INNOVATION IN AIR MONITORING OF PARTICULATE MATTER (PM)

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ABSTRACT

Evolving particulate matter (PM) air pollution regulations and health-related science initiatives have paved the way for innovations in automated continuous PM and PM chemical speciation monitors. Required are methods that provide a better measure of particles in the form that humans breathe. We present an overview of PM measurement methods that focus on the quantification of nonvolatile and volatile particles, as well as specific chemical species (particulate carbon, sulfate, and nitrate). These are commercially-available tools that address timely PM measurement concerns.

INTRODUCTION

Methods for the measurement of airborne PM have developed over the years to address the evolving need for the chemical and physical identification of particle-related air pollution. Most often, the mass concentration of airborne particles has been the quantity of interest as a regulatory indicator for PM. Simple gravimetric air samplers developed over the past fifty years have gradually been augmented or replaced by continuous PM monitors.

PM mass concentration data is gathered primarily in support of regulatory compliance rules that are in place in many industrialized countries. Some other ambient air applications for these types of data include research programs involving PM physical and chemical characterization, air pollution index (or air quality index) calculation for public health reporting, PM mapping and forecasting, compliance monitoring at waste remediation or other dust generating industry facilities, and wood burning control programs.

A number of continuous and gravimetric methods are in use today to gather PM mass concentration data. Historically, the gravimetric methods have been used as the reference to which all other methods are compared. An increasing interest in acquiring more data with greater temporal resolution has lead to a sharp increase in the popularity of continuous methods.

Improvements in semiconductor electronics have helped continuous methods for the assessment of airborne PM make technological advancements. These monitors now often incorporate microprocessor control, active high precision flow control, and digital communications capability. While the guiding science behind each continuous method has not changed, method optimization has been possible through a variety of technological improvements.

It is often desirable for continuous monitors to provide 24-hour integrated data that correlate well with gravimetric methods. This can be problematic, however, since even these gravimetric reference methods may not fully measure the PM as it exists in ambient air. This is due to the sample filter and accumulated PM being subject to inconsistent thermodynamic conditions during sampling, conditioning and measurement.

The following summarizes two PM mass concentration measurements systems that seek to either minimize or better quantify the total atmospheric aerosol to which humans are exposed. Four additional monitors are presented that can provide species specific PM data for the application within the areas of health-related exposure impact, atmospheric processes, source apportionment, and control measures for attainment with regulatory standards.

CONTINUOUS PM MONITORING METHODS

TEOM® Series 1400a Ambient Particulate Monitor with FDMS® Series 8500 Filter Dynamics Measurement System

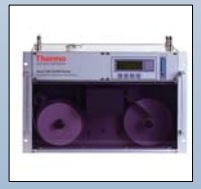
- Measures nonvolatile and volatile PM mass concentration components
- Uses the differential TEOM technology developed by H. Patashnick (Thermo Electron)
- Data cycle: 6-minutes
- Detection limit: < 0.06 µg/m³ (1-hour average)

The TEOM monitor with FDMS system is a self-referencing, primary mass traceable PM measurement system that uses proven TEOM inertial mass measurement technology. The system uses the patented differential TEOM technology and, for the first time, quantifies nonvolatile and volatile PM components as they exist in ambient air. Humidity interference is minimized using an integrated low-loss diffusion dryer.

Model 5030 SHARP, Synchronized Hybrid Ambient Real-Time Particulate Monitor

- Measures PM mass concentration components
- Combines light scattering photometry and beta radiation attenuation for continuous PM measurement (developed by Thermo Electron)
- Data cycle: 1-minute
- Detection limit: < 0.2 µg/m³ (1-hour average)

The SHARP monitor provides a real-time measure of the PM mass concentration using a C^{14} beta attenuation monitor in combination with a fast response light scatter photometer. The system minimizes the humidity interference and loss of volatile PM components through a combination of an Intelligent Moisture Reduction (IMR) system and frequent sample filter changes.



CONTINUOUS PM CHEMICAL SPECIATION

Model 5012 MAAP, Multi-Angle Absorption Photometer

- Measures black carbon (BC) content and light absorption property of PM
- Uses a technique of simultaneous measure of optical absorption and light scattering developed by A. Petzold.
- Data cycle: 2-minute; 10-minute; 30-minute
- Detection limit: < 100 ng/m³ (2-min); < 50 ng/m³ (10-min); < 20 ng/m³ (30-min)

rp Series 5400 Ambient Carbon Particulate Monitor

- Measures the elemental carbon (EC) and organic carbon (OC) contained in PM
- Uses a direct, thermal-CO_2 oxidation technology developed by G. Rupprecht & H. Patashnick (Thermo Electron)
- Data cycle: 3-hour (default); also 1 to 24 hour averaging
- Detection limit: < 200 ng/m³ (3-hour)

Model 5020 SPA, Sulfate Particulate Analyzer

- Measures the mass concentration of total ambient particulate sulfate
- Uses combined thermal reduction technique and pulsed fluorescence spectroscopy developed by Harvard School of Public Health.
- Data cycle: 15-minute
- Detection limit: < 0.5 µg/m³ (15-min)

rp Series 8400N Particulate Nitrate Monitor

- Measures the mass concentration of ambient particulate nitrate contained in PM-2.5
- Uses combined flash vaporization technique and chemiluminescence analyzer developed by S. Hering (Aerosol Dynamics)
- Data cycle: 10-minute
- Detection limit: < 0.2 µg/m³ (10-min)