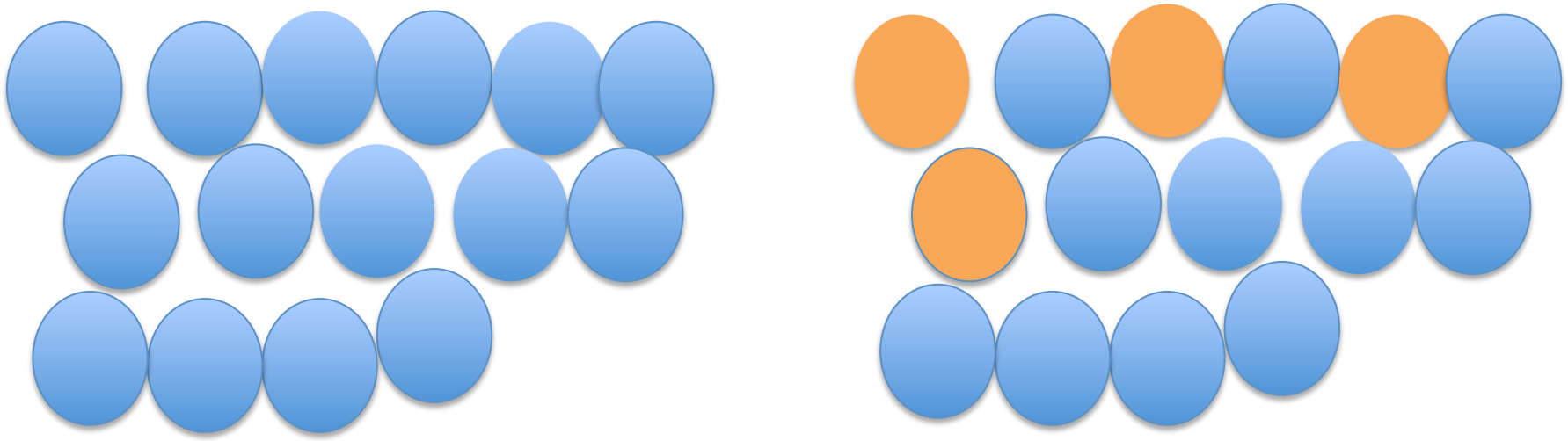
Cloud formation information adapted from Seinfeld, John. (2006) *Atmospheric Chemistry and Physics (2nd ed.)*. (pp. 55-6). Hoboken, NJ: John Wiley and Sons Inc.

Cloud Formation and the Kelvin Effect



Kelvin Effect **raises** vapor pressure of a liquid because **curvature lessens intermolecular forces so vaporization is easier**

