

Water Vapor Sorption Analyzer

Capabilities:

- Dynamic water vapor sorption isotherms from 5 to 85° C
- Water sorption kinetics
- *In-situ* preheating/drying of samples to 300°C
- Water diffusion and permeation measurements
- Optional Fiber Optic Raman
- Optional Color Video Microscopy
- Next generation experimental control and evaluation software



DVS Adventure

Dynamic Gravimetric Water Sorption Analysis

In 1992 Surface Measurement Systems invented the world's first Dynamic Vapor Sorption Analyzer. The DVS Adventure is the culmination of nearly 25 years of world leading innovation in gravimetric instrumentation. Our new DVS Adventure is a water vapor sorption analyzer measuring sorption and desorption isotherms over a broad range of humidities and temperatures (5-85°C 0-98%RH). The DVS Adventure offers unprecedented temperature stability and humidity performance as well as a range of optional modular features. It provides valuable information about the interactions of a sample with water vapor that is critical for the development of new materials and processes. Many industries consider water sorption properties of raw materials as key parameters in determining their storage, stability, processing and application performance.

Key Measuring Capabilities

- Water sorption and desorption isotherms
- Optional *in-situ* sample preheating/drying to 300°C
- Multiple sorption/desorption and sample drying or activation cycles
- Sample masses from 1mg to 5000mg
- Surface and bulk measurement capabilities and analysis

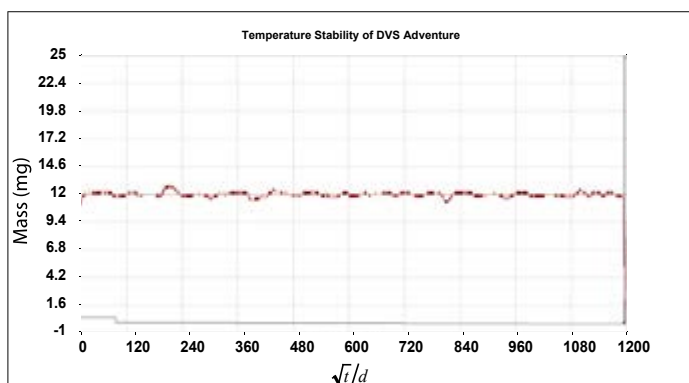
Key Hardware Benefits

- Open stand design enabling easy access to sample pan
- Stainless steel stand minimizes static electrical charging
- Broad range (5-85 °C) and uniform temperature enclosure
- Next generation control and evaluation software for the most advanced experimental design and data analysis
- Capable of upgrading to organic vapors
- Optional IR, Raman and Video imaging



A key feature of DVS Adventure is the combined ability to precisely control and measure temperature and relative humidity while recording the highest resolution changes in mass. DVS Adventure uses a dry carrier gas typically nitrogen or compressed air for its operation. Digital mass flow controllers regulate flows of dry and saturated gases. Relative humidity is generated by precisely mixing dry and saturated gas flows in desired flow ratios which produce expected relative humidity. In a typical experiment a known concentration of water vapor is delivered over a sample placed inside the sample pan connected to the Surface Measurement Systems Ultrabalance™ measuring real-time mass changes caused by sorption or desorption of water molecules. Prior to sorption measurements, the sample can be *in-situ* preheated/dried at temperatures of up to 300°C. Additionally, the sample chamber and water vapor generation are at thermal equilibrium in a single temperature enclosure allowing for operation over the entire temperature range (5-85 °C) without risk of condensation.

