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

Application News

# Measurement of Total Carbon in Plastic Particles

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## User Benefits

- Total carbon (TC) measurement using the TOC solid sample measurement system can easily determine the total carbon content of plastics.
- The measurement requires just 6 to 8 minutes per sample.
- TC measurement can quantify up to 30 mg of carbon in sample.

## ■ Introduction

Plastics are widely used in daily necessities, automobiles, furniture, etc., because of their ease of processing and high durability, making them an essential chemical material in our lives. While they are versatile and convenient, in recent years there have been concerns about the negative impact of plastics on the global environment. Examples include climate change caused by $CO_2$ emitted during incineration and the problem of microplastics entering the ocean. Various efforts are being made worldwide to quickly address these issues, and demand for plastics analysis technology is expected to increase in the future.

The TOC solid sample measurement system shown in Fig. 1 can easily measure total carbon (TC) and inorganic carbon (IC) in a solid sample. In TC measurement, a solid sample is combusted and oxidized at 900 °C, and the resulting $CO_2$ is detected to determine the TC concentration. This article describes TC measurements performed on various plastic particles and the confirmed recovery rates.

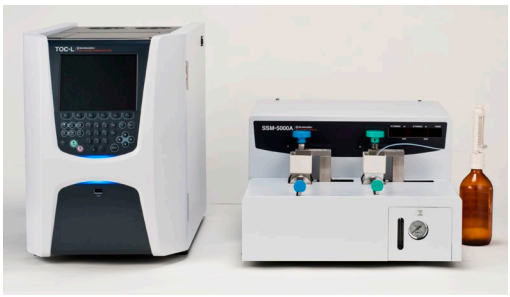


Fig. 1 TOC Solid Sample Measurement System

## ■ Analytical Method

A total of 7 types of plastic particles (PP, PS, HDPE, LDPE, PMMA, PC, PET) were prepared. As shown in Fig. 2, a grain of plastic sample (about 20 to 30 mg) was placed in a sample boat and used as a measurement sample. This sample boat was set in the TC sample port as shown in Fig. 3, and the TC measurement was performed under the measurement conditions shown in Table 1. To calibrate the analyzer, glucose powder reagent (carbon concentration: 40 %) was collected in a sample boat and its TC was measured.

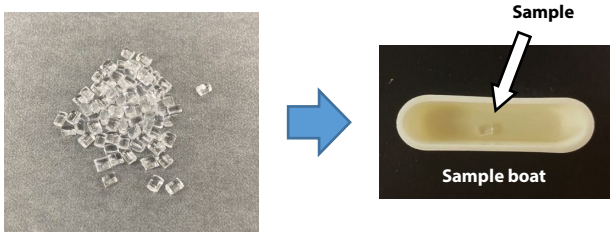



Fig. 2 PMMA Samples Used in Measurement and Placement in the Sample Boat

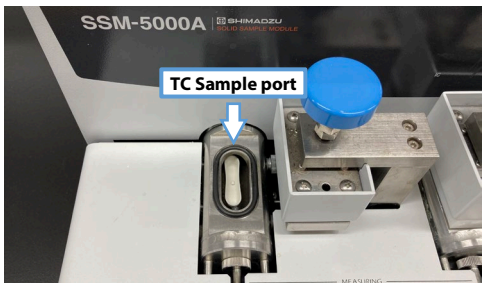



Fig. 3 Setting the Sample Boat in the TC Sample Port

Table 1 Measurement Conditions

| | |
|---|---|
| Analyser: | TOC Solid Sample Measurement System (TOC-LCPH Total Organic Carbon Analyzer + SSM-5000A Solid Sample Combustion Unit) |
| Cell Length: | Short cell |
| SSM Carrier Gas: | 500 mL/min oxygen gas |
| Measurement Items: | TC (total carbon) |
| TC Oxidation Method: | Combustion catalytic oxidation (TC furnace temp.: 900 °C) |
| Calibration Curve: | One-point calibration curve using glucose powder reagent (carbon concentration: 40 %) |
| Sample: | 7 types of plastic (commercial product) |
| | PP (Polypropylene) |
| | PS (Polystyrene) |
| | HDPE (High Density Polyethylene) |
| | LDPE (Low Density Polyethylene) |
| | PMMA (Polymethyl Methacrylate) |
| | PC (Polycarbonate) |
| | PET (Polyethylene Terephthalate) |