Cloud Formation and the Raoult Effect



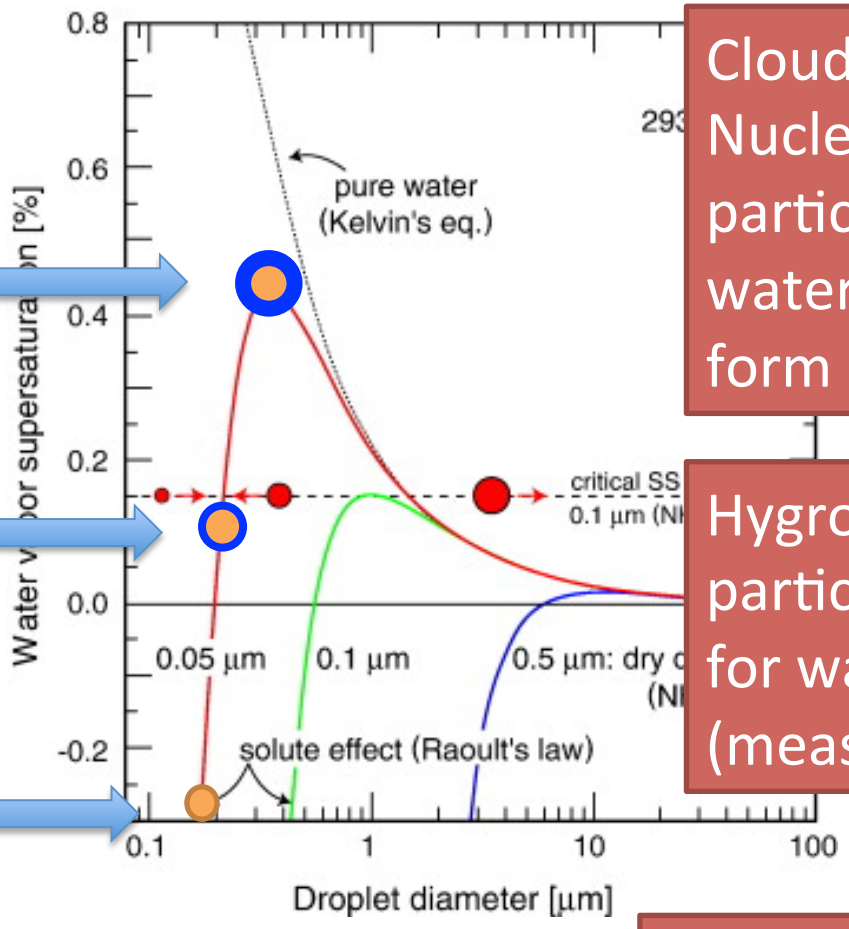
Raoult Effect **lowers** vapor pressure because solute particles reduce available surface area of water molecules to vaporize

Cloud Formation through Cloud Condensation Nuclei

CCN activates to droplet; cloud forms

Uptake of water

Initial aerosol (CCN)



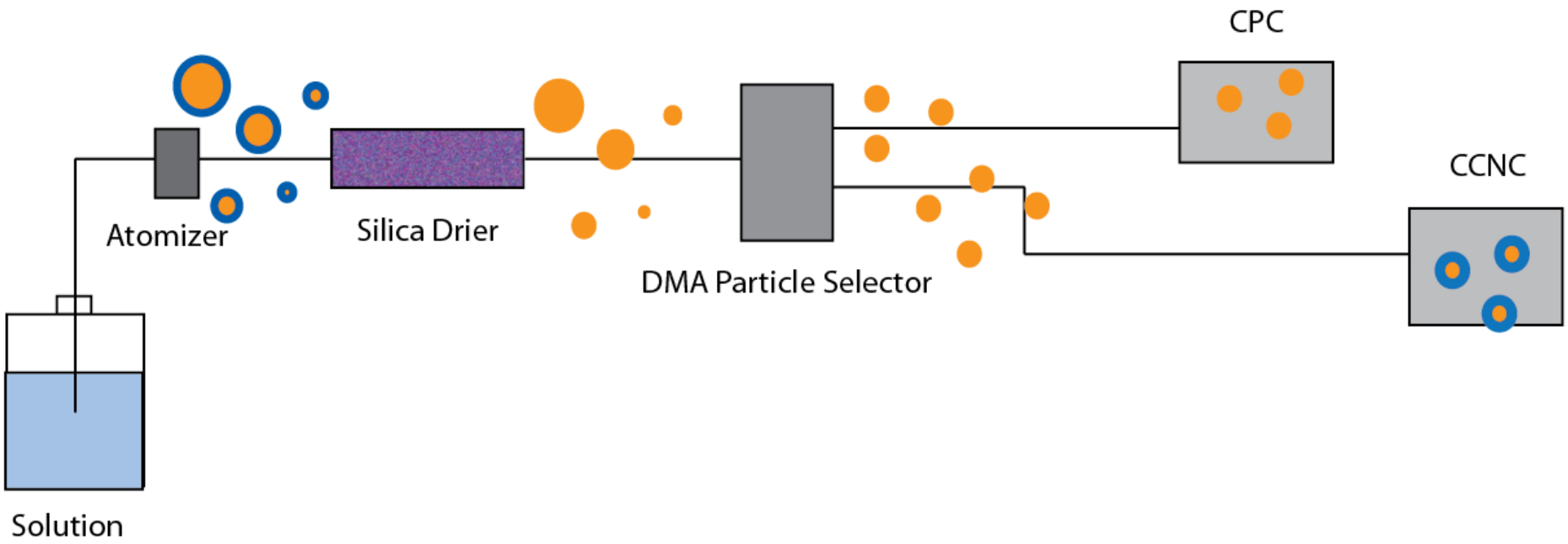
Cloud Condensation Nuclei (CCN): particles where water condenses to form cloud droplets

