

Evaluating the Quantity of CO₂ Absorbed in Concrete by TOC Solid Sample Measurement System

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User Benefits

- ◆ Quickly and easily measure the quantity of CO₂ absorbed in concrete, without extraction or other pretreatment steps (measurement time: 6 to 8 minutes).
- ◆ Measure sample quantities up to 1 g to minimize effects from uneven distribution within samples.
- ◆ The system can measure both total carbon (TC) and inorganic carbon (IC) content values, which can be subtracted to determine the total organic carbon (TOC) content.

Introduction

Reducing carbon dioxide (CO₂) emissions that cause global warming is a global issue that has resulted in a variety of initiatives for achieving carbon-neutrality in various industries. Since the process of manufacturing cement, which is a key ingredient in concrete, emits large quantities of CO₂, there have been various initiatives in the construction industry to reconsider the ingredients and manufacturing processes for producing concrete. One such initiative that has attracted interest is the development of a new type of concrete that can capture CO₂ that was emitted into the atmosphere by fixing it into the concrete ingredients. In addition to reducing the quantity of cement used, using CO₂-absorbing ingredients is expected to enable a significant reduction in the quantity of CO₂ emitted. Specific proposals include a method for fixing CO₂ in concrete as carbon salts by mixing CO₂-absorbing ingredients into concrete mixtures.

This article describes an example of using the TOC solid sample measurement system to evaluate the quantity of CO₂ absorbed and fixed in concrete by measuring its inorganic carbon (IC) content.

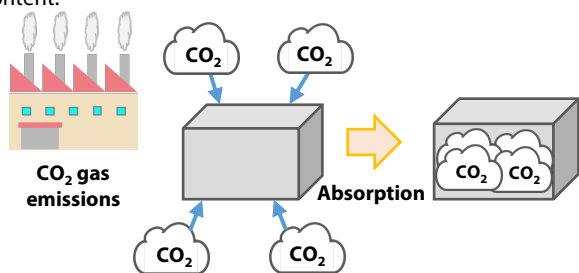


Fig. 1 Illustration of CO₂-Absorbing Concrete

TOC Solid Sample Measurement System

The TOC solid sample measurement system (Fig. 2), which is configured with TOC-L total organic carbon analyzer and SSM-5000A solid sample combustion unit, quantitates the carbon content in solid samples by detecting the carbon dioxide generated from combustive oxidation or acidification of solid samples. Since the system can measure both the total carbon (TC) content and inorganic carbon (IC) content values, the total organic carbon (TOC) content can be determined based on the difference between TC and IC values.

Though the inorganic carbon content can also be determined by thermal analysis, titration of hydrochloric acid solution, or other methods, such methods require significant time and effort and can only measure small sample quantities, which can result in skewed results from uneven distributions in samples. Using this system, samples can be analyzed quickly, easily, and accurately by simply weighing sample into sample boat and directly loading the boat into the system. Furthermore, the system can analyze sample quantities up to 1 g, which can minimize effects from uneven distribution within samples.



Fig. 2 TOC Solid Sample Measurement System

Analysis Method

For this example, two types of concrete samples were prepared. One was ordinary concrete and the other was a CO₂-absorbing concrete that had already absorbed a certain amount of CO₂. The samples were ground into powder and 50 mg of each was weighed into sample boats, as shown in Fig. 3. The sample boats were loaded into the system and a specialized phosphoric acid dispenser for IC measurement dripped phosphoric acid onto the samples. Then the sample boats were loaded into the IC furnace to measure the IC content. This requires grinding samples into a uniform fine powder in advance, because larger sample particles can require long reaction times or have inconsistent reactions with the phosphoric acid, which can affect measurement accuracy. Measurement conditions are listed in Table 1.

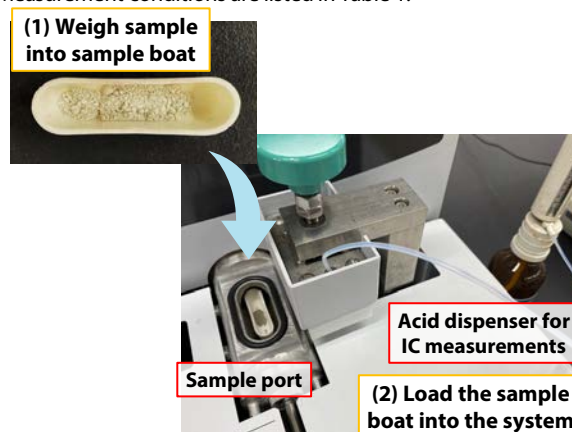


Fig. 3 Analysis Method

Table 1 Measurement Conditions

Analyzer:	TOC Solid Sample Measurement System (TOC-L _{CPH} total organic carbon analyzer + SSM-5000A solid sample combustion unit)
Cell Length:	Short
SSM Carrier Gas:	500 mL/min oxygen gas
IC Measurement Method:	Carbon dioxide extraction by acidification with phosphoric acid (IC furnace at 200 °C)
Measurement Parameter:	IC (inorganic carbon)
Calibration Curve:	1-point calibration curve using sodium carbonate powder reagent

■ Calibration Curve

The analyzer was calibrated by measuring powdered sodium carbonate reagent (11.3 % carbon) in a sample boat. Measurement data is shown in Fig. 4.

