Hydrogen Peroxide Detection by Ion Chromatography and Electrochemical Detection

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Overview

Purpose: To develop a new ion chromatography (IC) method using the Thermo Scientific™ Dionex™ CarboPac™ PA20 Carbohydrate Column, potassium hydroxide eluent, and electrochemical detection (ECD) for analysis of hydrogen peroxide.

Methods: A Reagent-Free™ IC (RFIC™) system and direct injection without derivatization of the samples was used in this application.

Results: Analysis of hydrogen peroxide from a variety of samples was successfully demonstrated.

Introduction

Hydrogen peroxide is a clear and colorless liquid with a slight pungent odor. It is a strong oxidizing agent and can be a reducing agent for strong oxidizers. Because the decomposition products of hydrogen peroxide are water and oxygen, hydrogen peroxide is preferred for many applications.

When hydrogen peroxide is used as a disinfectant in water purification and wastewater treatment, it decomposes in the presence of heat or light. Therefore, there is a need to carefully monitor various water samples for hydrogen peroxide. The presence of hydrogen peroxide in air degrades air quality. Measurement of atmospheric hydrogen peroxide also requires analytical methods to monitor its fate. Beverage samples, such as cola drinks, are also known to contain hydrogen peroxide and need to be monitored. Toothpastes and whitening kits also contain hydrogen peroxide and need to be analyzed.

Various chromatographic methods have been adapted for hydrogen peroxide analysis. An indirect method for detecting hydrogen peroxide was pursued using IC and conductivity detection.[1] This approach involved addition of bisulfite to the sample prior to analysis, and exploited a reaction between hydrogen peroxide and sulfite, detecting the resulting sulfate as a means of detecting hydrogen peroxide. Another method exploited an enzymatic reaction of hydrogen peroxide with catalase methanol to form formaldehyde, with subsequent derivatization of this species to achieve fluorescence detection.[2] Another publication reported two methods for analyzing hydrogen peroxide.[3] The first was based on a derivatization reaction with fluorescence detection. The second used a direct ECD method with a sodium acetate eluent which was adjusted to pH 10.5. Both methods exhibited excellent performance. The ECD method was simpler since it was a direct injection of the sample.

Methods

Conditions

Columns:	Dionex CarboPac PA20 Guard (3 × 30 mm) Dionex CarboPac PA20 Analytical (3 × 150 mm)
Eluent:	50 mM KOH
Eluent Source:	Thermo Scientific Dionex EGC-KOH Eluent Generator Cartridge with Thermo Scientific Dionex CR-ATC 500 Continuously Regenerated Anion Trap Column
Flow Rate:	0.5 mL/min
Temperature:	30 °C
Detection:	Pulsed amperometric detection, disposable gold electrode

ECD is a well established method of choice for carbohydrate and amino acid detection. The disposable gold electrode provides reproducible analysis while maintaining good peak shapes and excellent sensitivity. Time-consuming, labor-intensive electrode polishing steps are eliminated. Here, the disposable gold electrode was used for the detection of hydrogen peroxide.

Carbohydrate Waveform for the ECD:

Time (s)	*Potential (V)*
0.00	+0.1
0.20	+0.1
0.40	+0.1
0.41	-2.0
0.42	-2.0
0.43	+0.6
0.44	-0.1
0.50	-0.1

Sample Preparation

In this work, hydrogen peroxide analysis was pursued using standards without any sample pretreatment. Analysis of samples containing hydrogen peroxide, such as toothpaste and mouthwash, was pursued with the following sample preparation procedure.

Dilute approximately 1 gm of the sample (toothpaste or mouthwash) into 100 gm of deionized water. Place the sample on a vortex to fully disperse and then filter using a 0.45 μm Supor® (PES) Membrane Disc Filter.

Results

Analysis of hydrogen peroxide was pursued with minimal sample preparation and without any derivatization reactions. The detection used a gold electrode and ECD. Figure 2 shows the detection of a 20 ppm hydrogen peroxide standard. Excellent peak shape and sensitivity was observed using the present method. A response versus concentration study was pursued using the present method in two ranges: a high range (0.1–100 mg/L), and a low range (0.1–10 mg/L). Figure 3 shows the response versus concentration for the high range, demonstrating that the data fit to a quadratic curve. Figure 4 shows the response versus concentration for the low range, demonstrating that the data was linear. Analysis of unknown samples was pursued using the low range.