Hygroscopicity: particle's tendency for water uptake (measured by k)

CCN Activity determined by Kohler Curve and hygroscopicty

Figure 1 from M.O. Andreae, D. Rosenfeld. *Aerosol–cloud–precipitation interactions. Part 1. The nature and sources of cloud-active aerosols*
Earth-Science Reviews, Volume 89, Issues 1–2, July 2008, Pages 13–41

Measuring CCN Activity: Traditional

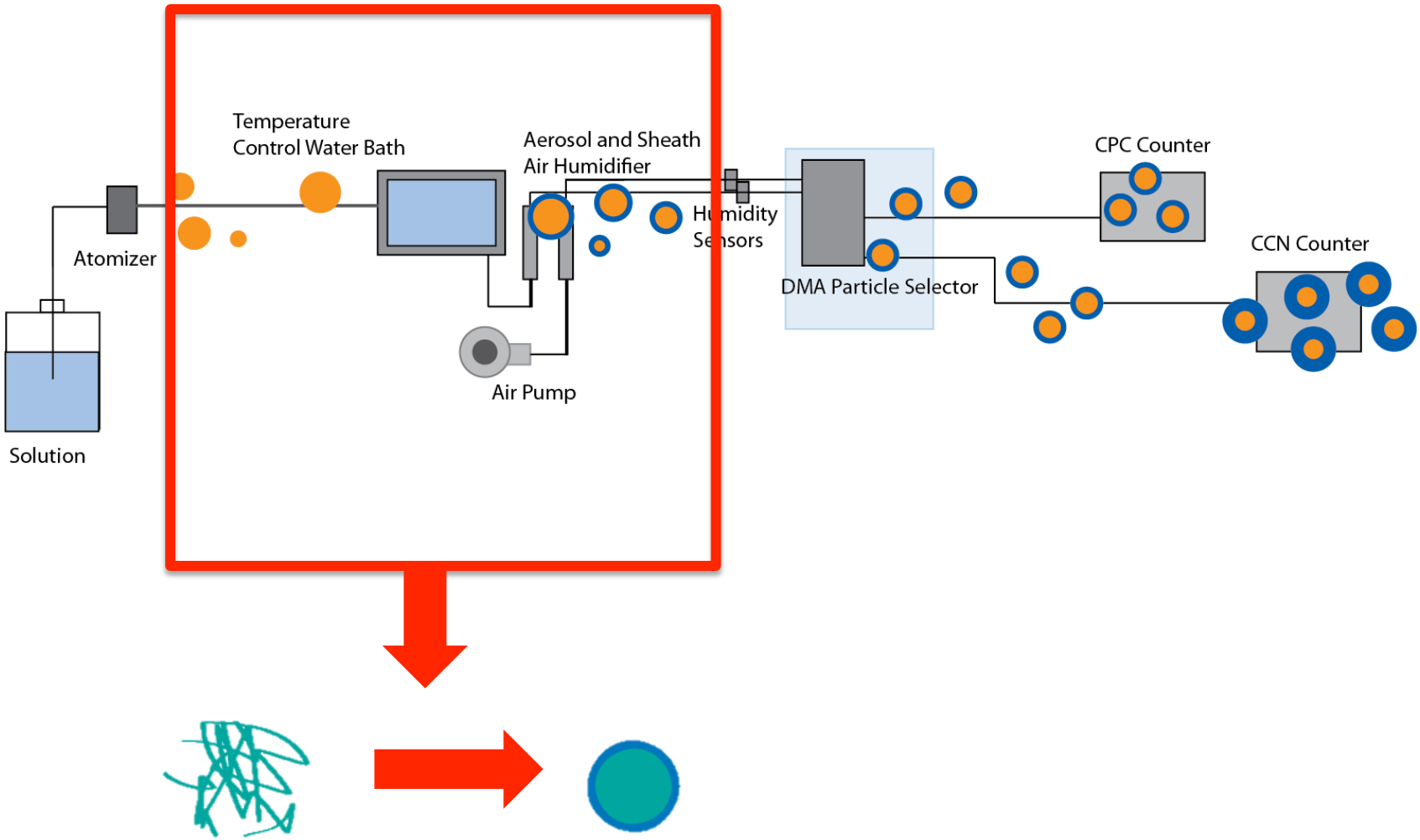


Amount of solute overestimated for iodine oxides and other non spherical particles

Diameter read by selector

Diameter of equivalent solute

Measuring CCN Activity: Wet Particle Method



Iodine in the Atmosphere

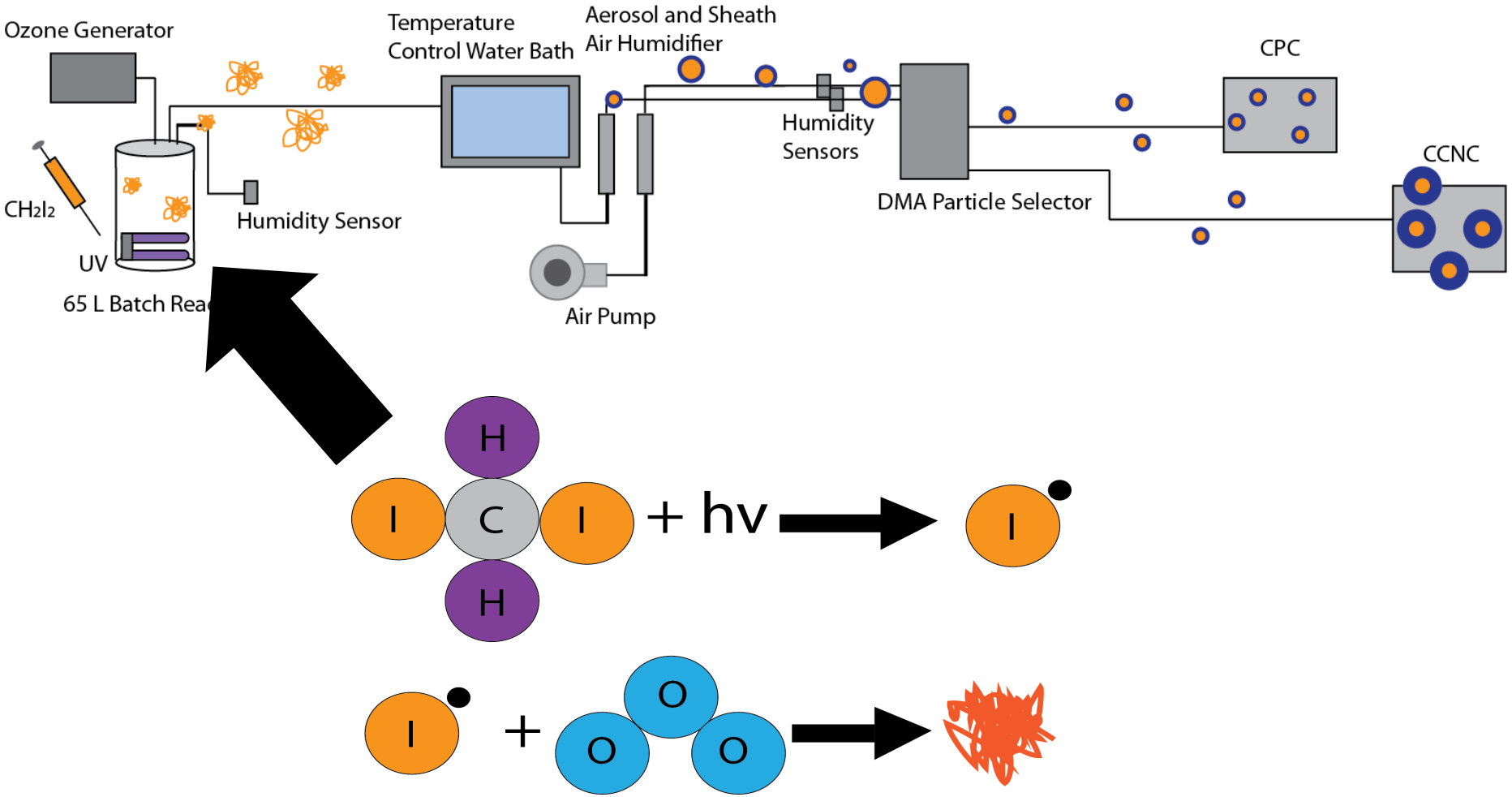
- CH_2I_2 and molecular I_2 emitted in **marine environments by algae**[1] exposed during low tide[2]