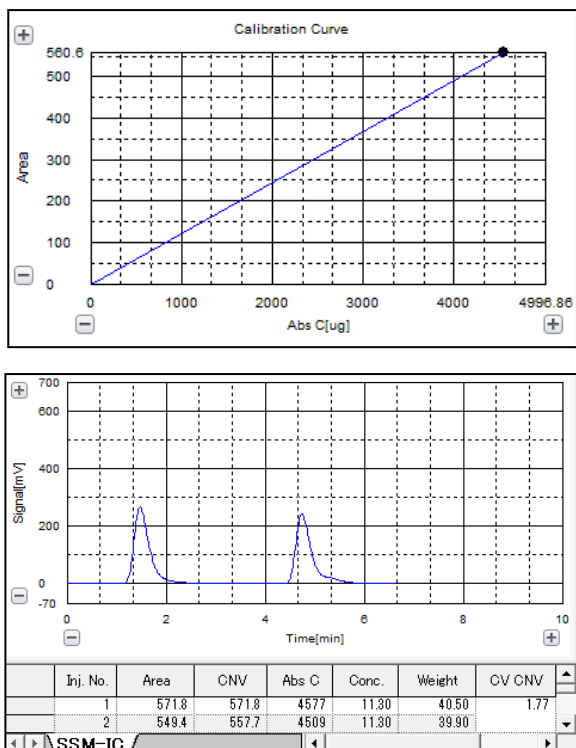


Fig. 4 Calibration Curve Measurement Data

■ Measurement Results

Table 2 indicates the measurement results and Fig. 5 shows the measurement data from the two types of concrete. The results show that the CO₂-absorbing concrete contained about five times higher IC concentrations than the ordinary concrete. Excellent reproducibility was achieved for all measurements, with coefficient of variation values of 3 % or less.

Table 2 Measurement Results

Sample	IC Conc. (%)	Coefficient of Variation (%)
Ordinary Concrete	1.41	2.96
CO ₂ -Absorbing Concrete	6.76	2.01

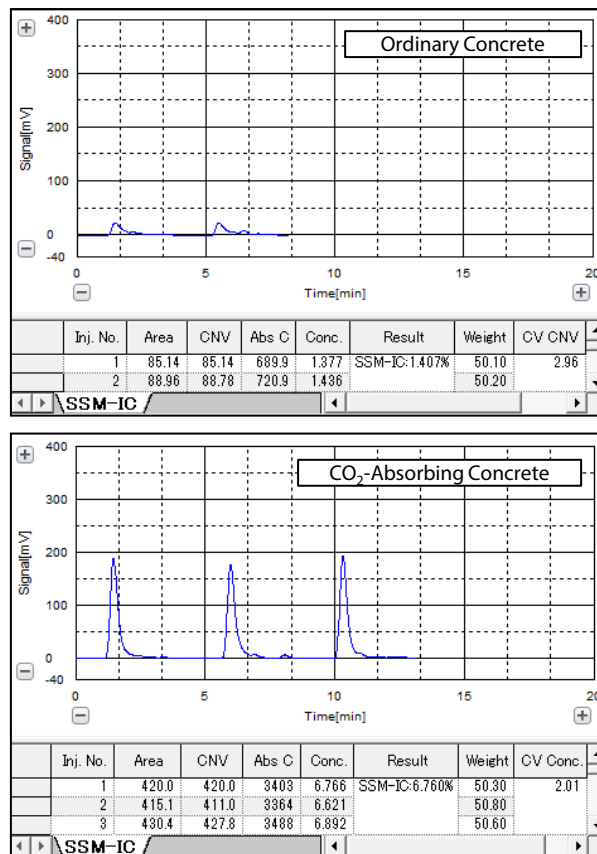


Fig. 5 Sample Measurement Data

■ Conclusion

This article describes an example of using the TOC solid sample measurement system to evaluate the quantity of CO₂ absorbed in concrete by measuring its inorganic carbon (IC) content. The measurement results showed that the CO₂-absorbing concrete contained about five times higher IC concentrations than the ordinary concrete, confirming the difference in the quantity of carbon salts contained in the two concretes.

The system can measure both total carbon (TC) and inorganic carbon (IC) content values, which can be subtracted to also determine the total organic carbon (TOC) content. Refer also to Application News No. O56, which describes measuring the TOC levels of cement admixtures in crushed concrete.