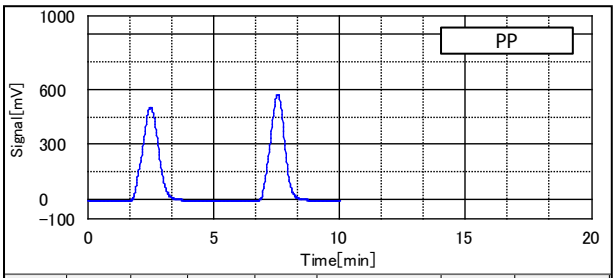
## ■ Measurement Results

Table 2 shows the measurement results and Fig. 4 shows the measurement data from the 7 types of plastic particles.

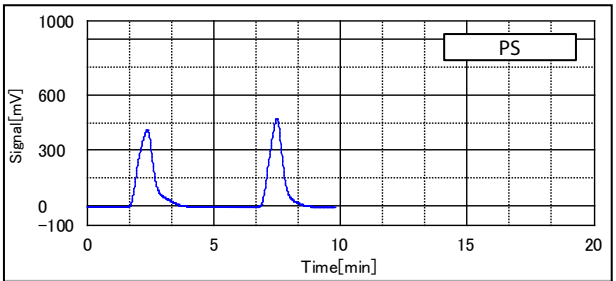
Excellent reproducibility was achieved for all measurements, with coefficient of variation values of 3 % or less. In addition, the recovery rates obtained from the theoretical TC concentration values were more than 95 % in both cases, indicating that the system can accurately measure the total carbon content of plastics.

Table 2 Measurement Results

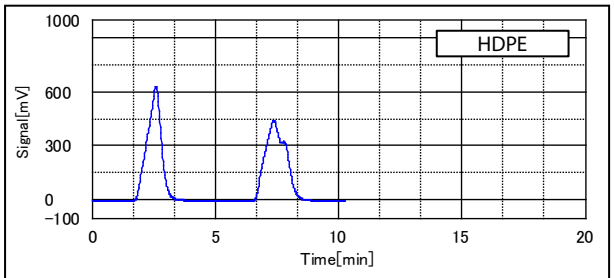
| Sample | TC Concentration (%) | | Recovery Rate (%) |
|---|---|---|---|
| | Measurement Value | Theoretical Value | |
| PP | 87.3 | 85.7 | 101.9 |
| PS | 89.8 | 92.3 | 97.3 |
| HDPE | 85.6 | 85.7 | 99.9 |
| LDPE | 83.2 | 85.7 | 97.0 |
| PMMA | 57.8 | 60.0 | 96.3 |
| PC | 72.3 | 75.6 | 95.6 |
| PET | 62.2 | 62.5 | 99.5 |



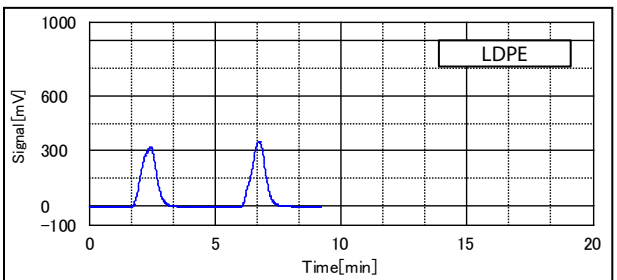

| Inj. No. | Area | CNV | Abs C | Conc. | Result | Weight | CV Conc. |
|---|---|---|---|---|---|---|---|
| 1 | 2220 | 2220 | 23367 | 87.19 | SSM-TC:87.27% | 26.80 | 0.13 |
| 2 | 2274 | 2224 | 23936 | 87.36 | | 27.40 | |



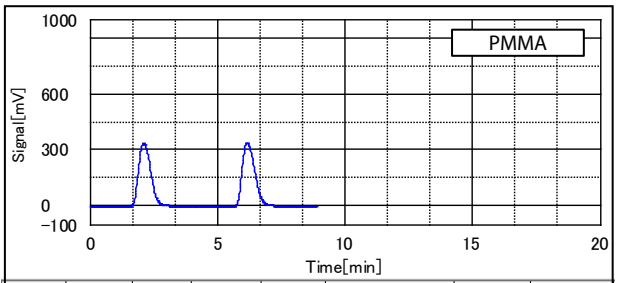

| Inj. No. | Area | CNV | Abs C | Conc. | Result | Weight | CV Conc. |
|---|---|---|---|---|---|---|---|
| 1 | 1783 | 1783 | 18767 | 90.66 | SSM-TC:89.77% | 20.70 | 1.40 |
| 2 | 1748 | 1748 | 18399 | 88.88 | | 20.70 | |



