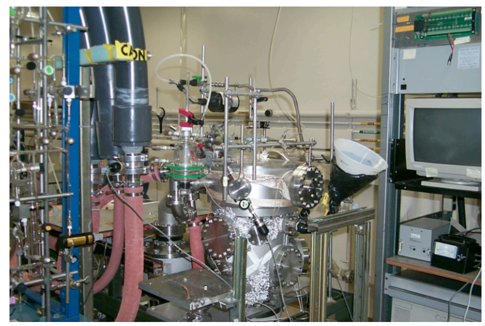
Ames Atmospheric Chemistry Laboratory

Aerosol Composition and Chemistry

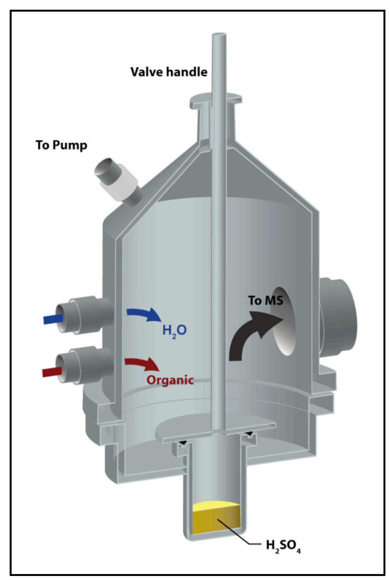
Interactions between gases and particles occur throughout the Earth's atmosphere and can have consequences such as the formation of acid rain and the destruction of stratospheric ozone. To understand how these processes occur in Earth's highly complex atmosphere, our research group studies aerosol processes in a controlled laboratory setting. By carefully varying parameters such as temperature, relative humidity, and particle composition, we can isolate the response due to changes in each of these conditions in the real atmosphere. Our results can then be used in an integrated analysis with field measurements and modeling studies to produce a more complete understanding of our environment and to predict how future changes in temperature or particulates may, in turn, affect the chemistry of the atmosphere. Questions of interest to us include:

- How does the atmosphere affect particle composition?
  - What is the nature of the organic material in stratospheric sulfate particles?
  - Does particle composition change due to human activities?
- How does the chemistry of particulate matter affect the atmosphere?
  - Can particles serve as temporary reservoirs for organic material, transporting it from one region to another?
  - Can particles facilitate reactions that don't occur in the gas phase?
- Can we understand and predict processes which control particle behavior and composition?
  - What chemical and physical factors control uptake of organics into mixed sulfuric acid/water solutions?
  - Do we understand the solubility & reaction of small organics in acid solutions?
- Does particle composition affect the formation of clouds?
  - Are humans affecting the radiative balance by changing cloud properties?

Recent research results include solubility and reactivity studies of methanol, ethanol, acetaldehyde, acetic and trifluoroacetic acid. We have discovered that acetic acid may be the dominant dissolved oxygenated organic compound in UT/LS aerosols and must ask if the presence of acetic acid will affect the uptake of other compounds. Ethanol and acetaldehyde solubilities in H_2SO_4/H_2O solutions have been mapped out under upper tropospheric and lower stratospheric conditions. Ethanol may be a dominant reactive component in particles, despite low levels observed in the gas phase. Propanal reacts easily in 50 and 60 wt% H_2SO_4 solution, and a surface film layer forms under some conditions. Will this film affect uptake of water or other gases? Methyl nitrate is formed from the reaction of methanol with nitric acid in H_2SO_4/H_2O solutions. Nitrobenzene may be formed in similar mixtures.



This Knudsen cell apparatus is used to study the interaction of gases with sulfuric acid or other low-vapor-pressure liquids. A quadrupole mass spectrometer detects changes in the gas of interest when exposed to the acid. The glass Knudsen cell is held together with a large green clamp to the left of center in the photo.

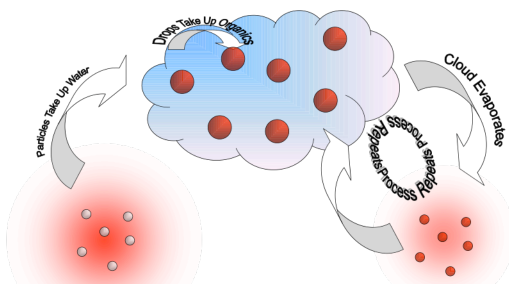


Schematic drawing of the Knudsen cell, showing the valve separating the gases from the liquid before reaction is initiated.

Cloud Growth: Microphysical Measurements and Effects on Aerosol Particles

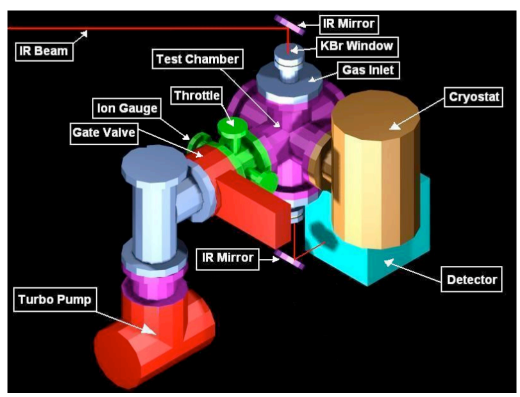
New projects in development will study cloud growth and chemical effects in the atmospheres of Earth and other planets. As aerosol particles activate into cloud droplets, they experience radical changes in composition, viscosity, and pH. These cloud conditions will favor different chemical behavior than did the starting conditions, but this evolution is not considered in chemical models of the particles in our atmosphere. Further, as non-precipitating cloud droplets dry out and return to the aerosol state, they will be changed relative to their original state. While the science community is starting to acknowledge probable changes to the physical form of aerosol particles during processes such as these, the potential chemical changes have not been explored.

Multiphase reactor allows temperature-controlled studies of aqueous processes. The gases in equilibrium with solution are monitored with infrared spectroscopy.



Our newest apparatus is being constructed to examine the growth of water ice clouds on present and past Mars to assist in the interpretation and modeling of results from the Mars Global Surveyor and Mars Odyssey missions. We will determine the super-saturation conditions needed to initiate ice cloud growth on martian dust particles. This number is crucial for modeling the cloud formation on Mars and understanding the heat balance of the atmosphere, yet values used currently have no experimental foundation. The importance of the chemical composition of the dust will be explored, as will the phase of ice formed and the effect of cooling rate on the ice properties.

Liquid nitrogen dewar and copper sample holder will cool and support martian dust analog materials in the beam of an infrared spectrometer, which can detect water ice formation.



Schematic drawing of the Mars Cloud Chamber, which will allow ice to be grown on dust samples held at pressure and temperature conditions representative of the martian atmosphere.

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