DVS Adventure - Outstanding Performance

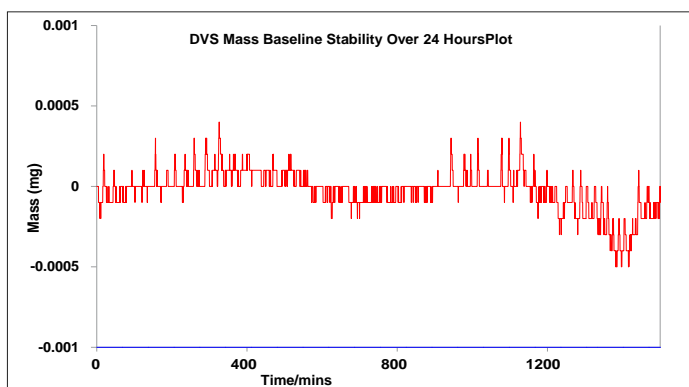
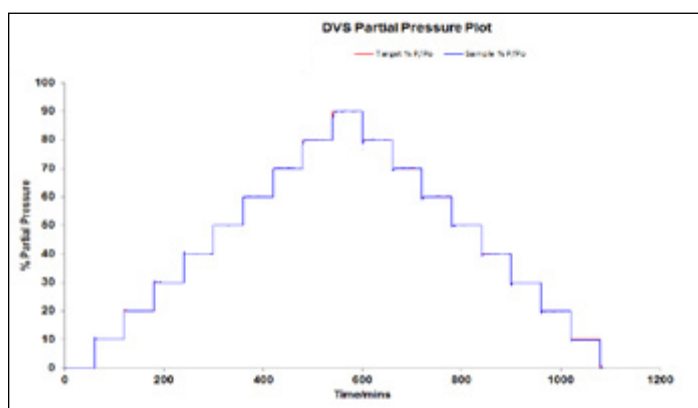


Long Term Temperature Stability

The DVS Adventure features an extremely stable single temperature enclosure around the entire instrument allowing vapor generation and delivery to occur at the sample temperature over the entire operational range of 5-85 °C. Typical stability at 25°C is $\pm 0.02^\circ\text{C}$. This prevents condensation issues found with multiple temperature zone instruments, and allows for more accurate and more stable humidity delivery.

Humidity Performance

The DVS Adventure has the highest level of humidity precision in any instrument we've ever produced. Generated humidities are typically within $\pm 0.1\%$ RH of target humidity.

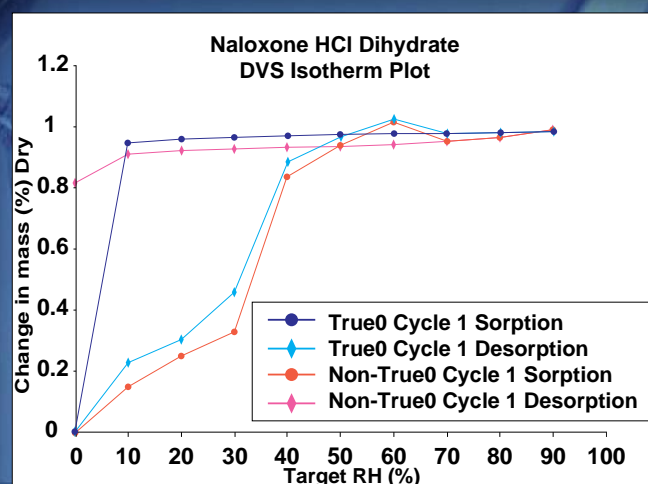


Balance Baseline Stability over 24 hours

The DVS Adventure is capable of measuring mass changes at a resolution of 0.1 μg with root mean square balance noise of less than or equal to 0.2 μg . The Surface Measurement Systems Ultrabalance™ is unrivaled in its precision and accuracy.

