APPLICATION NOTE: AN2302
TECHNOLOGY: TOC
INDUSTRY: ENV

Standard Method 5310B: TOC Measurement by High-Temperature Combustion

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Introduction

Total Organic Carbon (TOC) monitoring is fundamental for the treatment of drinking water and wastewater. The presence of organic carbon in water can promote unwanted biological growth and degrade ion-exchange capacity in treatment systems. In drinking water treatment facilities, organic carbon can react with disinfectants to produce harmful byproducts. Methods have been developed to detect organic carbon to ensure that water is safe for human consumption and the environment. Standard Method 5310 is a method for the determination of TOC in water. Section B contains information and guidelines for TOC analysis using high- temperature combustion. This study will focus on Section B and will demonstrate that Teledyne Tekmar's Torch high-temperature combustion TOC analyzer is the instrument to choose for analyzing water samples according to Standard Method 5310B.

Discussion

The high-temperature combustion method (5310B) is suitable for samples with higher TOC levels. Wastewater can reach TOC concentrations exceeding 300 mg/L. Wastewater samples typically contain suspended organic carbon and halides, sample types that are typically not compatible with other types of TOC methodology. 5310B is routinely used to determine organic carbon levels for sample types that are hard to oxidize. The Torch high-temperature combustion analyzer can operate up to 1000 °C and will oxidize the most stubborn sample types. This makes it an ideal instrument for TOC determination in wastewater analysis. The Torch is also sensitive enough to determine TOC levels in drinking water treatment facilities for source water and treated water. A common guideline for TOC in drinking water is <2.0 mg/L. Standard Method 5310B requires a minimum detectable concentration of 1.0 mg/L of carbon or less. This study demonstrates the Torch's ability to achieve this limit by using a 1.0 ppm calibration point for the drinking water calibration.

Methodology

To achieve a TOC result, the inorganic carbon (IC) fraction of the sample must be removed. IC removal occurs automatically inside the IC sparger. Phosphoric acid is added to the IC sparger followed by the sample. The acidified sample is then sparged for a predetermined time, releasing the IC from the sample. After IC removal, an aliquot of sample is injected into a combustion tube containing platinum catalyst at a high temperature. The carbon in the sample is converted into CO_2 and then swept into a non-dispersive infrared (NDIR) detector. Many method parameters are adjustable to tailor the methods for multiple sample types and concentration ranges. For this study the methods used are detailed in Figure 1 for the drinking water method, and Figure 2 for the wastewater method.

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Figure 1 Drinking Water Method

Name: TOC Drinking Water (TOC)

Version: 1
Ver Creation: 2009/05/19 10:37
Comment:

Parameter	Value
SampleVolume	0.5 mL
WaterChaseVolume	1.00 mL
Dilution	1:1
NumberOfInjectionLineRinses	1
InjectionLineRinse	On
InjectionLineRinseVolume	0.50 mL
AcidVolume	1.0 mL
ICSpargeFlow	300 mL/min
CarrierGasDelayTime	0.40 mins
ICSpargeTime	1.00 mins
DetectorSweepFlow	500 mL/min
FurnaceSweepTime	1.00 mins
SystemFlow	200 mL/min

Figure 2 Wastewater Method

Name: TOC Waste Water 5-500 ppm (TOC)

Version: 1
Ver Creation: 2023/04/05 10:17
Comment:

Parameter	Value
SampleVolume	0.2 mL
WaterChaseVolume	2.00 mL
Dilution	1:1
NumberOfInjectionLineRinses	1
InjectionLineRinse	On
InjectionLineRinseVolume	0.50 mL
AcidVolume	0.5 mL
ICSpargeFlow	200 mL/min
CarrierGasDelayTime	0.40 mins
ICSpargeTime	0.50 mins
DetectorSweepFlow	500 mL/min
FurnaceSweepTime	1.00 mins
SystemFlow	200 mL/min

Calibration

A 1000 mg/L organic carbon stock solution was prepared by dissolving 2.125 g of potassium hydrogen phthalate (KHP) in 1.0 L of reagent water. From this stock solution, two working standards were diluted. The working standards are the high concentration calibration points for each calibration curve. For drinking water, a 50.0 mg/L working standard was used. According to the newest revision of 5310B (May 23, 2022), wastewater can reach levels >300 mg/L. To reflect this concentration, the wastewater working standard used was 500 mg/L. The additional points for each calibration curve were made through the auto-calibration feature of the Torch. The calibration curves for each method are shown as follows: Figure 3 for drinking water and Figure 4 for wastewater.