University College Cork, Ireland
http://chemweb.ucc.ie/venablesgroup/Research.html

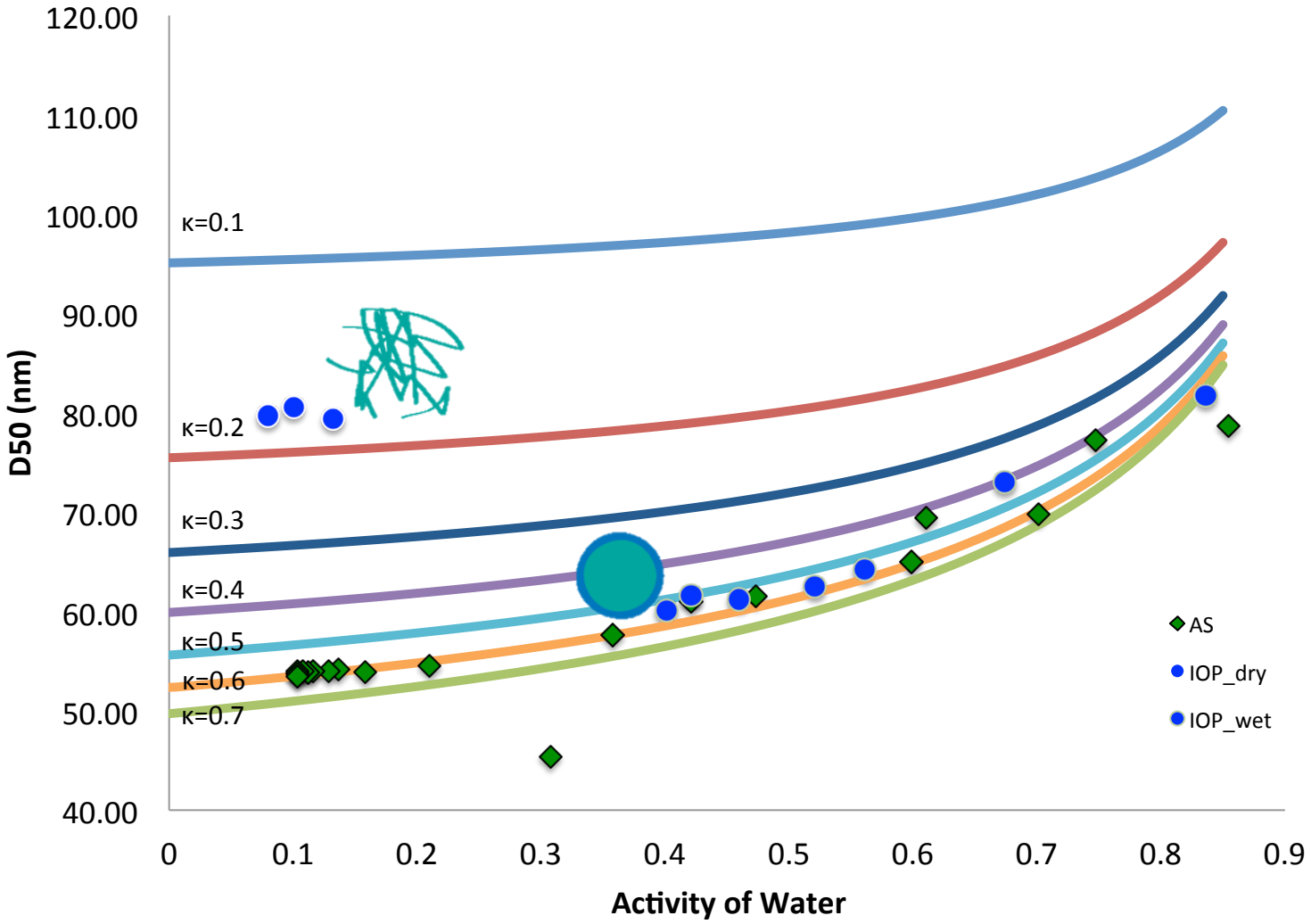
Daniel Mosquin, March 5 2008
http://www.botanicalgarden.ubc.ca/potd/2008/03/laminaria_setchellii_1.php