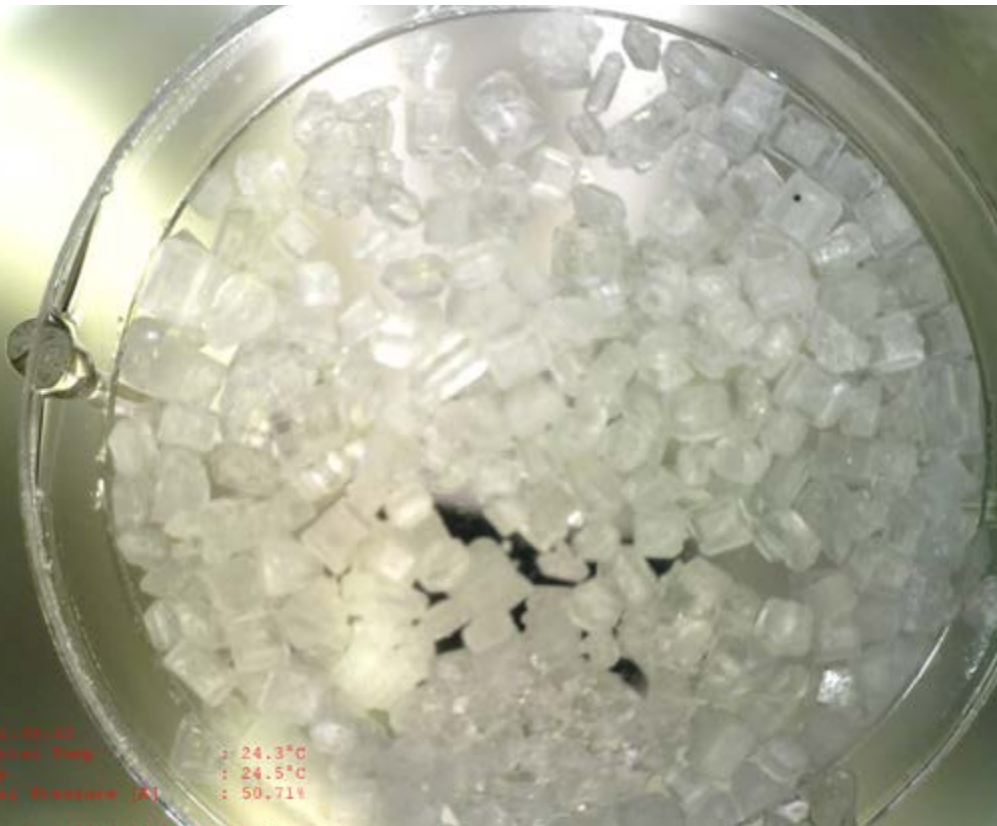
True0™ RH

Surface Measurement System's DVS gravimetric sorption analyzers are the only instruments of their type offering True0™ RH. Our DVS instruments achieve partial pressures of water as low as 0.0% RH. This is important for hydrates and other compounds that only completely dry below 1% RH and investigation of sorption/desorption at low RH levels.



Extended Capabilities of Water Sorption Analysis

Camera and Video

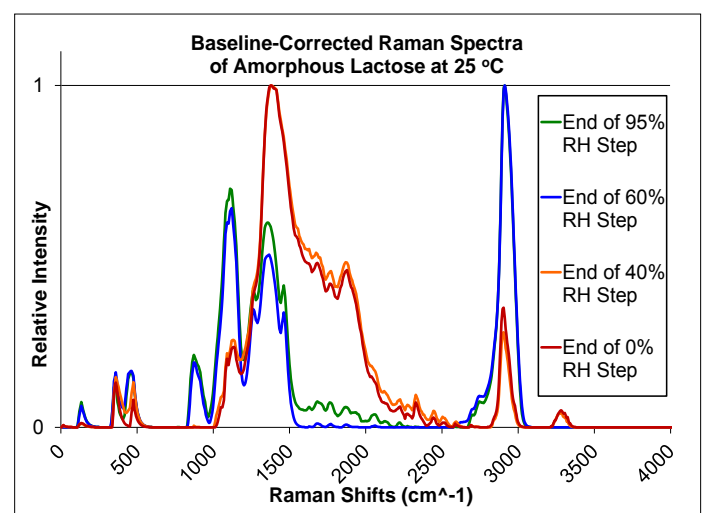


The DVS Adventure has an optional 5 megapixel color camera, over 4 times the resolution of our DVS Advantage. The camera is equipped with a 200x optical zoom lens for incredible detail.

This option allows you to visually explore the macroscopic effects of moisture on your samples. All images have time-date-temperature-humidity stamps.

Raman Spectroscopy

Raman spectroscopy is a widely used technique for physical characterization, and the DVS Adventure offers a fully integrated solution for triggering and capturing Raman spectra during sorption experiments. Combining Raman spectroscopy and Dynamic Vapor Sorption allows for a more complete understanding of vapor-solid interactions for materials as it relates to their chemical and structural properties.