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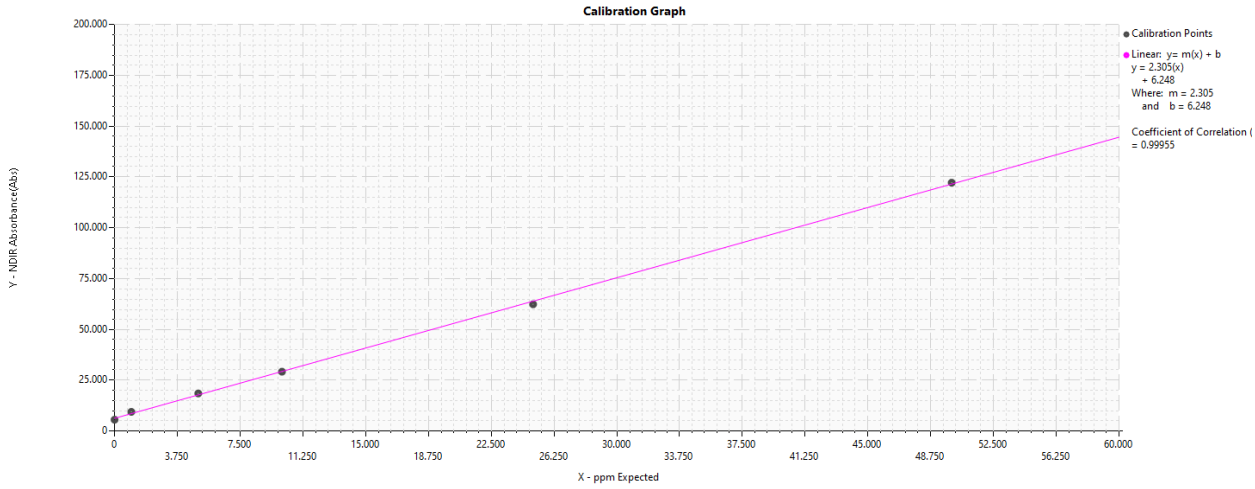
Figure 3 Drinking Water Calibration Curve

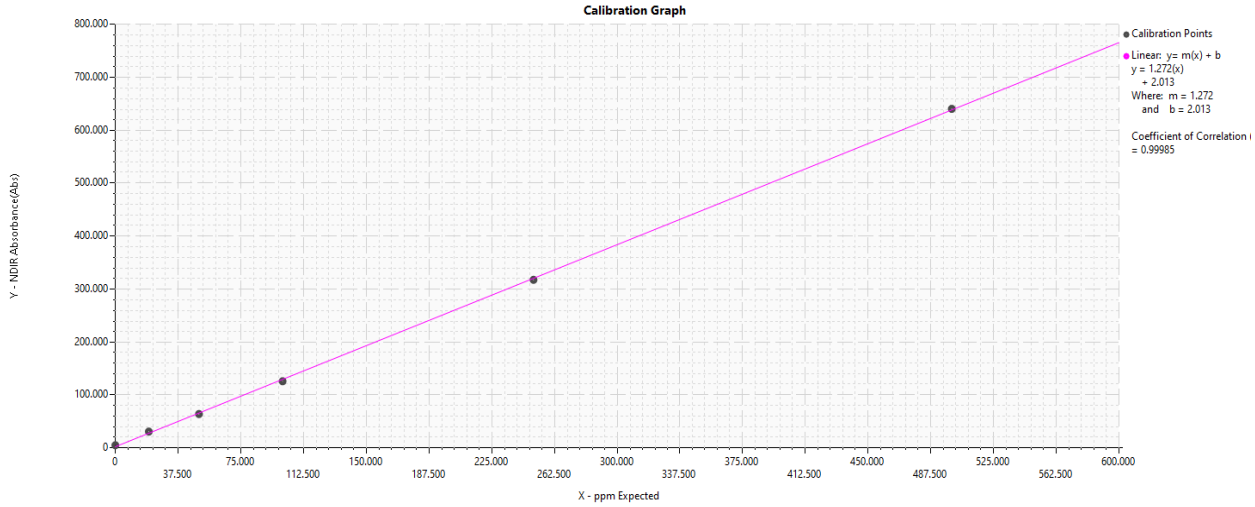


Analysis type: TOC

TOC | Comments

Use	Sample ID	Adj ABS	X Expected	Message	Date
☑	DI Water	5.5653	0.0000		2023/03/29 13:15
☑	1.000 ppm	9.4287	1.0000		2023/03/29 13:46
☑	5.000 ppm	18.4990	5.0000		2023/03/29 14:15
☑	10.000 ppm	29.1897	10.0000		2023/03/29 14:45
☑	25.000 ppm	62.3637	25.0000		2023/03/29 15:14
☑	50.000 ppm	122.1563	50.0000		2023/03/29 15:43

Figure 4 Wastewater Calibration Curve



Analysis type: TOC

TOC | Comments

Use	Sample ID	Adj ABS	X Expected	Message	Date
☑	DI Water	4.8407	0.0000		2023/04/05 12:49
☑	20.000 ppm	30.5290	20.0000		2023/04/05 14:25
☑	50.000 ppm	63.8070	50.0000		2023/04/05 14:56
☑	100.000 ppm	125.7277	100.0000		2023/04/05 15:28
☑	250.000 ppm	317.2930	250.0000		2023/04/05 16:00
☑	500.000 ppm	640.1457	500.0000		2023/04/05 16:31

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Accuracy and Precision

To demonstrate the accuracy and precision of the Torch, calibration check-standards and samples of known concentration were analyzed in triplicate. The results, including meta data for all replicates, are shown in Table 1 and Table 2 for drinking water and wastewater, respectively.

