Application Note

QbD1200 INORGANIC CARBON REMOVAL

A water sample initially contains two types of carbon:

- **T**otal **I**norganic **C**arbon (TIC) from CO_2 gas dissolved in H_2O and dissolved carbonates in the water
- **T**otal **O**rganic **C**arbon (TOC) from organic species

To quantify TOC, all analyzers must incorporate a strategy to account for the TIC. However, not all of these strategies are equally effective or reliable. Consider:

Strategy A: used in membrane conductometric methods, which calculate TOC = TC - IC

- Split a sample stream: in one half measure TC, in the other half measure IC, then calculate TOC.
- The measurement of IC is generally done by adding a fixed amount of acid for a fixed period of time. The acid facilitates the dissolved $CO_{2\ (liquid)}$ going to $CO_{2\ (gas)}$ and crossing the membrane, with the assumption that the amount of acid added and the time allowed are sufficient to reach an equilibrium state.
- There are at least 2 problems with this approach:
  - It does not work for samples with high levels of inorganic carbon. For these samples, this approach will actually report negative TOC values. The user's only option at this point is to purchase an expensive 'Inorganic Carbon Removal' module to pre-treat the sample prior to measuring.
  - It may not work for samples with high pH or greater buffering capacity. In these cases, if the acid added and time allowed are insufficient to get a proper IC reading across the membrane, the TOC value calculated will be inaccurate, but the user will never know it. There is no way to confirm that the IC reading used in the formula TC - IC = TOC is actually correct. This would be especially problematic for customers who know that some of their samples may be higher pH or have greater buffering capacity than plain neutral water (for example, Cleaning Validation samples where an alkaline cleaning agent is utilized).

Strategy B: used in High Temperature Combustion methods

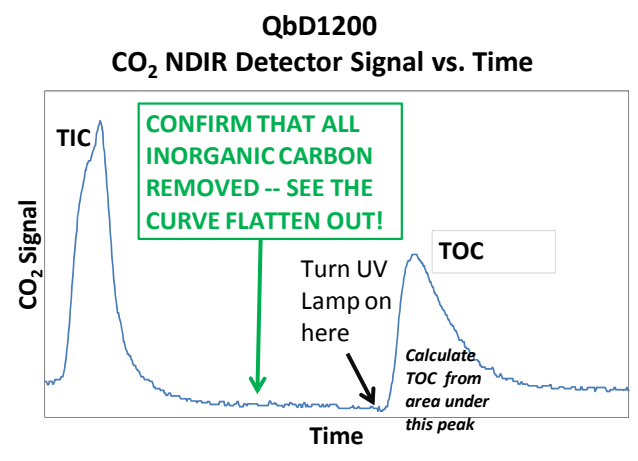
- The sample is drawn into a syringe pump, acid is added, and carrier gas sparges out inorganic carbon as CO_2.
- Like Strategy A, this is normally performed for a fixed period of time. Because this CO_2 is not sent through the NDIR detector, there is no way to confirm whether all of the inorganic carbon has actually been sparged from the sample prior to converting organic carbon into CO_2 gas during the combustion process.
- The result is that when the sample is combusted in the furnace and carrier gas moves the resulting CO_2 through the NDIR detector, there is no way to be assured that the CO_2 being measured is entirely from

organic sources. In fact, it is common for this technique to suffer from non-reproducible results due to incomplete removal inorganic carbon prior to TOC measurement.

- Like Strategy A, this would be especially problematic for samples that might have higher pH or buffering capacity, such as Cleaning Validation.

<u>QbD1200 Strategy</u> - (UV/persulfate/NDIR with Dynamic Endpoint Detection

- The QbD1200 is designed to ensure all Inorganic Carbon is removed from the sample prior to oxidation of the organic carbon.
- Carrier gas is sparged through the reaction chamber, which contains sample and acid. As $CO_{2\ (gas)}$ is generated, it leaves the reaction chamber and passes through the NDIR detector. A dynamic endpoint detection algorithm is used to monitor this inorganic derived CO_2. This ensures the UV lamp does not turn on to begin oxidation of organic carbon until all of the inorganic carbon has been removed.
- Neither membrane conductometric nor high temperature combustion methods can provide assurance that inorganic carbon has been properly accounted for during the quantification of TOC.



- Membrane Conductometric TOC cannot provide assurance that Inorganic Carbon is properly accounted for
- Membrane Conductomtric TOC requires an expensive Inorganic Carbon Removal module for high TIC samples
- High Temperature Combustion TOC cannot provide assurance that TIC has been removed prior to measurement of TOC

Inorganic Carbon Removal Notes:

- TOC analyzers must employ some strategy to account for inorganic carbon.
- Not all strategies can provide assurance that inorganic carbon is not interfering with TOC measurement.
- QbD1200 with dynamic endpoint detection eliminates risk and uncertainty by ensuring that TIC is removed prior to measuring TOC.

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