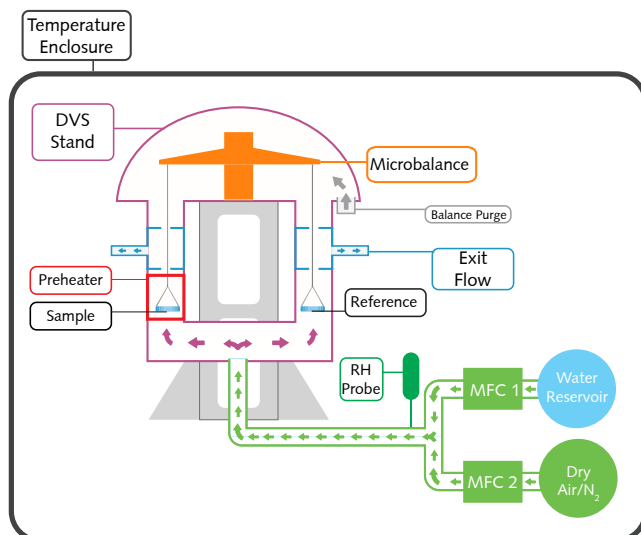
In-situ Raman spectra for MCC at 25 °C exposed to different RHs.

Expandable Manifold for various sample geometries and mass up to 5 grams.

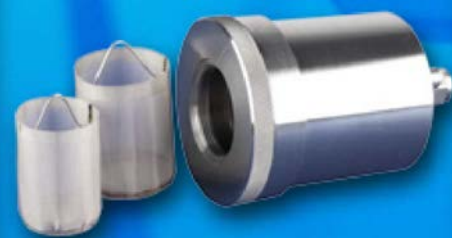
The DVS Adventure offers an optional Expandable Manifold allowing for large and varied sample geometries. The expanded manifold can accommodate samples such as catalytic converters, as well as larger volumes of powdered materials. This coupled with a high mass Ultrabalance™ allows for the use of large samples in cases where smaller samples may not be representative. The expanded manifold has an inner diameter of 59 mm (2.25in) and a depth of 65mm (2.5in) and combined with our high mass Ultrabalance™ increases the experimental possibilities dramatically. Samples can include circuit boards, biscuits, construction materials, wood chips, blister packs, small bottles, capsules, inhalation devices, freeze drying vials and electronic components.

High temperature enclosure and preheater for accurate vapor generation at elevated temperatures.

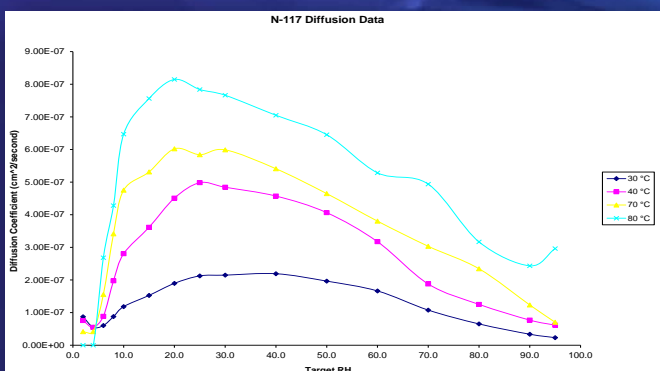
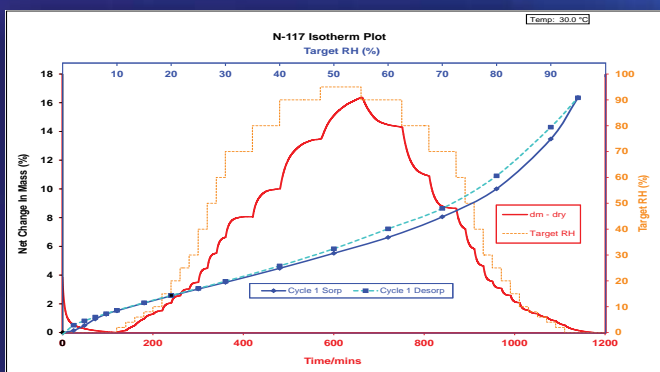
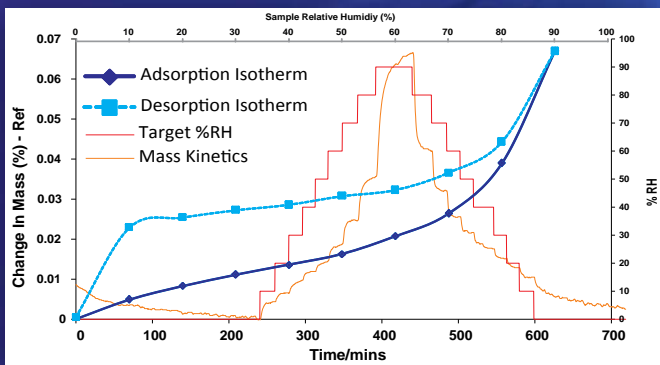
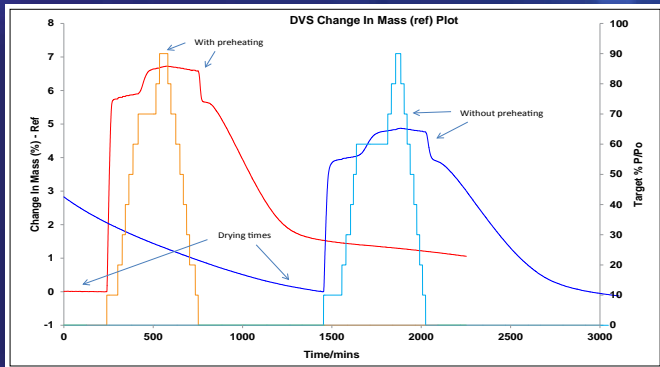
A high temperature pre-heater is optional for *in-situ* degassing/activation of samples up to 300°C. The temperature is measured by Pt100 placed below a stainless steel sample pan. It is also possible to incorporate humidity generation at temperatures up to 150°C.



