

What is Charge Detection?

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Executive Summary

Analytical chemists can maximize the confidence in their results for peak identification and peak purity analysis with additional sample data by combining charge and conductivity detection for ion analysis.

Keywords

Charge detection, conductivity detection, weakly disassociated ions, membrane-based technology

What Is Charge Detection?

When paired with suppressed conductivity detection, charge detection can be utilized as a confirmatory tool to obtain additional analytical information. A charge detector (QD) responds to ionic species by drawing a current at a fixed potential. Figure 1 illustrates how ions detected by the charge detector yield a signal response that is proportional to their charge state.

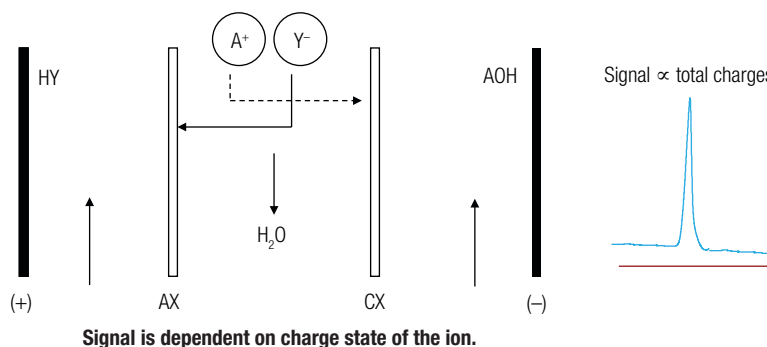


Figure 1. Charge detector operation principle.

For example, the QD produces an up to 3× greater signal for triply charged ions than singly charged ions when compared to a conductivity detector (CD). Figure 2 demonstrates the increase in signal response for multivalent ions in drinking water analysis. It should be noted that ions with the same charge and concentration will yield similar responses.

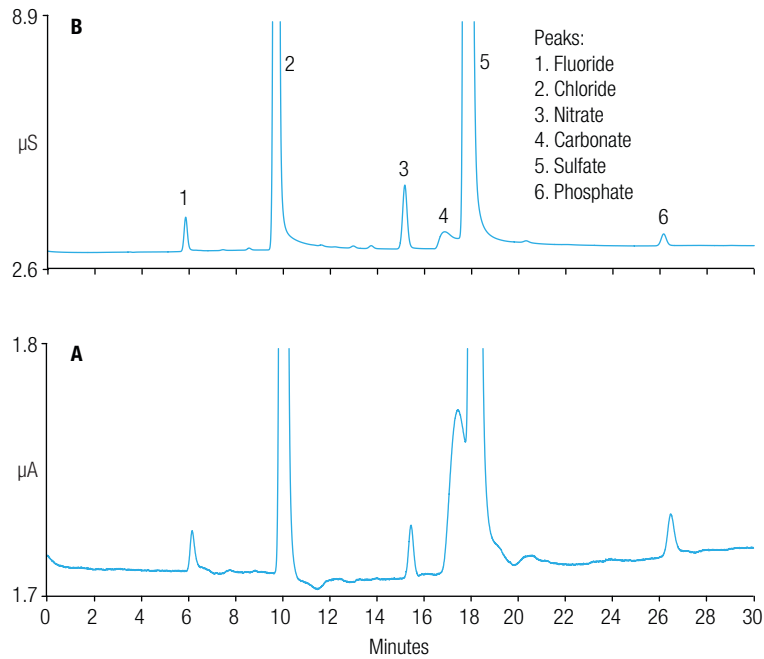


Figure 2. Drinking water analysis comparing conductivity (A) vs. the charge detector (B). Carbonate is more sensitive with QD. Shown here is QD without the CRD-200 Carbonate Removal Device typically used to remove carbonate from the sample injection.

Since the QD cell removes ions from the eluent stream through the membranes and eventually to the electrode for detection, its ion removal efficiency depends on the applied voltage. The voltage creates an electrical field which forces these analytes out of the eluent stream into the membranes. The higher the voltage applied, the faster this process will occur as demonstrated in Figure 3. However, there will be an increase in baseline and background noise due to the dissociation of water.