1. Jimenez et al. *New Particle Formation from Photooxidation of Diiodomethane (CH2 I2)* Journal of Geophysical Research 2003
2. Pechtl et al. *Modeling the possible role of iodine oxides in atmospheric new particle formation* Atmospheric Chemistry and Physics 2006

Experimental Set-up: Wet Method for Iodine Oxides

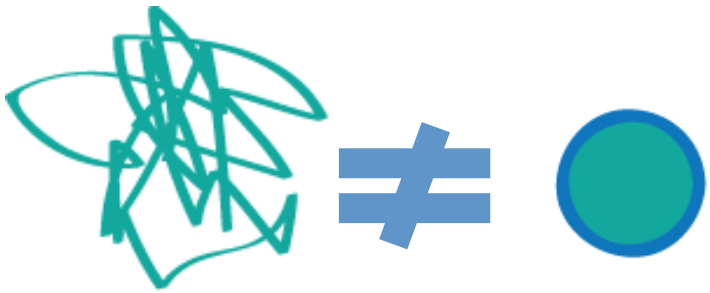


Results: Fractal Collapses for Accurate Diameter Measurement

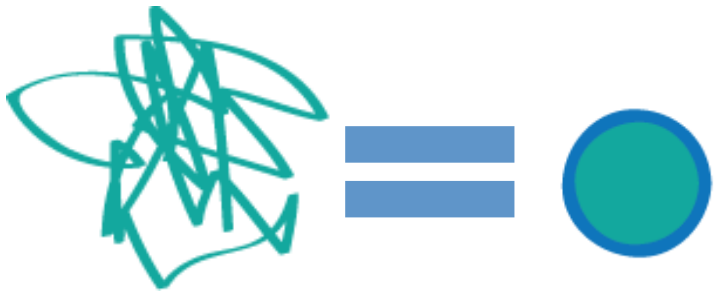


Summary

- Dry method of CCN measurement overestimates the amount of solute and thus underestimates solute hygroscopicity
- Wetting iodine oxides effectively collapses the fractal particle to model solute as sphere



Fractal and Collapsed Diameter



Fractal and Collapsed Solute Volume

Extra Slides

Solving for κ (Hygroscopicity Parameter)