System Schematic



Applications of DVS Adventure



Drying

Drying is one of the most important industrial processes involving many solid state materials. Using a pre-heater in the DVS Adventure will allow rates of drying at a range of temperatures to be easily studied. In addition the pre-heater also allows water sorption experiments to be conducted when the sample is exposed to temperatures as high as 150°C.

Moisture Sorption with very low uptake

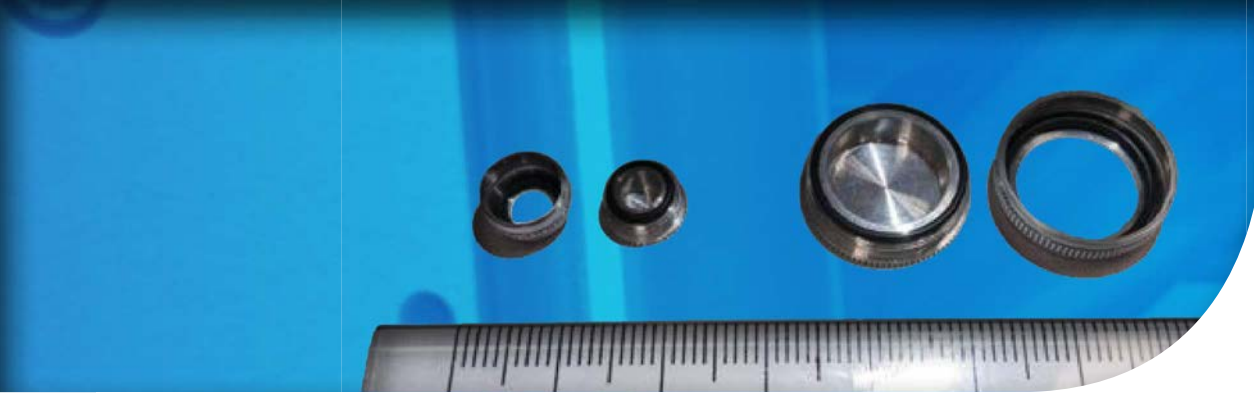
The DVS Adventure features Surface Measurement Systems' Ultrabalance™ for incredible precision when measuring very low water uptake in crystalline or hydrophobic samples. Materials whose maximum water sorption uptake is as low as a 0.05% mass increase can be routinely studied.

