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TOC-L Total Organic Carbon Analyzer + SSM-5000A Solid Sample Combustion Unit

Application News

Evaluation of CO_2 Fixation by Enhanced Weathering

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User Benefits

- The inorganic carbon (IC) content analysis with TOC solid sample measurement system enables the quantitation of CO_2 fixed as carbonate in rock easily.
- The measurement requires just 6 to 8 minutes per sample.
- Measure sample quantities up to 1 g to minimize effects from uneven distribution within samples.

■ Introduction

Achieving carbon-neutrality will require implementing a wide variety of CO_2 emission reduction measures. As part of such efforts, negative emissions technologies (NETs) for absorbing CO_2 gas emissions are being researched. NETs achieve net-negative CO_2 emissions by using direct air capture (DAC), biological functions, or other technologies to capture, absorb, fix, and store CO_2 gas.

An example of NETs is the research on enhanced weathering that absorbs CO_2 gas from the atmosphere by grinding mineral ore or other rock material into powder to increase its surface area and then artificially inducing the weathering process to convert CO_2 gas into carbonate. In order to evaluate such enhanced weathering technology, the quantity of CO_2 absorbed by conversion to carbonate by the rock or other material must be quantitated.

This article describes using TOC solid sample measurement system to determine the quantity of CO_2 of carbonate, a component of rock, by measuring the quantity of inorganic carbon (IC).

■ TOC Solid Sample Measurement System

The solid sample TOC analyzer system (Fig. 1), which was 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. Since the system can measure both the total carbon (TC) content and the inorganic carbon (IC) content values, the total organic carbon (TOC) content can be determined based on the difference between the TC and IC values.

Although the inorganic carbon content can also be determined by thermal analysis, titration of a hydrochloric acid solution, or other methods, these require significant time and effort and can only measure small sample quantities, which can result in skewed results from uneven distributions in the samples. By using the TOC solid sample measurement system, samples can be analyzed quickly, easily, and accurately by simply weighing the samples in a sample boat and directly loading the boat into the system. Furthermore, the system can analyze sample quantities up to 1 g, which minimizes the effects of uneven distributions within samples.

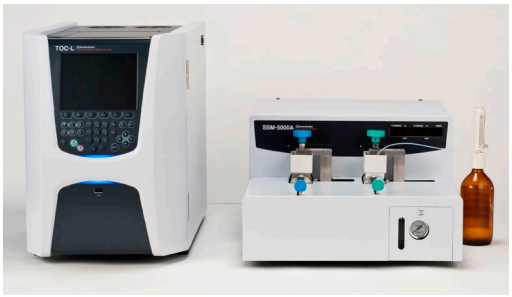


Fig. 1 TOC Solid Sample Measurement System

■ Analysis Method

In this report, commercial carbonate reagents (Fig. 2) were used as enhanced weathering samples. Samples of approximately 30 to 50 mg were weighed in the sample boats. The sample boats were then loaded into the system, as shown in Fig. 3, and a specialized dispenser was used to drip phosphoric acid onto them for IC measurement. Then the sample boat was loaded into the IC furnace and the IC content was measured. Because commercial reagents were used for the samples, they were in a powdered form, but samples in solid form, such as rocks or mineral ore, would need to be finely ground beforehand and be as uniform as possible. Samples with larger particles may cause longer or non-uniform reactions, which could affect the measurement accuracy. The measurement conditions are listed in Table 1.

Fig. 2 Carbonate Reagent in the Sample Boat

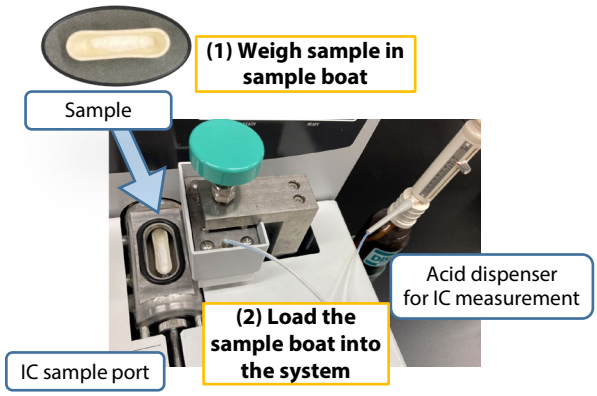


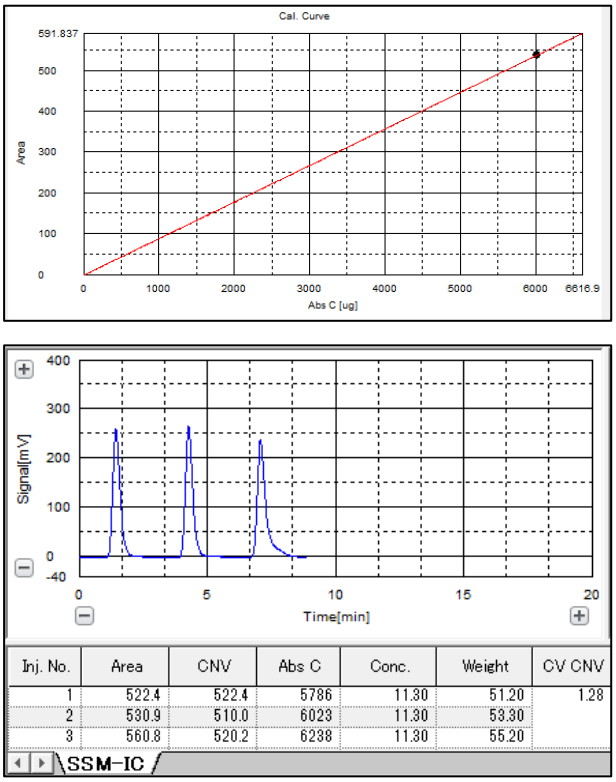
Fig. 3 Analysis Method

Table 1 Measurement Conditions

Analytical Instrument:	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
Samples:	Calcium carbonate, magnesium carbonate (basic), and potassium carbonate (commercial reagent)

■ Calibration Curve

The analyzer was calibrated by placing powdered sodium carbonate reagent (11.3 % carbon) in a sample boat and measuring the IC content. The measurement data is shown in Fig. 4.