Super-saturated conditions (DMA-CCNC):

$$D_d = \left(\frac{4A^3}{27\kappa_{super} ln^2 Sc}\right)^{1/3}$$

Sub-saturated conditions (H-TDMA):

$$D_w = D_d \left(1 + \kappa_{sub} \frac{a_w}{1-a_w}\right)^{1/3}$$

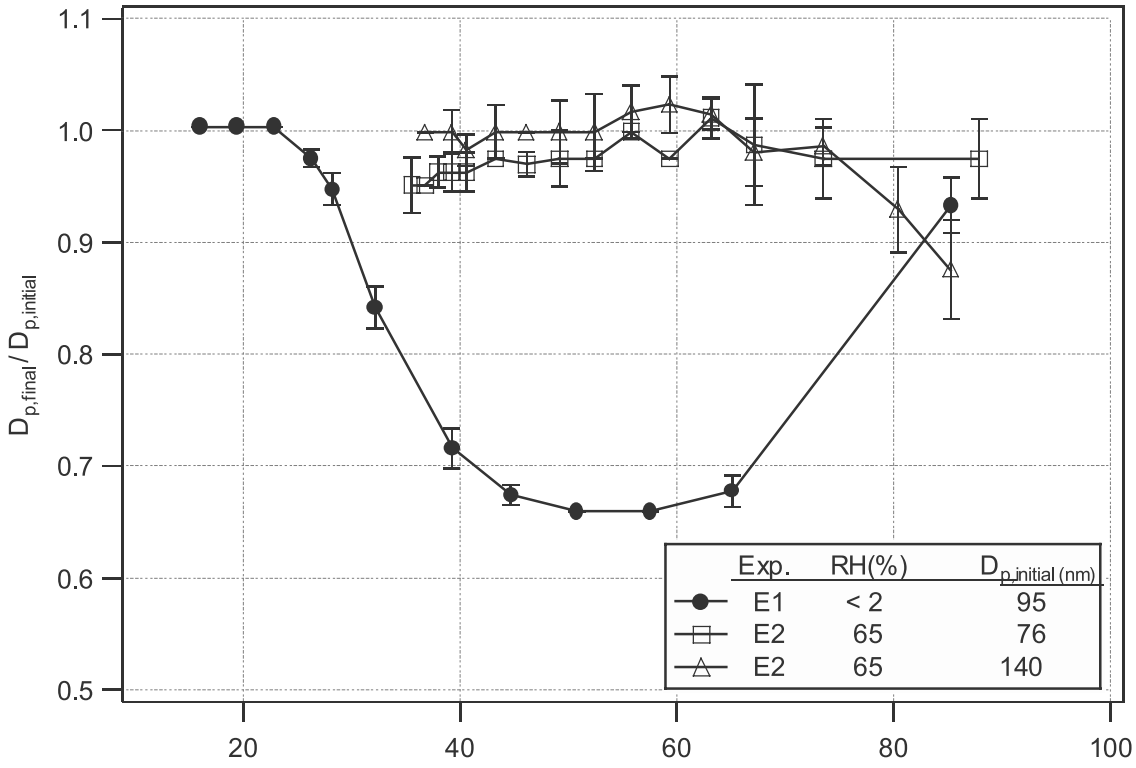
Sub-saturated conditions (H-TDMA):

$$D_w = D_d \left(1 + \kappa_{sub} \frac{a_w}{1-a_w}\right)^{1/3}$$

$$D_{50} = \left(\frac{4A^3}{27\kappa_{super} ln^2 Sc}\right)^{1/3} \left(1 + \kappa_{sub} \frac{a_w}{1-a_w}\right)^{1/3}$$

