PRODUCT INFORMATION

Model 1040XP—Humidified Tandem Differential Mobility Analyzer (HTDMA)

This humidified tandem DMA system has two differential mobility analyzers and a humidification section in between. Aerosol from the ambient atmosphere or from the built-in aerosol generator can be classified by the first DMA to produce a monodisperse aerosol for size analysis by the second DMA to determine the growth in particle size as a function of relative humidity.

INTRODUCTION

The Model 1040XP Humidified Tandem Differential Mobility Analyzer (HTDMA) is a multi-function aerosol instrument comprised of :

- an atomizer aerosol generator, a non-radioactive electrical ionizer, a differential mobility analyzer (DMA) and a condensation particle counter (CPC) for monodisperse aerosol generation and measurement
- a high-accuracy humidity conditioner
- a differential mobility particle spectrometer.

The atomizer generates a polydisperse aerosol, which is then neutralized and electrostatically classified by mobility to generate a monodisperse aerosol. The output aerosol concentration is continuously monitored by the built-in CPC.

The humidity conditioner is used to condition the monodisperse aerosol to a precisely controlled relative humidity in the 10 to 93% RH range, the humidity being user selectable and is accurately measured by a dew point hygrometer.

The second differential mobility analyzer (DMA) and the condensation particle counter (CPC) in the system can function as a differential mobility spectrometer (DMS) or as a scanning mobility spectrometer (SMS) to measure the size distribution of the humidity-conditioned aerosol from 10nm to 1000nm.

The HTDMA method has been used to study the growth of hygroscopic particles in humid atmospheres. For such studies, the aerosol is generated at one relative humidity and following electrostatic classification by one DMA, the aerosol is then exposed to a different relative humidity. The resulting particle size is then measured by a second DMA with a CPC to determine the change in particle size due to moisture absorption or desorption by the hygroscopic particles. Figure 1 shows the growth of NaCl aerosol in a humid atmosphere.

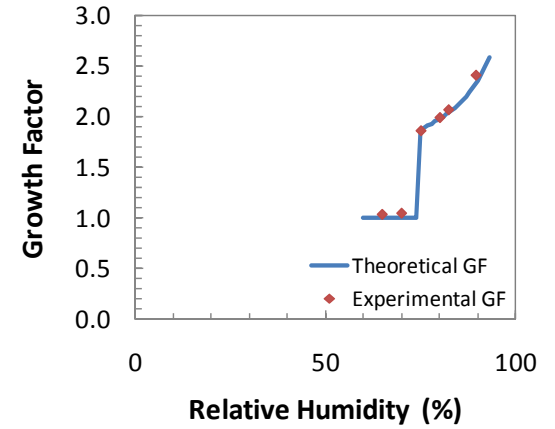

Figure 1. Growth of 100-nm NaCl particles

DESCRIPTION

The Model 1040XP is provided with three basic aerosol instrument components:

- a monodisperse aerosol generation system comprised of an atomizer to produce a polydisperse aerosol, a dryer, a diluter, a neutralizer, a DMA and a CPC.
- a humidity conditioner for accurate conditioning of the generated aerosol to a user-selected relative humidity (10 to 93% RH)
- a differential mobility analyzer for size classification of the conditioned aerosol by electrical mobility and a condensation particle counter for counting particles by vapor condensation and droplet growth, followed by droplet detection by laser light scattering.

Figure 2 is a simplified schematic diagram of the HTDMA system. The instrument is designed to be user friendly and easy to operate. Many of the key components are easily accessible to the user.

