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Total Organic Carbon Analyzer TOC-L

Application News

TOC Evaluation of Ammonia Solution

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User Benefits

- The total organic carbon (TOC) in 2 % ammonia solution can be determined directly without dilution, which is optimal for organic contamination management of ammonia solution.
- By measuring inorganic carbon (IC), the contained carbon dioxide (CO_2) concentration can also be quantified.
- Automatic analysis of multiple samples is possible, with the use of the auto-sampler ASI-L.

■ Introduction

Ammonia solution is widely used for various purposes in modern society, such as use as a laundry detergent, in cosmetics and pharmaceuticals, as well as for the treatment of nitrogen oxides (NOx) generated in thermal power plants and waste treatment plants. Furthermore, ammonia fuel has gained attention in recent years as a zero-emission fuel for realization of a decarbonized society. Various types of research on ammonia fuel are underway due to its lack of CO_2 emissions.

To use ammonia solution in these applications, there is a requirement for high purity, so control of organic impurities is important. Using the Shimadzu total organic carbon (TOC) analyzer enables rapid and simple control of organic impurities in ammonia solution.

This article introduces an example of TOC measurement of 2 % ammonia solution, using the Shimadzu TOC-L analyzer.

Fig. 1 Applications of Ammonia Solution

■ Analysis Method

In this experiment, 25 % ammonia solution (special reagent grade) was diluted with pure water to prepare 2 % ammonia solution. Then, potassium hydrogen phthalate was added to the ammonia solution to achieve TOC concentrations of 1 mgC/L, 5 mgC/L, and 10 mgC/L, respectively. Table 1 summarizes the sample preparation.

Table 1 Sample Preparation

Samples	Ammonia solution [%]	TOC [mgC/L]
2 % ammonia solution	2	0
2 % ammonia solution + TOC 1 mgC/L		1
2 % ammonia solution + TOC 5 mgC/L		5
2 % ammonia solution + TOC 10 mgC/L		10

Fig. 2 Shimadzu TOC-L Analyzer (Right) and Auto-Sampler ASI-L (Left)

Table 2 Analytical Conditions

Instrument	TOC-L_{CPH} total organic carbon analyzer
Catalyst	Standard catalyst
Measurement Item	TOC (based on TC-IC)
No. of Injections	3 / Max. 5
Calibration Curves	TC: 2-point calibration curve with 0 and 20 mgC/L of potassium hydrogen phthalate aqueous solution
	IC: 2-point calibration curve with 0 and 20 mgC/L of sodium carbonate and sodium hydrogen carbonate aqueous solution
Injection Volume	50 µL
Samples	Special reagent grade, 25 % ammonia solution
	Potassium hydrogen phthalate

Table 2 presents the measurement conditions used for TOC analysis of ammonia solution using the total carbon (TC) and inorganic carbon (IC) subtraction method. This method involves measuring the TC and IC in the sample, and then subtracting IC from TC to obtain the TOC concentration. In addition, when it comes to TOC analysis, IC typically refers to dissolved CO_2 and carbonates (carbonic acid H_2CO_3, bicarbonate ion HCO_3^-, carbonate ion CO_3^{2-}) in the solution. The results were calculated using the mean value of three tests, up to a maximum of five tests. If a measurement result exceeded the set limit of maximum standard deviation (SD) and maximum coefficient of variation (CV), additional tests were performed up to the maximum of five tests.

Calibration of the instrument was performed using 0 and 20 mgC/L potassium hydrogen phthalate aqueous solutions for TC measurements, and 0 and 20 mgC/L sodium carbonate and sodium hydrogen carbonate aqueous solutions for IC measurements. The calibration curves were corrected by performing an origin shift to account for the TOC contained in the pure water used in preparing the standard solution.

■ Measurement Results

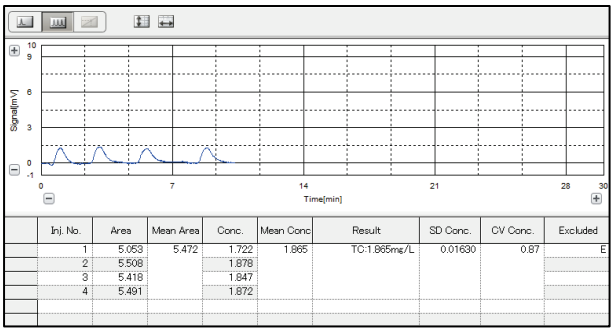
Table 3 Measurement Results of 2 % Ammonia Solution

Samples	TC [mgC/L]	IC [mgC/L]	TOC [mgC/L]
2 % ammonia solution	0.950	0.888	0.0624
2 % ammonia solution + TOC 1 mgC/L	1.87	0.754	1.11
2 % ammonia solution + TOC 5 mgC/L	6.52	1.45	5.07
2 % ammonia solution + TOC 10 mgC/L	10.3	0.481	9.83

The results of ammonia solution measurement are shown in Table 3. The TC and IC concentrations were obtained from the mean value of up to 5 tests, and the TOC results were calculated by subtracting IC from TC.