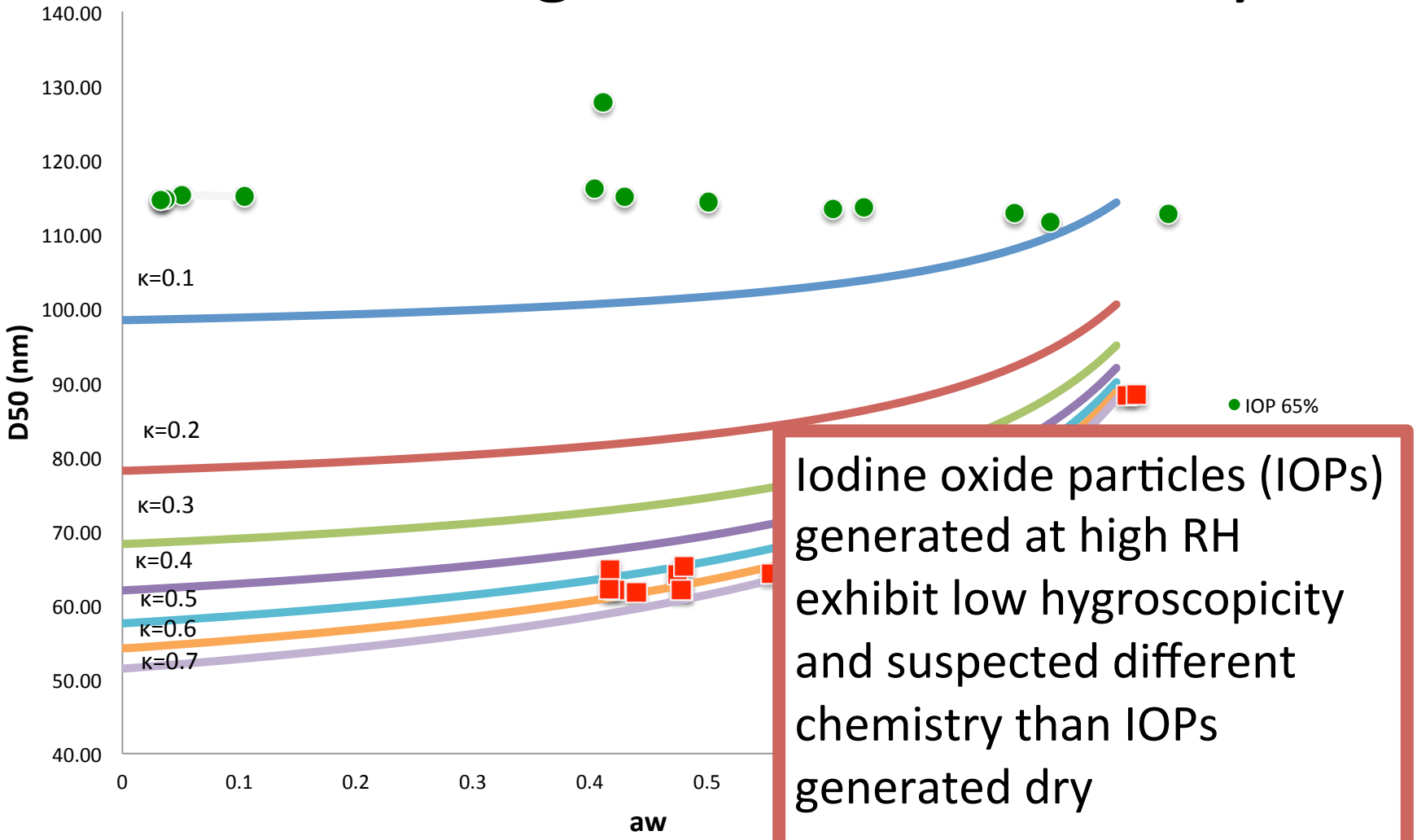
Petters and Kreidenweis, 2007.
Nakao ICNAA Presentation 2013

Varying Reactor Humidity



Based on findings by Jimenez et al. 2003; low hygroscopicity observed for RH 65%

Results: Low Hygroscopicity for IOPs Formed at High Relative Humidity



Iodine oxide particles (IOPs) generated at high RH exhibit low hygroscopicity and suspected different chemistry than IOPs generated dry