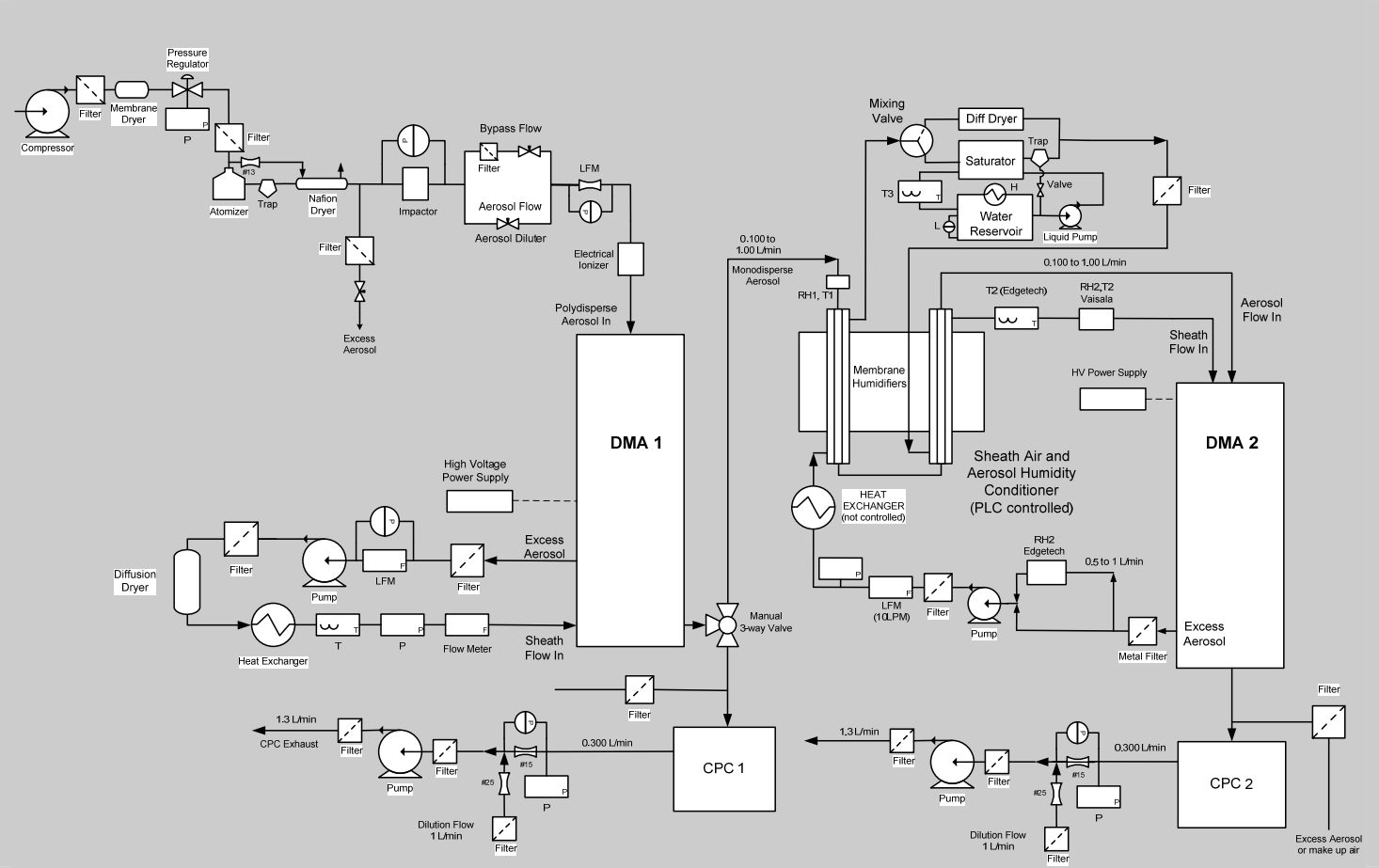

Figure 2. Simplified schematic diagram of the HTDMA

Built-in Atomizer Aerosol Generator

A compressed-air atomizer is used to generate a spray of fine droplets suspended in air. This droplet aerosol is then dried to form a polydisperse aerosol comprised of residue particles formed from the dissolved non-volatile material in the atomized liquid. Common materials used for laboratory aerosol generation include NaCl, other soluble salts, polystyrene latex (PSL) spheres suspended in water; and organic materials such as oleic acid dissolved in ethanol.

The atomizer used is a single jet Collison-type device operated by compressed air. The droplet spray is about 2 µm in volume-mean diameter for an aqueous solution. Drying is by means of a Nafion^{R} membrane dryer. The bypass-type diluter allows the

user to control the concentration of the polydisperse aerosol generated by the system over a wide range.

Electrical Ionizer and Differential Mobility Analyzer

In the Model 1040XP, an electrical ionizer is used to generate the ions (no radioactive source is needed) to neutralize the aerosol particles bringing the particles to a state of Boltzmann charge equilibrium. The resulting charged particles are then classified into a narrow size distribution by the built-in DMA to provide a monodisperse aerosol at the output.

The DMA is cylindrical in shape and has an overall height of 15.6 inches (400mm). When operated with a sheath flow of 10.0 L/min, the DMA has a mobility range to allow particles as small as 8nm to be classified. At 3 L/min flow, particles as large as 1,000nm can be classified. The aerosol particle size selected for size classification can be adjusted by varying the DC high voltage applied to the DMA.

The DMA is operated in a re-circulating sheath flow mode, with the sheath flow being controlled accurately by feedback control. A heat exchanger is used to maintain the sheath flow to the same temperature as the ambient room air.

Condensation Particle Counter

The Model 1040XP uses a condensation particle counter to monitor the aerosol output concentration. The CPC is of a patented MSP design, with two separate fluid reservoirs: one containing the working fluid, typically 1-butanol, and the other for collecting the condensate of butanol and condensed moisture in the condenser. The CPC has a nominal detection limit of 5nm in particle diameter. The nominal flow rate of the CPC is 0.3 L/min.

The monodisperse aerosol concentration in the Model 1040XP is automatically monitored by the built-in CPC. Under normal operation, the concentration range of the CPC is from approximately 1 to 30,000 particles/cc with automatic real-time coincidence correction.