Moisture Sorption Kinetics and Isotherms

Moisture sorption and desorption kinetics (red) and isotherm (blue) for the proton exchange membrane at 30°C. Water sorption kinetics are relatively fast as the sample rapidly approaches equilibrium with each change in humidity. Water sorption is dominated by bulk sorption for this specific amorphous polymer.

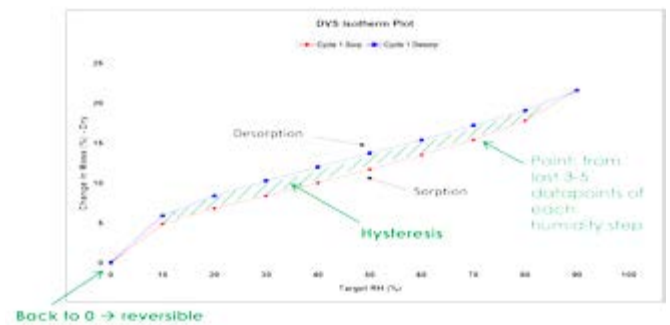
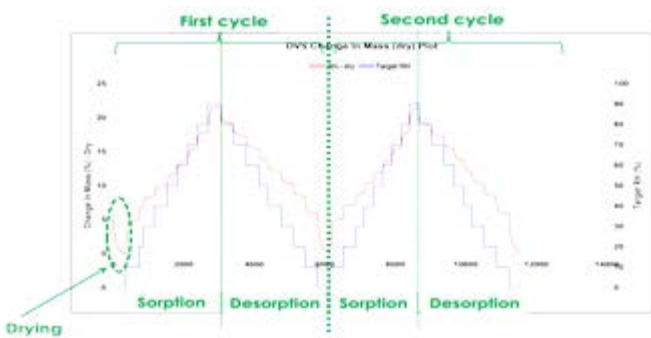
Diffusion coefficients

Diffusion coefficients for N-117 proton exchange membrane. The calculations have been made at 30, 40, 70, and 80°C from 0 to 95% RH. Optional Payne type cell extends measurement range to include vapor permeation and moisture vapor transmission rates (MVTR) through porous materials such as silicone membranes, human skin and electrospun polymer fiber mat.



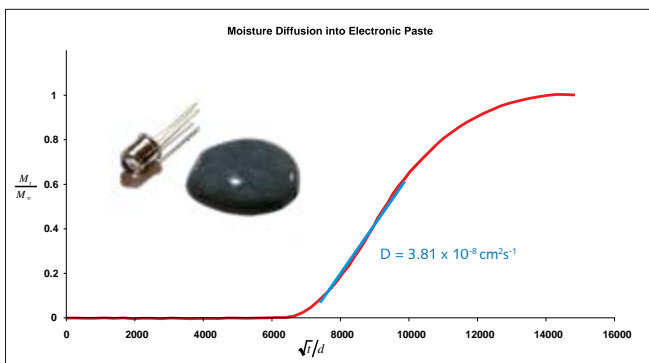
Water sorption/desorption Isotherms

DVS Adventure can be used to determine water sorption isotherms, which depict mass changes as a function of varying relative humidity at constant temperature; i.e. mass is increased during sorption and decreased during subsequent desorption. This is achieved by exposing the sample to a selected relative humidity until mass equilibrium at each RH step has been established. This is repeated until a complete sorption and/or desorption isotherm is completed. In addition, hygroscopicity of solids can be measured at constant temperature with controlled changes in RH.



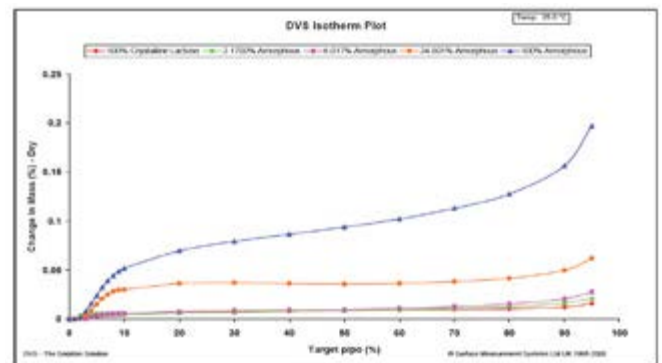
Moisture Diffusion into Electronic Pastes

Post curing diffusion plot for Electronic Pastes. *In-situ* curing at 150 °C with subsequent diffusion coefficient (D) calculation using the slope of the linear portion of mass data between 0-90% RH at 60 °C.



