

Application News

No.059

Total Organic Carbon Analysis

Measurement of Water Soluble Organic Carbon in Particulate Matter 2.5

Atmospheric particulate matter 2.5 (PM_{2.5}) is composed of primary particles emitted directly into the atmosphere by a source, and secondary particles generated by chemical reactions in the atmosphere. PM_{2.5} describes fine particles of 2.5 μm or smaller in diameter that some fear may affect the respiratory system and circulatory system. In 2009, governmental environmental standards on fine particulate matter were established in Japan. Since their establishment, findings related to sources of fine particulate matter and mechanisms of secondary particulate generation have been deliberated and control measures discussed. Particular emphasis has been placed on measurements for the concentration of water soluble organic carbon (WSOC) in PM_{2.5}, which is linked to mechanisms of secondary particulate generation.

The WSOC measurement method issued by Japan's Ministry of the Environment describes that it uses ultrapure water to extract WSOC from PM_{2.5} collected on a filter, after which measurements are performed with a TOC analyzer or carbon analysis system. Diesel vehicles are one source of PM_{2.5}, and since the particles generated in diesel particulate matter are 1 μm or smaller, these particles are regarded as being an important part of PM_{2.5}. The main components of diesel particulate matter are carbon components, including WSOC. In this article, we will describe using the Shimadzu TOC-L total organic carbon analyzer to measure the WSOC content in diesel particulate matter based on the measurement method issued by Japan's Ministry of the Environment.

■ Preparation of Water Soluble Organic Carbon Solution

A test solution was prepared by the procedure shown below and according to the WSOC measurement method described by the Ministry of the Environment.

1. Diesel particles were adhered to a 45 mm-diameter quartz fiber filter.
2. The filter was placed in a glass extraction vessel and immersed in 15 mL of ultrapure water.
3. The glass extraction vessel was then immersed in an ultrasonic bath and exposed to ultrasound waves for 10 minutes. During the exposure, the glass vessel was shaken several times to ensure thorough extraction of soluble components from the filter.
4. All extraction liquid was collected in a syringe and passed through a disk filter (pore size 0.20 μm).
5. Filtered extraction liquid was diluted with ultrapure water to make up 100 mL and used as the test solution.
6. A procedural blank solution was prepared by following steps 1 to 5 but without using diesel particles.
7. The two test solutions were measured using the TOC-L analyzer.

■ NPOC Measurement of WSOC Solution

TOC can be obtained by measuring TC (total carbon) and IC (inorganic carbon) then calculating the difference (TOC = TC - IC), or by removing IC by sample acidification and sparging before measuring TOC (TOC = TC). The latter method is called the non-purgable organic carbon (NPOC) method. We used the NPOC method for this experiment.

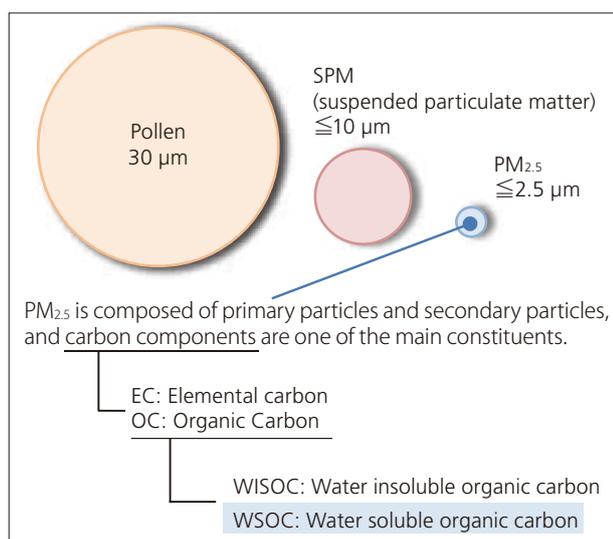


Fig. 1 Components of PM_{2.5}

Table 1 Measurement Conditions

Analyzer	: TOC-L _{CPH}
Catalyst	: High-sensitivity TC catalyst
Measurement Item	: NPOC
Calibration Curve	: Two-point calibration curve obtained from an aqueous solution of NPOC; 0-3 mgC/L potassium hydrogen phthalate
Sample	: Diesel particles (NIST product)