Humidity Conditioner

The monodisperse aerosol is introduced to a humidity conditioner. Two Nafion® Humidifier tubes connected in series are mounted on a metal plate attached to the back of the second DMA. The aerosol circulates through the interior of the membranes, while the DMA sheath air flow rate circulates through the outside of the membranes. The direct contact between the Nafion® tubes and the DMA casing, and the strong circulation provided by the fan of the sheath flow heat exchanger minimizes thermal gradients and ensures uniform temperature of both flow streams. Two humidity sensors are used in the RH sheath flow loop. A capacitive sensor is used to drive the control loop right after the set point has been entered. When the RH is close to the set point, the control loop then switches to a chilled mirror dew point sensor to achieve the set point with high accuracy.

Electrical Mobility Spectrometer

The humidity conditioned aerosol and sheath air streams are introduced to the second DMA, which is used in the voltage stepping or scanning mode to measure the resulting aerosol size distribution of the aerosol after humidity conditioning. A second CPC of the same design described before is used to measure the number concentration of the DMA classified aerosol.

Calibration

The Model 1040XP HTDMA is calibrated at the factory to provide NIST-traceable particle size calibration by using polystyrene latex (PSL) spheres of 101-nm and 269-nm diameter from the National Institute of Standards and Technology (NIST).

System Control

The Model 1040XP is a fully automated instrument controlled by two single-board computers to provide automatic feedback control of all major operating parameters.

FEATURES

- High stability atomizer aerosol generator
- High accuracy aerosol humidity conditioner
- Wide range, high resolution DMAs
- Patented dual-reservoir CPCs
- DMS and SMS data analysis software
- User friendly user interface with touch screen display
- Automatic data logging

APPLICATIONS

- Study of the hygroscopic growth of aerosols for accurate deliquescence and efflorescence measurements.
- Other aerosol studies by the TDMA method.

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SPECIFICATIONS

Overall Specifications of the Model 1040XP HTDMA*

Aerosol Generator (Part 1 of system)	460 mm (H) x 610 mm (D) x 525 mm (W)
Part 1/Part 2 Total Weight	100 lbs (45 kg)/ 140 lbs (60 kg)
Power Requirements (Part 1)	115 or 230 VAC, 50-60 Hz, single phase, 250 W max, 160 W steady
Humidity Conditioner/Spectrometer (Part 2)	460 mm (H) x 610 mm (D) x 525 mm (W)
Power Requirements (Part 2)	100- 240 VAC, 50-60 Hz, single phase, 500 W max, 400 W steady
Operating Aerosol Pressure	800 to 1050 mbar absolute pressure
Ambient Temperature Range	10 to 35 ºC
Ambient Humidity Range	0-90% RH, non-condensing

Polydisperse Aerosol Generation System

Single-Jet Atomizer	Stainless Steel Construction
Pressure	5 to 60 psig (5 to 415 kPa gage), controlled by manual pressure regulator
Aerosol Flow Rate	Typical 3 L/min @ 35 psig (240 kPa gage)
Volume Mean Droplet Diameter	about 2 µm (GSD< 2.0)
Aerosol Size Range	10 to 2000 nm
Aerosol Concentration	> 10^7 particles/cm^3 (typical for NaCl)
Dryer	Diffusion type (Nafion^R membrane requires dry comp. air, -20 ºC dew point)

Humidity Conditioner

Relative Humidity Control Range	10 to 93% with user-selected set point in 1% intervals
Flow Rate	1 to 10 L/min
RTD and Dew Point Accuracy	± 0. 2 ºC
RH Accuracy	± 1.5% for chilled mirror sensor; ± 2.5% for capacitive sensor
RH control stability	± 1.2% (typical)
Response Time for < 10% ΔRH	< 3 min (typical)
Water Reservoir Heater Control	25 to 50 ºC in 5 ºC intervals
Saturator	Nafion® Humidifier with DI water closed loop circulation
Dryer	Diffusion type (Drierite® desiccant)

Differential Mobility Analyzer

Inlet Aerosol Flow Rate	0.1 to 1.0 L/min, controlled externally from Model 1500 AGM
Monodisperse Aerosol Flow Rate	0.1 to 1.0 L/min (equal to inlet aerosol flow rate)
Sheath Air and Excess Air	1.0 to 9.0 L/min, closed-loop, user-selected set point
High Voltage Power Supply	10 to 10,000 V, user-selected (software limits max voltage to 9,000V)
Aerosol Size Range	8 to 1000 nm, user-selected
Maximum aerosol input conc.	10^8 particles/cm^3
Particle Type	Solids and non-volatile liquids

Condensation Particle Counter

Working Principle	Laminar continuous flow with single particle detection
Flow Rate	0.3 L/min controlled by internal feedback control system
Particle Diameter Range	5 nm to 2 µm
Concentration Accuracy	± 10% (compared to calibrated reference MSP CPC)
Concentration Range	0 to 3x10^4 particles/cm^3; (single particle counting with coincidence correction)
Working Fluid	1-butanol (n-butyl alcohol)
Response Time (95% response)	< 5 sec

*Specifications are subject to change without notice