Determination of Amorphous Content

DVS can quantify amorphous content as the amorphous phase sorbs more water than the crystalline phase. Amorphous contents of < 0.05% by mass can be routine determined using the DVS.



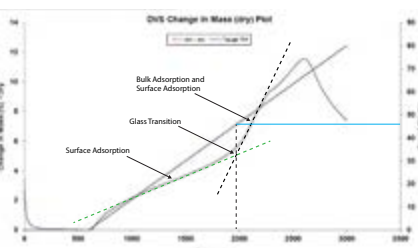
Ramped Humidity/Moisture induced phase transitions

Amorphous solids often absorb relatively large amounts of water vapour, which is a plasticizing agent.

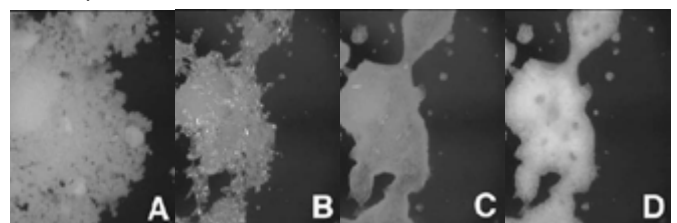
Measuring the temperature and humidity for T_g is thus critical. By measuring water uptake as humidity is ramped the moisture induced T_g can be determined.

DVS Video Imaging - Phase Changes

Amorphous solids upon sorbing water can change from free flowing solids(A) to gels(B) and then to liquids(C) prior to crystallizing(D) as shown below for spray dried amorphous lactose.



At 25°C this material has a T_g of 38% RH



In-situ images collected on amorphous lactose at 0% (A), 50% (B), 60% (C), and 90% RH (D).



Surface Measurement Systems

World Leader in Sorption Science

Temperature

Temperature controlled enclosure

Control range: 5°C to 85°C
Control precision: $\pm 0.1^\circ\text{C}$ from 5-60°C, $\pm 0.2^\circ\text{C}$ from 60-80°C
Enclosure also provides anti-condensation protection.

High temperature pre-heater for sample drying/activation

Two temperature options: 150°C and 300°C (maximum local temperature)
Heating ramp rates: up to 10°C/min
Sensors: Pt-100 thermocouple

Adventure stand

Manifold: stainless steel
Seals: Viton
Tubing: 1/4inch stainless steel

Water Reservoir

Material: glass
0.5 and 1L as standard

Relative humidity generation and measurement

High accurate digital mass flow controllers for delivering gases with humidity control of less than $\pm 0.1\% \text{RH}$
Relative humidity sensor with measurement precision of $\pm 0.1\% \text{RH}$

Range

5 to 60 °C - 0 to 98%RH
60 to 85 °C - 0 to 85%RH

Accuracy

5 to 60°C $\pm 0.5\% \text{RH}$
60 to 85°C $\pm 1\% \text{RH}$

Instrument Platform

System Software

Next generation purpose built control and evaluation software for the most advanced experimental design and data analysis.

Analysis

- Isotherms
- Permeability and diffusion
- Kinetics information
- Heat of sorption
- T_g determinations
- Amorphous content

Control

Complex protocols for multiple experiments using sample pre-heating, with change of sample temperatures and time, with ramp or step changes, can be set up, and run fully automatically, thus releasing valuable operator time.

Mass measurement

Ultrabalance 1

High Mass SMS microbalance
Sample mass: between 1 and 1000mg
Mass change: $\pm 150\text{mg}$
Resolution (precision): 0.1 μg
Root mean square balance noise: $\leq 0.2 \mu\text{g}$

Ultrabalance 2

High Mass SMS microbalance
Sample mass: between 10 and 5000mg
Mass change: $\pm 1000\text{mg}$
Resolution (precision): 1 μg
Root mean square balance noise: $\leq 5 \mu\text{g}$

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