The RFIC system used in this work provided significant ease of use, automating eluent generation and reliably providing consistent eluent. The disposable electrodes facilitated reproducible analysis that was fast and complete within 5 minutes. Overall, the present method was simple and easy to implement.

FIGURE 1. Thermo Scientific Dionex ED Electrochemical Detector Cell configuration.

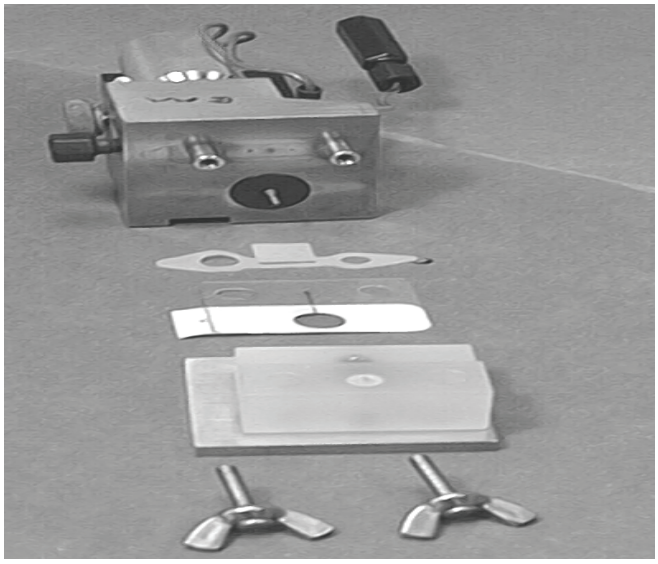
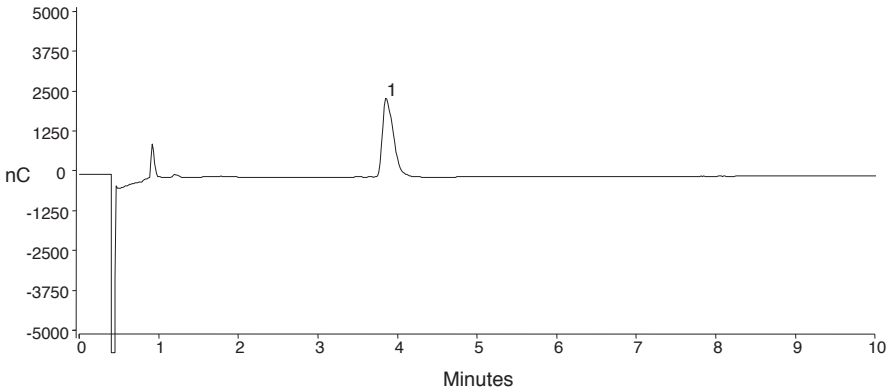


FIGURE 2. Analysis of a 20 mg/L standard of hydrogen peroxide.



Analysis of hydrogen peroxide was demonstrated (above) under isocratic conditions with good peak shape. The analysis was complete in 5 minutes.

FIGURE 3. Response versus concentration curve for the high range of hydrogen peroxide sample (0.1–100 mg/L).

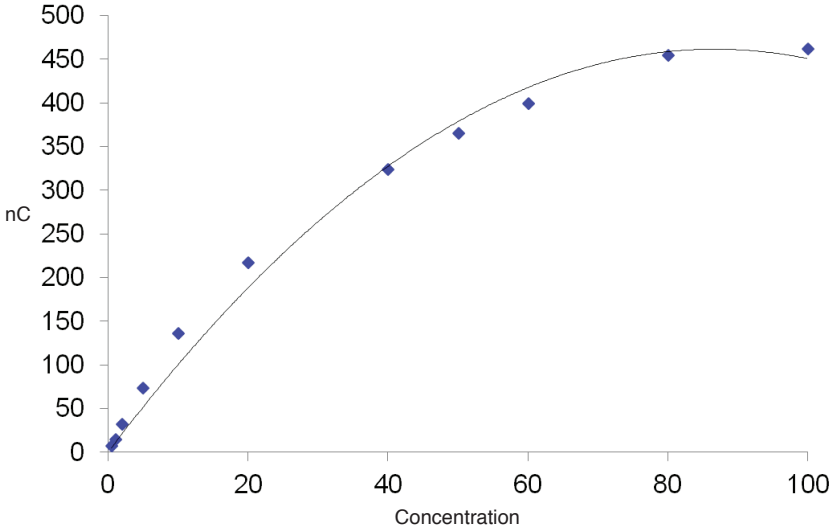


FIGURE 4. Response versus concentration curve for the low range of hydrogen peroxide sample (0.1–10 mg/L).