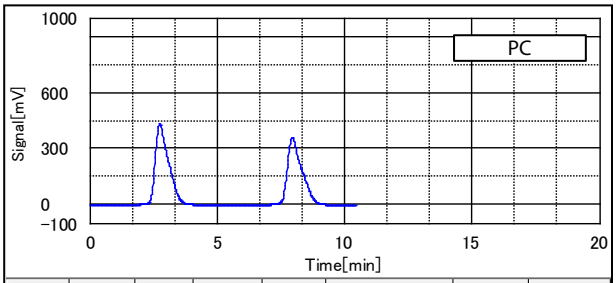

| Inj. No. | Area | CNV | Abs C | Conc. | Result | Weight | CV Conc. |
|---|---|---|---|---|---|---|---|
| 1 | 2490 | 2490 | 26209 | 84.00 | SSM-TC:85.59% | 31.20 | 2.62 |
| 2 | 2584 | 2584 | 27199 | 87.17 | | 31.20 | |



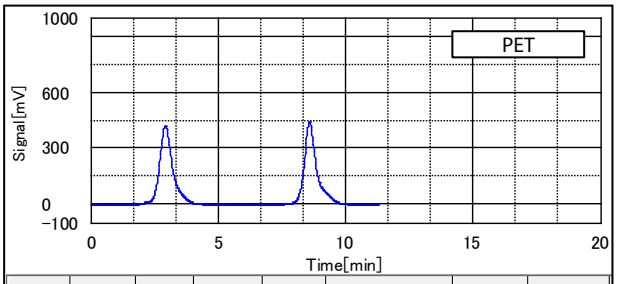

| Inj. No. | Area | CNV | Abs C | Conc. | Result | Weight | CV Conc. |
|---|---|---|---|---|---|---|---|
| 1 | 1331 | 1331 | 14010 | 83.89 | SSM-TC:83.17% | 16.70 | 1.22 |
| 2 | 1363 | 1308 | 14347 | 82.45 | | 17.40 | |




| Inj. No. | Area | CNV | Abs C | Conc. | Result | Weight | CV Conc. |
|---|---|---|---|---|---|---|---|
| 1 | 1106 | 1106 | 11641 | 57.35 | SSM-TC:57.82% | 20.30 | 1.16 |
| 2 | 1163 | 1124 | 12241 | 58.29 | | 21.00 | |




| Inj. No. | Area | CNV | Abs C | Conc. | Result | Weight | CV Conc. |
|---|---|---|---|---|---|---|---|
| 1 | 1592 | 1592 | 16757 | 72.54 | SSM-TC:72.30% | 23.10 | 0.46 |
| 2 | 1431 | 1582 | 15062 | 72.07 | | 20.90 | |




| Inj. No. | Area | CNV | Abs C | Conc. | Result | Weight | CV Conc. |
|---|---|---|---|---|---|---|---|
| 1 | 1552 | 1552 | 16336 | 62.35 | SSM-TC:62.18% | 26.20 | 0.39 |
| 2 | 1520 | 1544 | 15999 | 62.01 | | 25.80 | |

Fig. 4 Measurement Data

## ■ Conclusion

The results confirmed that the TOC solid sample measurement system can accurately measure concentrations of total carbon (TC) in various plastic particles.

The system, which can easily and quickly measure the total carbon content of solid samples, holds promise for applications such as screening tests for plastic content, and because it detects $CO_2$ emitted when samples are burned at 900 °C, it can be used to assess the amount of $CO_2$ emitted when plastics are incinerated. We hope you will find this useful in your testing and research in the environmental field.

Shimadzu Corporation
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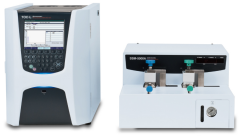
## Related Products Some products may be updated to newer models.

› TOC-L Series
Total Organic Carbon Analyzer



› SSM- 5000A
Solid Sample Combustion Unit

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