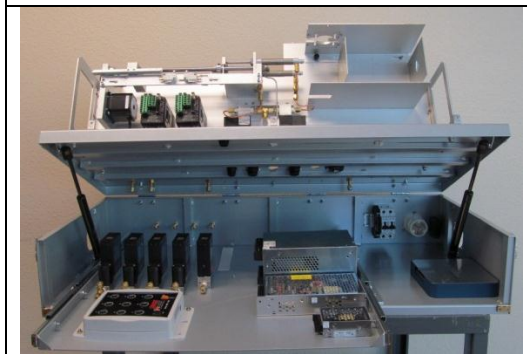


DRI Model 2015

Multi-Wavelength Thermal/Optical Carbon Analyzer

Overview

The DRI Model 2015 Multi-Wavelength Thermal/Optical Carbon Analyzer enhances the widely-used DRI Model 2001 system for quantifying organic carbon (OC), elemental carbon (EC, also termed Black Carbon [BC]), and temperature-separated carbon fractions on aerosol filter deposits. The Model 2015 retains OC and EC consistency with previous measurements while reducing costs of supplies and maintenance compared with the Model 2001. It replaces the 633 nm optical monitoring that accounts for OC charring with reflected (R) and transmitted (T) intensities at wavelengths of 405, 445, 532, 635, 780, 808, and 980 nm. The additional optical information can be used to estimate multi-wavelength light absorption of the sampled particles, quantify the concentration of brown carbon (BrC) in each sample, and further complement the use of carbon fractions in source apportionment studies. Model 2015 software includes temperature programs for commonly-used protocols such as IMPROVE_A, EUSAAR, and NIOSH, and it can be programmed to emulate any other protocol. The simultaneous measurement of both R and T at all wavelengths throughout each analysis allows for reproducing any other thermal/optical method and holds potential for better characterizing additional properties of the carbonaceous aerosol.



Applications

- Air quality and climate change research
- Particulate Matter (PM) speciation trends networks
- PM source apportionment
- Carbonaceous material analysis

Key Features and Improvements

- Compatible with the IMPROVE_A carbon analysis protocol, used in the U.S. urban Chemical Speciation Network (CSN), the non-urban Interagency Monitoring of PROtected Visual Environments (IMPROVE) Network, and long-term networks in other countries.
- High-intensity light sources and perpendicular orientation for R and T measurements to maximize optical sensitivity.
- Nondispersive infrared (NDIR) CO₂ detection eliminates need and maintenance for methanator and hydrogen gas used with Model 2001 flame ionization detector (FID).
- Reduced helium gas consumption.
- Mass flow controllers provide more precise throughput measurements.
- LabVIEW-based software provides enhanced user interface and instrument control.
- Ergonomic engineering provides improved access for maintenance and repair.

Contact Magee Scientific (www.mageesci.com) or Dr. Judith C. Chow (judith.chow@dri.edu) at DRI for more information and availability of instrumentation and calibration standards.

Operating Principle

Thermal/optical carbon analysis is based on the preferential oxidation of OC and EC materials under different temperatures and atmospheres. A $\sim 0.5 \text{ cm}^2$ punch from a particle-laden quartz-fiber filter (or other sample form) is heated in programmed temperature steps. Organic compounds are liberated under a non-oxidizing helium atmosphere at lower temperatures up to $580 \text{ }^\circ\text{C}$, while EC is combusted in an oxidizing atmosphere with 2% O_2 at temperatures up to $840 \text{ }^\circ\text{C}$. The liberated carbon is oxidized to carbon dioxide (CO_2) by heated manganese dioxide (MnO_2), and the CO_2 is quantified by an NDIR detector. Seven modulated diode lasers measure the reflectance from, and transmittance through, each filter at wavelengths from 405 to 980 nm.

Nominal Specifications

Measurement Range: 0.05 to $750 \mu\text{g carbon/cm}^2$ (depending on carbonaceous composition)

Minimum Detection Limit (MDL):

- Total OC: $0.43 \mu\text{g/cm}^2$
- Total EC: $0.12 \mu\text{g/cm}^2$
- Total Carbon: $0.49 \mu\text{g/cm}^2$

Wavelengths:

- 405, 445, 532, 635, 780, 808, and 980 nm

Support Gases:

- Ultra-high purity (UHP) helium (hydrocarbon free, $>99.999\%$ purity)
- 10% oxygen in UHP helium
- 5% methane in UHP helium
- Compressed air

Data Reporting Interval:

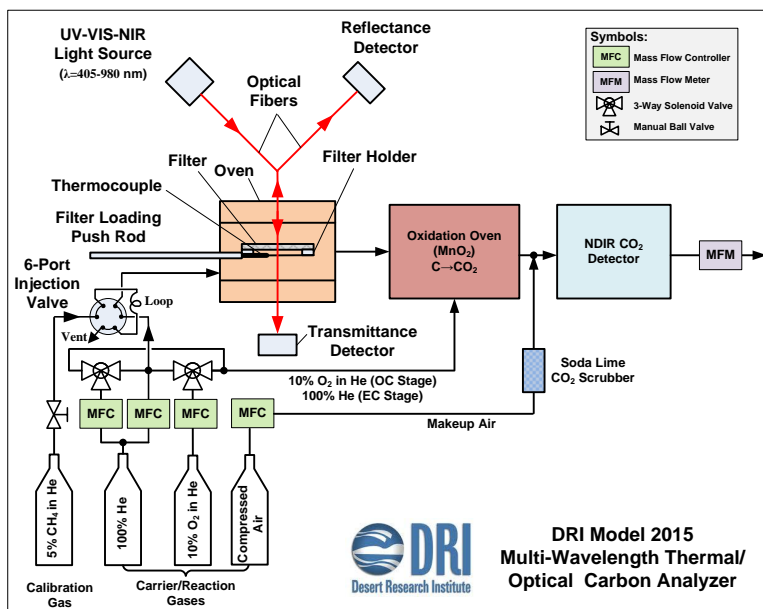
- 1 second

Software:

- LABVIEW-Based

Environmental Operating Conditions:

- Temperature: 10 to $35 \text{ }^\circ\text{C}$
- Relative Humidity: 0 to 90%, noncondensing



Operating Temperatures:

- Sample oven: programmable from 60 to $900 \text{ }^\circ\text{C}$ with maximum heating rate $250 \text{ }^\circ\text{C/minute}$
- Oxidation oven: $900 \text{ }^\circ\text{C}$
- Temperature accuracy: $\pm 5 \text{ }^\circ\text{C}$ or 1%, whichever is greater

Power Requirements:

- 100 to 240 VAC, 50/60 Hz, and 1500 W maximum

Dimensions (H x W x D):

- $44 \times 92 \times 41 \text{ cm}$ ($17 \times 36 \times 16 \text{ inch}$)

Weight:

- 23 kg (50 lbs)

Reference: Chen, L.-W.A.; Chow, J.C.; Wang, X.L.; Robles, J.A.; Sumlin, B.; Lowenthal, D.H.; Watson, J.G. (2014). Multi-wavelength optical measurement to enhance thermal/optical analysis for carbonaceous aerosol. *Atmos. Meas. Tech. Discuss.*, **7**:9173-9201. <http://www.atmos-meas-tech-discuss.net/7/9173/2014/amtd-7-9173-2014-print.pdf>.

Contact Magee Scientific (www.mageesci.com) or Dr. Judith C. Chow (judith.chow@dri.edu) at DRI for more information and availability of instrumentation and calibration standards.