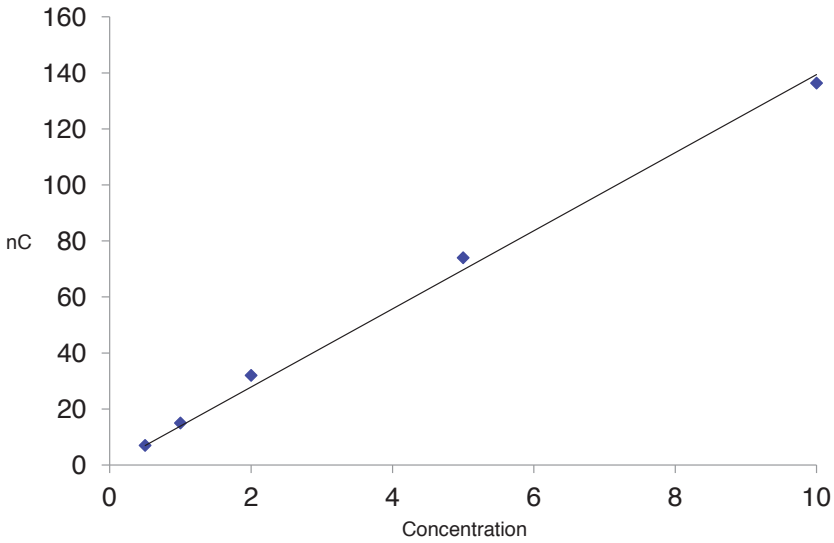
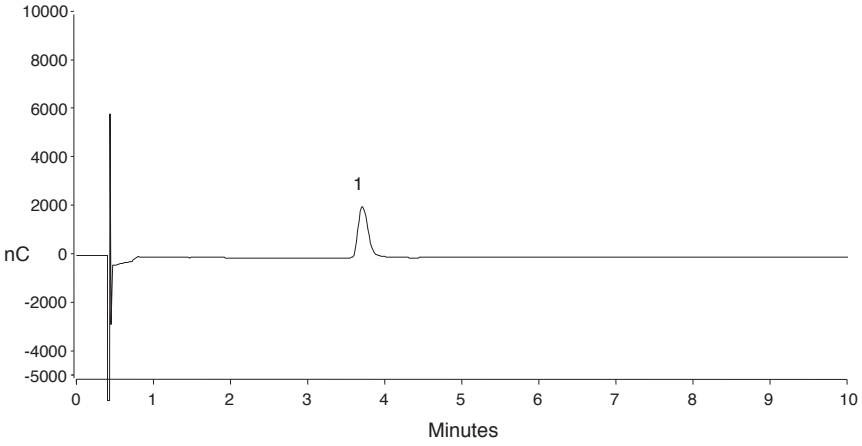
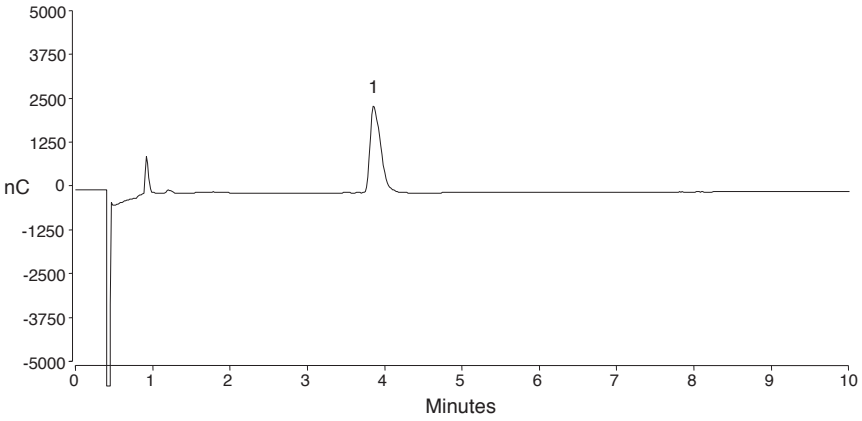


FIGURE 5. Analysis of a commercial toothpaste sample containing hydrogen peroxide.



