Determination of chloride and phosphate in sports drinks by ion chromatography

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Abstract

Chloride and phosphate are important electrolytes found in most sports drinks. They are used to prevent water intoxication in athletes by maintaining the nominal concentration of electrolytes. Therefore it is important that they are present in the sports drinks in a sufficient amount. Two brands of sports drink, Gatorade and PowerAde were analyzed for their phosphate and chloride content and it was found that Gatorade contained both in greater amounts than PowerAde.

Introduction

Sports drinks were created to prevent water intoxication among athletes. Water intoxication occurs when through heavy exertion, large amounts of water and electrolytes are sweated out of the body and water is used in an attempt to rehydrate. The introduction of water into the body has the effect of diluting the remaining electrolytes in the body which reduces central nervous function. Therefore, it is important to know the concentration of electrolytes in sports drinks so one can determine their effectiveness at replenishing the body’s supply. Phosphate is also an important structural molecule and is used in high-energy molecules like ATP. Chloride is important for athletes as it helps to retain water by maintaining concentration gradients. PowerAde and Gatorade are isotonic sport drinks, which mean that the amounts of electrolytes present in solution are similar to that of the human body. PowerAde and Gatorade actual concentrations should be very similar to that of the human body. Any method used to determine ions in solution, such as AA or ICP-MS could be used, but ion chromatography was used in this study.

Experimental

Materials and Reagents

PowerAde and Gatorade samples were both purchased at Walgreen’s pharmacy. Ion chromatography phosphate standard stock solution was prepared from monopotassium phosphate (Fisher-Scientific) and dissolved in de-ionized water to a final stock concentration of 1000 ppm. Ion chromatography chloride standard stock solution was pre-prepared at a concentration of 1000 ppm (Metrohm-Peak). Mixed standards were prepared with concentrations of phosphate ranging between 2 and 8 ppm and concentrations of chloride ranging between 1 and 4 ppm diluted with de-ionized water from stock solutions.
Eluent Preparations

Ion chromatography eluent was prepared by dissolving 0.18 g sodium bicarbonate in 300 mL of degassed ultrapure water. The pH of the solution was adjusted to 10.8 with the addition of 0.1 M sodium hydroxide with constant stirring. The pH 10.8 solution was then diluted to a final volume of 500 mL with degassed ultrapure water.

Sample Preparation

Samples of Gatorade were prepared by diluting with de-ionized water to concentrations of 0.5 v/v% and 2 v/v%. Samples of PowerAde were prepared by diluting with de-ionized water to concentrations of 0.5 v/v% and 15 v/v%. All samples were then used directly for IC analysis.

Instrument Preparation

The IC analysis was carried out on a Metrohm ion chromatography system with a conductivity detector. Analytes were separated on a Metrosep A Supp 5-100 column, 4.0 × 100 mm and a particle size of 5.0 μm. The column temperature was 35.0°C, the flow rate was 0.70 mL/min, and the injection loop volume was 1.0 μL.

Results and discussion

Calibration Curves

A peak with a retention time of 4.00 minutes was present in all standard chromatograms (Fig. 1) and was selected as the quantitative signal for chloride, as it increased proportionally to concentration. The calibration curve (Fig. 2) was created by plotting the peak area vs. the concentration of the standards. Linearity was achieved in the range of 1-4 ppm with a correlation coefficient of 0.996.

A peak with a retention time of 8.15 minutes was present in all standard chromatograms (Fig. 1) and was selected as the quantitative signal for phosphate, as it increased proportionally with concentration. The calibration curve (Fig. 3) was created by plotting the peak area vs. the concentration of the standards. Linearity was achieved in the range of 2-8 ppm with a correlation coefficient of 0.9975.
Figure 1. Sample chromatogram of mixed standard with chloride concentration of 3 ppm and phosphate concentration of 4 ppm.

Figure 2. Calibration plot for chloride standards. Chloride standard concentrations vs. area of detected signal around 4.00 minutes.
Significant peaks were found at retention times relating to chloride and phosphate in the standards and it was determined with the appropriate calibration plots that the concentration of chloride and phosphate in Gatorade equaled 792 (±5) ppm and 300 (±2) ppm, each taken from three measurements, respectively. Compared to literature values of 425 (±2) and 320 (±2) for chloride and phosphate we were off by 86.3% and 6.25%, respectively.

A third peak was observed at around 3.00 minutes and it is unknown as to what could have caused it. Possibly some anion that Gatorade possesses that PowerAde does not.
Analysis of Powerade Samples

Significant peaks were found at retention times relating to chloride and phosphate in the standards and it was determined with the appropriate calibration plots that the concentration of chloride and phosphate equaled 675 (±7) ppm and 20.2 (±0.5) ppm, each taken from three measurements, respectively. Compared to literature values of 348 (±2) and 22.7 (±0.7) we were off by 94% and 11%, respectively.

Figure 5. IC Data taken from Powerade

Conclusions

A procedure for determining the concentration of chloride and phosphate in sports drink was developed. This procedure is fairly time consuming as it involves making two separate dilutions for each brand of sports drink as the concentrations of each electrolyte differ by a great amount.

There is no apparent explanation for the great innaccuracy of the chloride concentration, but as the stock standard solution was bought from a manufacturer and had been opened before we used it, it can be assumed that some of the water dissolving the chloride had evaporated, leaving a more concentrated chloride solution than advertised. If this experiment is repeated, a fresh solution of chloride will be prepared to test this hypothesis.

It was found that Gatorade has a greater concentration of both phosphate and chloride and as the true concentrations of these electrolytes are not revealed by their companies further testing is needed to pin down the exact concentrations.

References

