

Title: A Simple and Accurate Method for the Determination of CO₂ Levels in Carbonated Beverages Using Total Organic Carbon (TOC) Analysis

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Introduction:

The history of beverage carbonation is long and varied. Chemists, such as Robert Boyle, experimented with ways of making carbonated beverages for the purpose of flavor enhancement and preservation. The level of CO₂ contained in most carbonated beverages today is much more of a science in that it is instrumental in achieving the desired combinations of taste, texture (foam/froth in beers) and appearance.¹ Because of the diffusive properties of air and CO₂, levels in plastic bottles are sometimes higher initially to account for some expected losses over time.² In the case of beer, it is not only important during the production/fermentation process, but also in the packaging stages in that bottled and canned beers require much higher CO₂ levels than kegged beers. Although Infra-red spectroscopy is an oft used means of monitoring CO₂ levels in situ, age-old and sometimes cumbersome methods for the off-line determination of CO₂ levels in beer and other beverages exist (titration, Corning Method, etc.).³ The need for faster and more accurate means of measuring CO₂ in beverages has precipitated a number of analytical advancements in recent years, but none more promising than the use of total organic carbon (TOC) analysis.

Experimental Discussion:

Equipment:

As a method of comparison to the TOC, a Dionix ICS-1000 Ion Exchange system was first employed with limited success with an Allsep 50 x 4.6 mm column; 4-mM p-Hydroxybenzoic acid mobile phase, and the best results were obtained with a Metrosep Dual 4 monolithic column 100 – 4.6 high-capacity column. Eluents with a higher basic ionic strength worked best (buffered calcium chloride for example), and direct conductivity detection of the species.

A Teledyne Tekmar Phoenix 8000 which was calibrated for high inorganic carbon levels (up to 5000 ppm) with bicarbonate solutions was used to measure the CO₂ concentrations in the samples. The Phoenix 8000 employs UV-Persulfate oxidation and NDIR detection of CO₂. and was selected for its fast, accurate analysis capabilities and reputation for having extremely low sample carryover. Reagents used were a 10% ammonium persulfate/5% phosphoric acid oxidizing solution and a 21% phosphoric acid solution for sample pH control. Purified water for the TOC system and standard preparation was obtained from a U.S. Filter ion exchange purification system. The system was operated in TIC-IC mode as opposed to the non-purgeable organic carbon mode (TOC mode) that is used to monitor exclusively organic carbon in samples.

Results:

The results for a series of beer samples are shown in Table 1 and Figure 1, with the same samples paired for TOC and Ion-Chromatography. Although conditions for the comparison were imperfect in that the handling of the samples and analysis times were difficult to keep constant, the data clearly shows agreement. It should be noted that these values are lower than expected based on the knowledge we have regarding CO₂ concentrations in beers, which again, can likely be attributed to the inconsistent and non-ideal nature of the sample handling. CO₂ levels in beer are typically around 5000 ppm, but vary from 4000-6000 ppm in general.⁶ The ion chromatography results were converted from carbonic acid results into a representation of CO₂ in the samples.

Sample	TOC (ppm)	Ion-Chrom (ppm)
1	4745.6	3547.2
2	4564.8	4084.8
3	3180.8	3430.4
4	3384	2801.6
5	4384	3208
6	4259.2	3966.4
7	4414.4	3198.4
8	3203.2	2913.6
9	3484.8	3661
10	4214.4	3139.2

Table 1 – Comparison of Results for TOC and Ion Chromatography

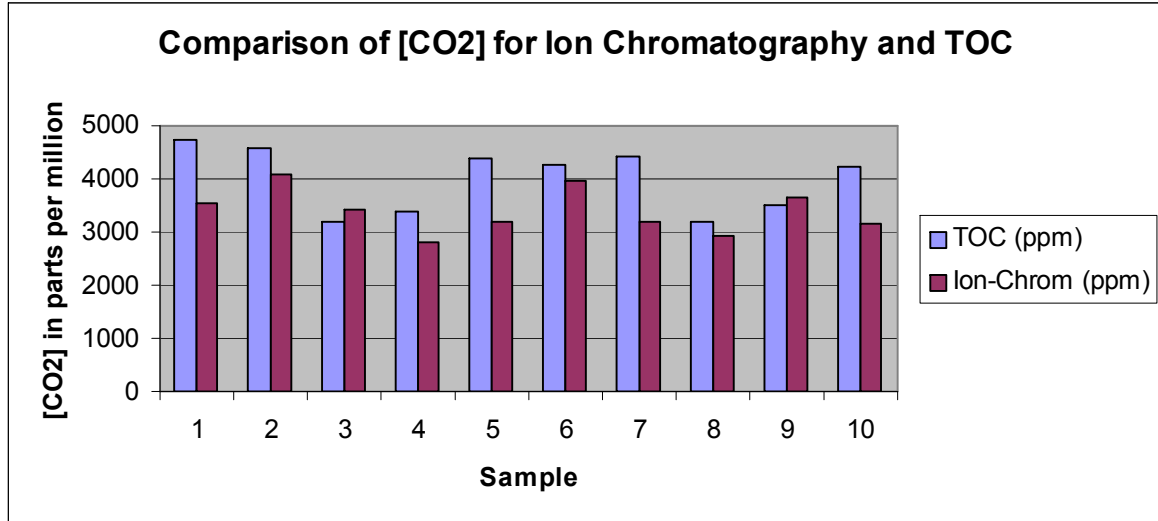


Figure 1 – Comparison of Results for TOC and Ion Chromatography

Conclusion:

Utilizing the fast and easy method of inorganic carbon analysis available with a Teledyne Tekmar Phoenix 8000 TOC analyzer, it was possible to obtain CO₂ levels in beer comparable to those obtained by ion chromatography. With 3-5 minute analysis times and no special sample handling requirements, the method is much faster and simpler than traditional methods for laboratory analysis of CO₂ in beverages. With an analysis range

of 0-10,000 ppm for inorganic carbon, the Phoenix 8000 is able to accommodate a wide range of carbonated beverage samples. Due to time constraints, the study was limited to the analysis of beer only, but is being expanded to include other carbonated beverages at the time of this publication.

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