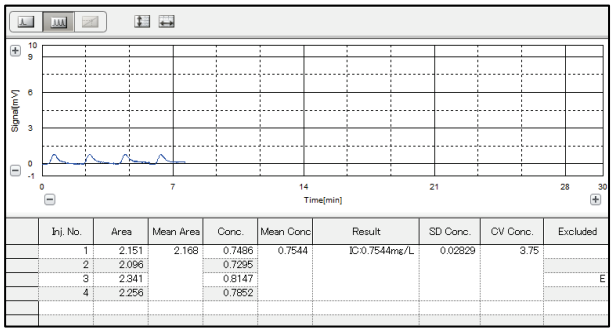
Examples of detailed peak data from the TOC-L analyzer are presented in Figs. 3 and 4. The correlation between the TOC added concentration and the measured concentration is shown in Fig. 5, where the correlation coefficient was 0.9999, indicating good correlation and confirming the accurate measurement of added TOC.

From these results, it is clear that the TOC concentration of 2 % ammonia solution can be measured up to 1 mgC/L, by using the Shimadzu TOC-L analyzer.



Inj. No.	Area	Mean Area	Conc.	Mean Conc	Result	SD Conc.	CV Conc.	Excluded
1	5.053	5.472	1.722	1.865	TC:1.865mg/L	0.01630	0.87	E
2	5.508		1.878					
3	5.418		1.847					
4	5.491		1.872					

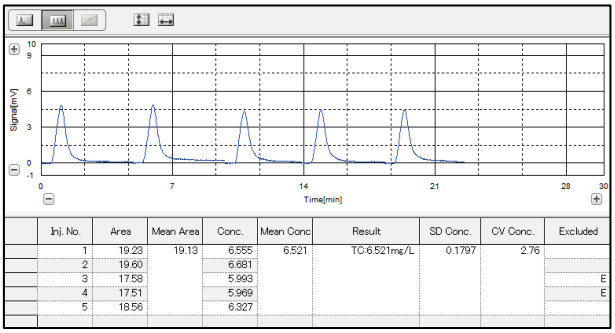
(a)



Inj. No.	Area	Mean Area	Conc.	Mean Conc	Result	SD Conc.	CV Conc.	Excluded
1	2.151	2.168	0.7486	0.7544	IC:0.7544mg/L	0.02829	3.75	
2	2.096		0.7295					
3	2.341		0.8147					E
4	2.256		0.7852					

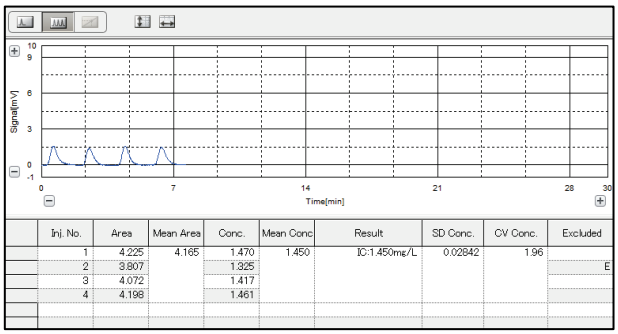
(b)

Fig. 3 Results of 2 % Ammonia Solution + TOC 1 mgC/L
(a) TC Measurement (b) IC Measurement



Inj. No.	Area	Mean Area	Conc.	Mean Conc	Result	SD Conc.	CV Conc.	Excluded
1	19.23	19.13	6.555	6.521	TC:6.521mg/L	0.1797	2.76	
2	19.60		6.681					
3	17.58		5.993					E
4	17.51		5.969					E
5	18.56		6.327					

(a)



Inj. No.	Area	Mean Area	Conc.	Mean Conc	Result	SD Conc.	CV Conc.	Excluded
1	4.225	4.165	1.470	1.450	IC:1.450mg/L	0.02842	1.96	
2	3.807		1.325					E
3	4.072		1.417					
4	4.198		1.461					

(b)

Fig. 4 Results of 2 % Ammonia Solution + TOC 5 mgC/L
(a) TC Measurement (b) IC Measurement

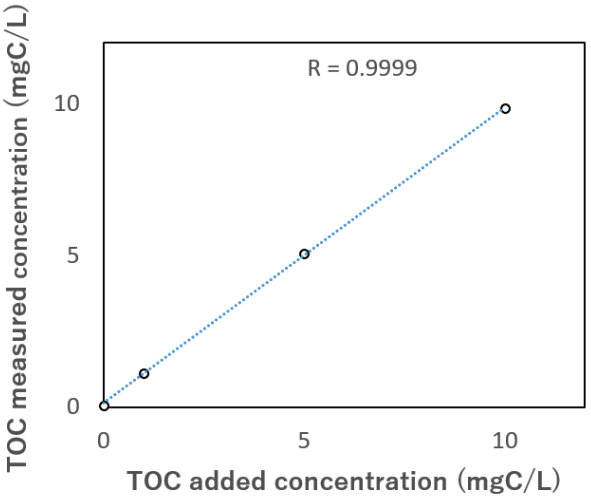


Fig. 5 Correlation between
the TOC Added Concentration and the Measured Concentration

■ Conclusion

This article confirmed that the Shimadzu TOC-L analyzer is applicable in TOC analysis of 2 % ammonia solution with a precision of up to 1 mgC/L. In the case of higher concentration ammonia solution, appropriate dilution prior to analysis can be utilized for TOC measurement. Moreover, the amount of CO_2 in ammonia solution can be quantified through IC measurement.

Ammonia has attracted attention for realizing a decarbonized society, and it is expected that the TOC-L analyzer will play a vital role in managing organic impurities in ammonia solution.

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