

Application News

Total Organic Carbon Analysis

Shimadzu's Total Nitrogen Module Eliminates Environmentally Un-friendly Environmental Methods

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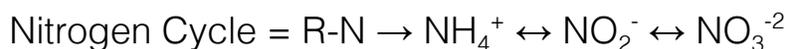
It has been the goal of many over the past hundred years to find ways to improve life and the world we live in, and to find easy solutions to everyday problems. Science has come a long way. We now have clean drinking water and a governing body to protect it. We have luxury cars and the ability to see both the East and West coast in the same day. But with all the good there is always the bad. Having luxury cars and readily available flights also gives us pollution and waste; for every clean drinking water supply there is a polluted body. For every two steps forward in technology we take one step back in terms of pollution. The same goes for monitoring the environment. For every test or method developed to identify and isolate toxins, a large amount of toxic waste is produced. Simply stated, environmental methods shouldn't be harmful to the environment.



Total Nitrogen is composed of four separate methods: Total Kjeldahl Nitrogen (TKN), Ammonia (NH_3^+), Nitrite (NO_2^-), and Nitrate (NO_3^{-2}).

$$\text{Total Nitrogen (TN)} = \text{R-N (Organic Nitrogen)} + \text{NH}_3^+ + \text{NO}_2^- + \text{NO}_3^{-2}$$

All components that comprise total nitrogen "are biochemically interconvertible and are components of the nitrogen cycle," and can occur in both wastewater and natural waters (Standard Methods)¹.



As with most wet chemical analyses, these four methods require sample prep which is time consuming and laborious. Nitrite and Nitrate are relatively easy methods, although nitrate requires a separate sampling so it can be acidified prior to analysis and nitrite requires analysis within 48 hours of sampling. The method for ammonia requires hazardous chemicals such as phenol and nitroprusside, is prone to interference issues, and calls for sulfuric acid to be added during sampling. Total Kjeldahl Nitrogen is a commonly used analysis testing for bound nitrogen. This EPA-approved method is extremely laborious, easily skewed high or low, and calls for the use of mercuric oxide, sulfuric acid, cupric sulfate, boric acid, nitroprusside, and phenol. All are known and documented toxins, harmful to both life and land. Prior to TKN analysis the sample must be digested for at least 60 minutes, if not more, using hazardous chemicals at high temperatures. In addition to the cost of chemicals, multiple samplings, and hazardous waste removal, analysis equipment for all of these methods must be purchased and maintained. This proves to be a high cost for a single total nitrogen concentration. All four EPA-approved methods needed for total nitrogen would take one analyst nearly 8 hours to complete, produce hazardous waste which then needs to be properly disposed, and prove very costly with little return.

Shimadzu's Total Nitrogen Module (TNM-1) analyzes Total Nitrogen in less than 4 minutes, requires no reagents or chemicals, and produces no hazardous wastes. Conforming to the American Society for Test Method's (ASTM) D5176 procedure, the TNM-1 uses combustion oxidation and chemiluminescence detection. Samples containing nitrogen are introduced into an oxygen rich combustion tube with platinum catalyst at a temperature of 720°C. Bound nitrogen is then converted to Nitrogen Monoxide (NO), further oxidized to Nitrite (NO₂) in the presence of ozone, and is then detected by the chemiluminescence detector. A corresponding peak is produced; area counts are then converted to a corresponding concentration [Figure 1]. All nitrogen gas byproducts are passed through absorbers and then released to the atmosphere, thereby resulting in no hazardous waste due to analysis. Coupling Shimadzu's TNM-1 with a TOC-VC analyzer, two methods, Total Organic Carbon (TOC) and Total Nitrogen, can be analyzed on the same sample simultaneously in approximately 4 minutes. This saves time and money, and introduces no waste back into the environment.