Table 1: Check standards and Samples of known Concentration for Drinking Water Method

Pos	Basic Analysis Type	Concentration	Dil	Sample ID	Min / Max (% dev)	Result	Std. Dev.	RSD
B	TOC	10.0000	1:5	[TOC] 10 ppm Drinking Water Cal Ck [10.000 ppm]	9.0000 / 11.0000 (90% / 110%)	10.1546 ppm (PASS)	0.1296 ppm	1.28%

Pos	Base Analysis Type	ID	Rep #	ppmC	µg	Adjusted (abs)	NDIR (Abs)	Baseline (Abs)
B	TOC	10.000 ppm	1	10.2753	5.1377	29.93	30.59	0.66
B	TOC	10.000 ppm	2	10.0176	5.0088	29.33	30.27	0.93
B	TOC	10.000 ppm	3	10.1708	5.0854	29.69	30.43	0.74

	Pos	Analysis Type	Sample ID	Result (ppmC)	Std. Dev. (ppmC)	RSD
	2	TOC	10 ppm	10.5044	0.4349	4.1400%

Rep #	Base Analysis Type	ppmC	µg	Adjusted (Abs)	NDIR (Abs)	Baseline (Abs)
1	TOC	10.0830	5.0415	28.84	30.00	1.15
2	TOC	10.4787	5.2393	29.76	30.82	1.07
3	TOC	10.9517	5.4758	30.85	31.65	0.80

	Pos	Analysis Type	Sample ID	Result (ppmC)	Std. Dev. (ppmC)	RSD
	B	TOC	50 ppm	48.5002	0.9615	1.9800%

Rep #	Base Analysis Type	ppmC	µg	Adjusted (Abs)	NDIR (Abs)	Baseline (Abs)
1	TOC	47.7210	23.8605	115.58	116.49	0.91
2	TOC	49.5747	24.7874	119.86	121.28	1.42
3	TOC	48.2048	24.1024	116.70	117.63	0.94

Table 2: Check standards and Samples of known Concentration for Wastewater Method

Pos	Basic Analysis Type	Concentration	Dil	Sample ID	Min / Max (% dev)	Result	Std. Dev.	RSD
B	TOC	100.0000	1:5	[TOC] 100 ppm Wastewater Cal Ck [100.000 ppm]	85.0000 / 115.0000 (85% / 115%)	103.4457 ppm (PASS)	0.9745 ppm	0.94%

Pos	Base Analysis Type	ID	Rep #	ppmC	µg	Adjusted (abs)	NDIR (Abs)	Baseline (Abs)
B	TOC	100.000 ppm	1	102.4012	20.4802	132.27	132.88	0.61
B	TOC	100.000 ppm	2	104.3304	20.8661	134.72	135.89	1.17
B	TOC	100.000 ppm	3	103.6055	20.7211	133.80	134.80	1.00

	Pos	Analysis Type	Sample ID	Result (ppmC)	Std. Dev. (ppmC)	RSD
	B	TOC	500 ppm	504.6298	2.1428	0.4200%

Rep #	Base Analysis Type	ppmC	µg	Adjusted (Abs)	NDIR (Abs)	Baseline (Abs)
1	TOC	506.9581	101.3916	650.41	651.28	0.87
2	TOC	504.1909	100.8382	646.89	648.06	1.17
3	TOC	502.7405	100.5481	645.05	646.86	1.81

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	Pos	Analysis Type	Sample ID	Result (ppmC)	Std. Dev. (ppmC)	RSD	
	2	TOC	200 ppm	207.5544	12.0115	5.7900%	

Rep #	Base Analysis Type	ppmC	µg	Adjusted (Abs)	NDIR (Abs)	Baseline (Abs)
1	TOC	194.4525	38.8905	252.90	253.58	0.68
2	TOC	218.0463	43.6093	282.91	283.72	0.81
3	TOC	210.1644	42.0329	272.88	273.90	1.01

Conclusion

Teledyne Tekmar's Torch high-temperature combustion TOC analyzer is an instrument of proven quality and performance. It can meet all conditions and guidelines presented in Standard Method 5310B. The Torch features a robust built-in autosampler with the ability to create calibration curves from one standard. It has the sensitivity to analyze drinking water samples and the analytical range to monitor wastewater samples. Should a sample exceed the calibrated range, the Torch can utilize Intellidilution, which will dilute the sample to within the calibration range without interrupting the schedule. Additionally, Teklink is the fully optimized user interface that simplifies operating and maintaining the Torch. Predeveloped methods allow for quick start-up and variable parameters within methods permit for method development for analyzing uncharacteristic samples.

References

1. American Public Health Association (APHA) 2022. Standard Methods of Water and Wastewater. 24th ed. American Public Health Association, American Water Works Association, Water Environment Federation publication. APHA, Washington D.C.