Inj. No.	Area	CNV	Abs C	Conc.	Weight	CV CNV
1	522.4	522.4	5786	11.30	51.20	1.28
2	530.9	510.0	6023	11.30	53.30	
3	560.8	520.2	6238	11.30	55.20	

SSM-IC

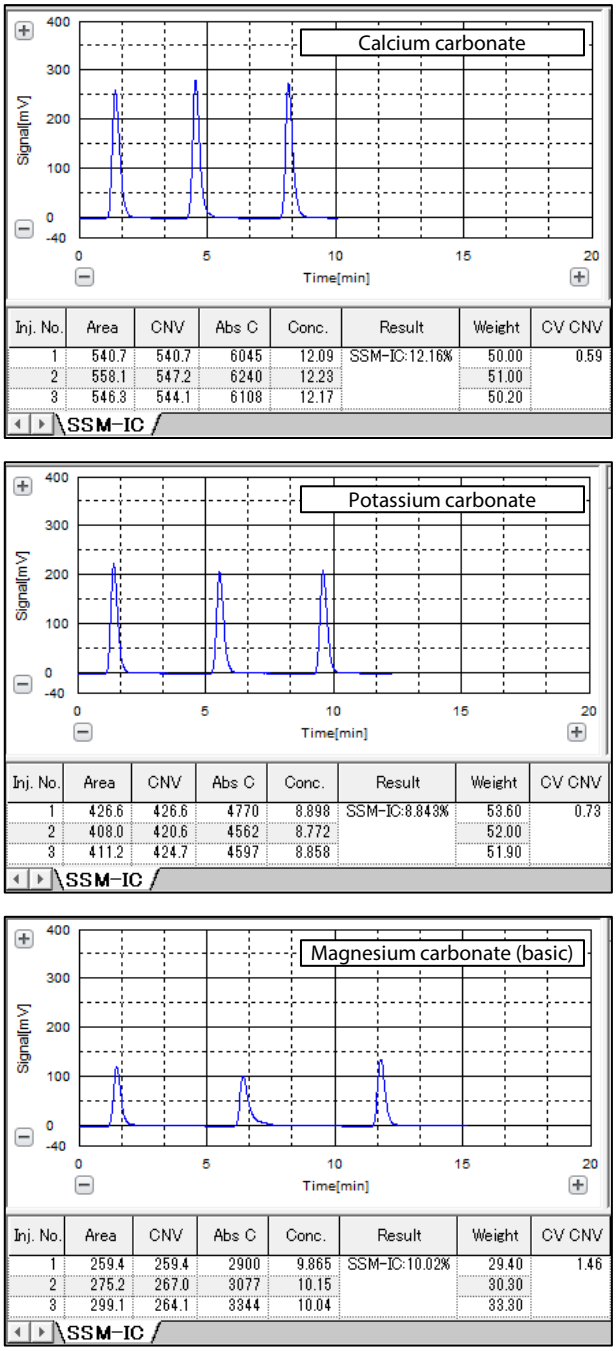
Fig. 4 Calibration Curve Measurement Data

■ Measurement Results

The results from measuring the reagent samples of calcium carbonate, magnesium carbonate (basic), and potassium carbonate, the main constituents of stones and rocks, are listed in Table 2, with the corresponding measurement data shown in Fig. 5. Recovery rates were determined from the IC measurement value and the theoretical value for each sample, assuming a 100 % recovery rate of sodium carbonate measured for the calibration curve. Recovery rates of approximately 100 % were achieved for all sample measurement results, which confirmed that IC concentrations were measured with good accuracy.

Table 2 Measurement Results

Sample	IC Conc. (%) Measurement Value	IC Conc. (%) Theoretical Value	Recovery Rate (%)
Sodium Carbonate	—	—	100
Calcium Carbonate	12.2	12.0	101
Potassium Carbonate	8.84	8.69	102
Magnesium Carbonate (Basic)	10.0	10.1	99.0



Inj. No.	Area	CNV	Abs C	Conc.	Result	Weight	CV CNV
1	540.7	540.7	6045	12.09	SSM-IC:12.16%	50.00	0.59
2	558.1	547.2	6240	12.23		51.00	
3	546.3	544.1	6108	12.17		50.20	

SSM-IC

Inj. No.	Area	CNV	Abs C	Conc.	Result	Weight	CV CNV
1	426.6	426.6	4770	8.898	SSM-IC:8.843%	53.60	0.73
2	408.0	420.6	4562	8.772		52.00	
3	411.2	424.7	4597	8.858		51.90	

SSM-IC

Inj. No.	Area	CNV	Abs C	Conc.	Result	Weight	CV CNV
1	259.4	259.4	2900	9.865	SSM-IC:10.02%	29.40	1.46
2	275.2	267.0	3077	10.15		30.30	
3	299.1	264.1	3344	10.04		33.30	

SSM-IC

Fig. 5 Sample Measurement Data

■ Conclusion

The results confirmed that the TOC solid sample measurement system can accurately measure concentrations of inorganic carbons (IC) in various carbonate. The quantity of CO_2 present in mineral ore or other rock materials can be evaluated by converting the respective IC concentration values into CO_2 concentration values. In consequently, the TOC solid sample measurement system is useful for testing and researching CO_2 fixation technology.

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