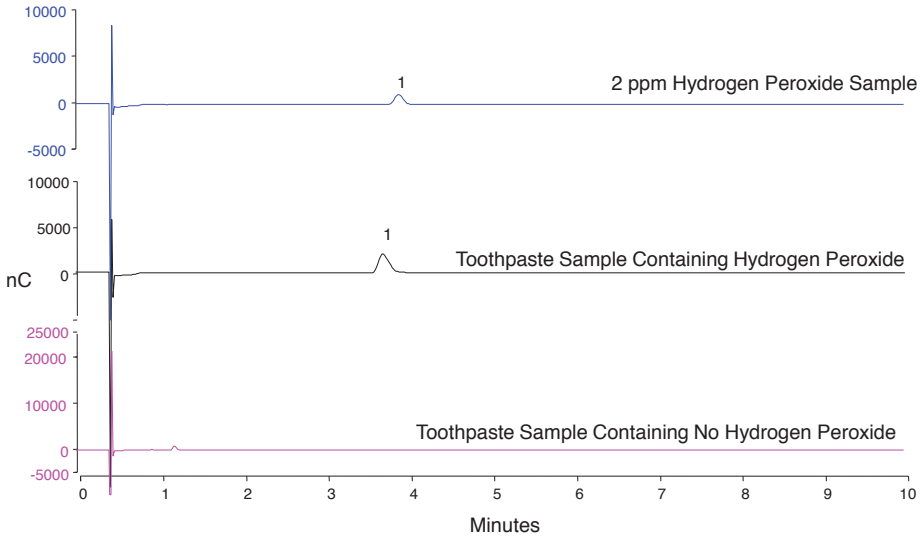
Excellent peak shape for the hydrogen peroxide can be inferred from the above chromatogram. There were no other interfering components in this toothpaste sample using the present method. It is clear that the run time can be adjusted to 5 minutes.

FIGURE 6. Analysis of a commercial mouthwash sample containing hydrogen peroxide.



Excellent peak shape for the hydrogen peroxide can be inferred from the above chromatogram. There were no other interfering components in this mouthwash sample using the present method. It is clear that the run time can be adjusted to 5 minutes.

FIGURE 7. Comparison of a sample containing a 2 ppm hydrogen peroxide standard versus a toothpaste sample containing hydrogen peroxide and one that did not contain hydrogen peroxide.



The above figure shows a comparison of a standard containing 2 mg/L of hydrogen peroxide with a toothpaste sample containing hydrogen peroxide. A control run was also pursued with a toothpaste sample that did not contain hydrogen peroxide and no peaks for hydrogen peroxide were detected as shown.

Conclusion

A simple, reliable method for hydrogen peroxide analysis was demonstrated in this work using an RFIC system. It was a direct injection method with minimal sample pretreatment. The combination of an RFIC system with ECD with disposable gold electrodes made the overall method fully automated, easy to use, and reliable. The Dionex IonPac PA20 column provided excellent separation of hydrogen peroxide and fast analysis with a run time of less than 5 minutes, as demonstrated in this work.

References

1. Jenke, D. R. Indirect Determination of Hydrogen Peroxide by Ion Chromatography. *J. Chromatogr. Sci.* **1986**, *24* (8), 352–355.
2. Hamano, T.; Mitsuhashi, Y.; Yamamoto, S. Determination of Hydrogen Peroxide in Beverages by High-Performance Liquid Chromatography with Fluorescence Detection. *J. Chromatogr.* **1987**, *411,* 423–429.
3. Tarvin, M.; McCord, B.; Mount, K.; Sherlach, K.; Miller, M. L. Optimization of Two Methods for the Analysis of Hydrogen Peroxide: High Performance Liquid Chromatography with Fluorescence Detection and High Performance Liquid Chromatography with Electrochemical Detection in Direct Current Mode. *J. Chromatogr., A.* **2010**, *1217*, 7564–7572.

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