■ Results of NPOC Measurements

Results from analyzing the procedural blank and WSOC test solutions with the TOC-L analyzer are shown in Table 2 and Fig. 2. There was a significant difference between the two results that is assumed to be caused by the WSOC content of diesel particles collected on the filter.

Table 2 Results of NPOC Measurements

Sample Name	NPOC Result [mgC/L]
Procedural Blank	0.131
Test Solution	0.496

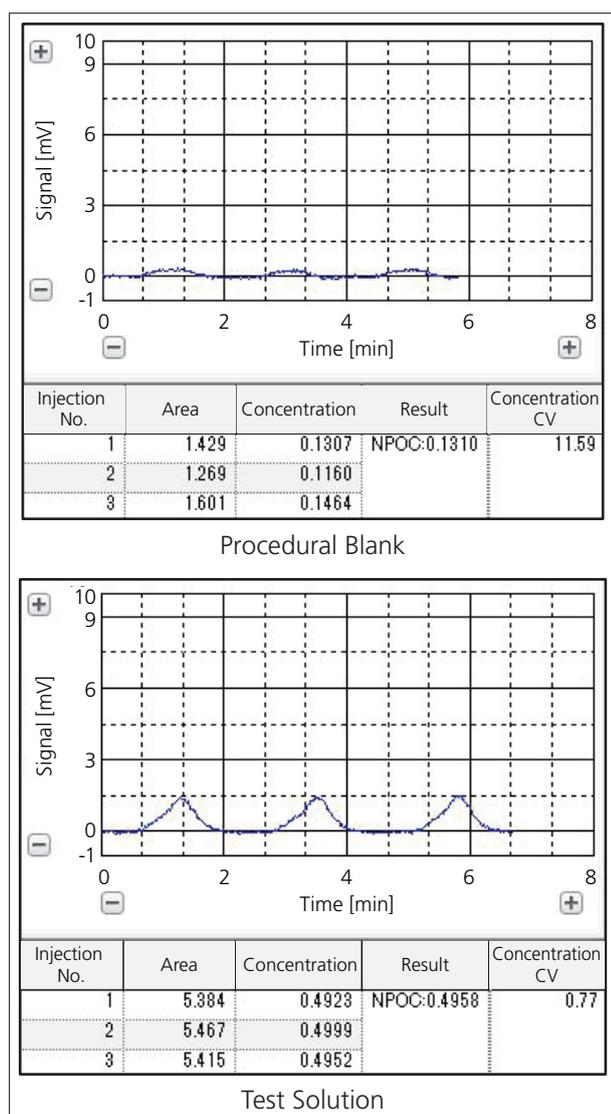


Fig. 2 NPOC Measurement Data

■ Calculation of WSOC Concentration

The WSOC concentration of atmospheric fine particulate matter (PM_{2.5}) can be calculated from the NPOC results shown above using the formula specified in the WSOC measurement method. Fine particulate matter is normally collected using a particulate trap system comprising a particle size selector, flow controller, and suction pump. For this experiment, WSOC concentration was calculated assuming collection conditions of 20 °C air temperature, 1 atmospheric pressure, 16.7 L/min flowrate, and capture time of 24 hours (trapped volume approximately 24 m³).

$$\text{WSOC concentration} = 1.52 \mu\text{g}/\text{m}^3$$

WSOC concentration can be calculated with a TOC analyzer by this method, which can be utilized in the study of diesel engines and investigation of PM_{2.5} generation sources.



Fig. 3 Shimadzu TOC-L Total Organic Carbon Analyzer