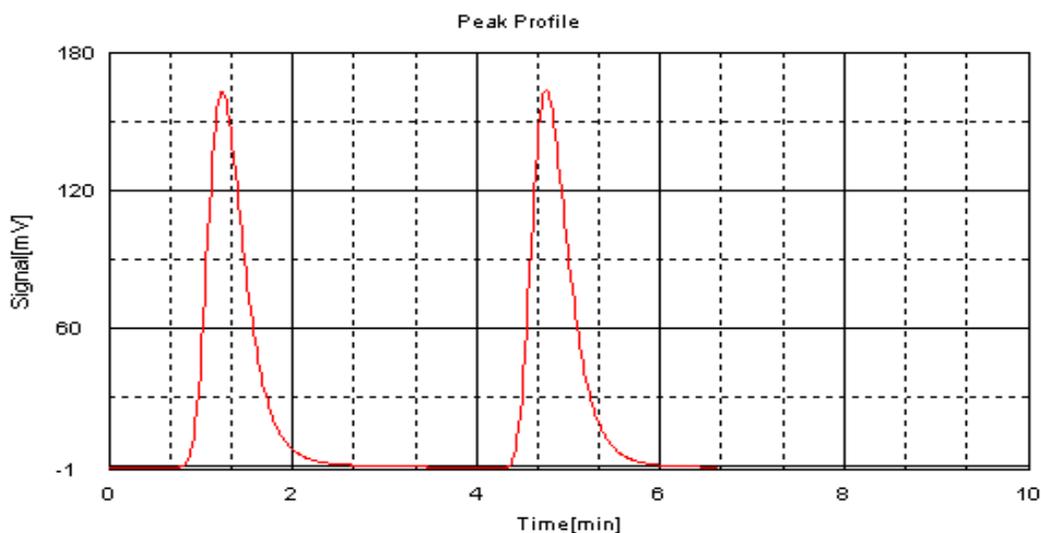


Figure 1: Two Total Nitrogen Peaks produced using Shimadzu's Total Nitrogen Module.

Table 1: Percent Recoveries for a range of Nitrogen Sources

Compound	TN ppm	Recovery (%)
Ammonium Chloride	0.01	102
Ammonium Sulfate	2	102
Ammonium Sulfate	100	100
Aniline	0.014	101
Arginine	0.007	99
Calcium Nitrate	10	99
Glutamic Acid	0.013	98
Glycine	0.016	103
L-gultamic Acid	2	102
1,6-Hexanediamine	50	101
Imidazol	0.011	100
Nitroanilines	50	100
Nitrophenols	50	102
Potassium	10	99
Potassium Nitrate	0.009	99
Potassium Nitrate	50	105
Proline	0.010	99
RNA	0.018	103
Sodium Nitrite	0.009	101
Tri-peptide (Glu-Cys-Gly)	0.014	99
Tryptophan	0.009	101
Urea	0.013	99

Shimadzu's TNM-1 has a lower detection limit of 0.05 ppm and an upper limit of 4000 ppm when used in conjunction with the auto dilution feature. This range meets most regulatory low-level requirements. The TNM-1 maintains a coefficient of variation of 3% or better and is less prone to interferences than TKN. A wide range of applications or sources of nitrogen can be tested. As shown in Table 1, recoveries for various nitrogen sources are well within a ten percent tolerance. This allows for a wide range of applications without the need for multiple methods.

Conclusion

By using Shimadzu's Total Nitrogen Module, a method that once took up to a full day to complete can now be completed in approximately 4 minutes. Total Organic Carbon can also be analyzed simultaneously, reducing analytical time even further, reducing long-term costs and allowing for a high sample throughput. With a lower detection limit of 0.05 ppm, sensitivity is not lost by using Shimadzu's TNM-1. A broad range of

sample matrixes can be analyzed with ease and high accuracy. In addition, by incorporating four separate methods into one, hazardous wastes and toxic chemicals are no longer necessary. This helps reduce costs and eliminates toxins from being introduced back into the environment. Shimadzu's Total Nitrogen Module helps to keep the environment clean while eliminating costly procedures.

Reference

1. Standard Methods for the Examination of Water and Wastewater, 20th Edition, 4500-N Nitrogen, pages 4-99-110 and 4-124-127.