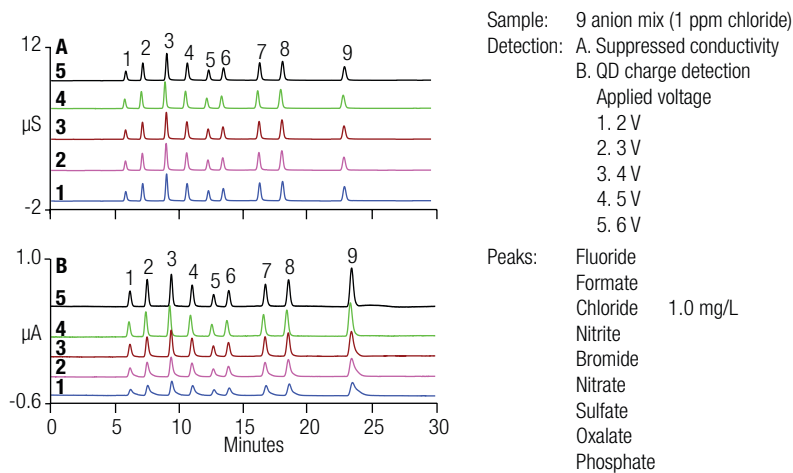


Figure 3. Effect of the applied voltage.

Additionally, the QD is termed a destructive detector simply because analytes passing through are ultimately consumed. As a result, if a series of multiple detectors are being utilized, the QD must be last.

In terms of applicable markets, the QD can be utilized for environmental (e.g. phosphate), food/beverage (e.g., organic acids) and chemical applications (e.g., ethanolamines).

How is the combination of a Charge Detector with a Conductivity Detector Powerful?

Weakly Dissociated Ions

The QD provides a unified response for strongly and weakly dissociated ions. However, weakly dissociated ions (e.g. ammonia, organic amines, organic acids and silicate) and multivalent ions will show a higher QD response than on a conductivity detector (CD). As a result, there is a linear correlation between response and concentration for these types of weakly dissociated species when using a QD. Figure 4 shows the differing correlations between response and concentration when comparing a conductivity detector (CD) and a charge detector for weakly dissociated species.

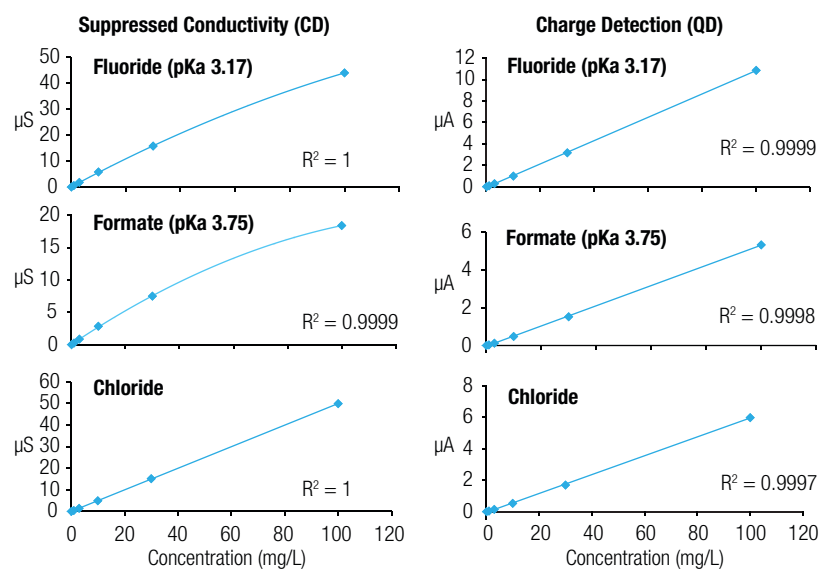


Figure 4. Response vs. concentration (CD vs. charge detector).

Quantification of Unknowns

The combination of the QD and CD allows for the quantification of unknown analytes. Chemists can compare the predicted concentrations for unknown analytes from the calibration of standards from each of the two detectors as shown in Figure 5. In addition to the information found using retention time-based identification, if the predicted analyte concentrations match between the QD and CD, there is increased confidence in narrowing down the identity of the unknown analyte. It is important to note that for co-eluting species, predictions may favor the largest response contributor.

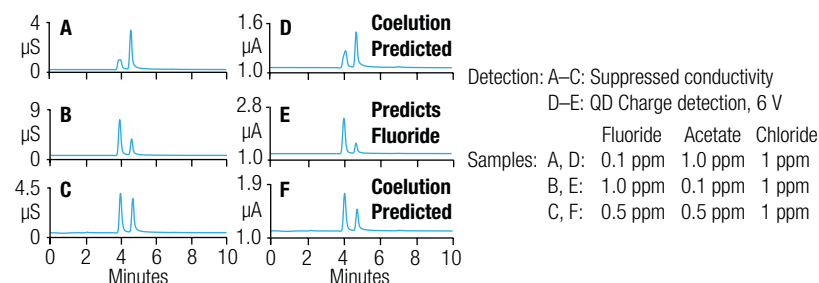


Figure 5. Confirmation with two detectors in series.

What Solutions Exist on the Market?

The Thermo Scientific™ Dionex™ QD detector uses patented membrane-based technology. When combined with conductivity detection, it provides improved peak identification and peak purity analysis. The Dionex QD charge detector is integrated into the Thermo Scientific™ Dionex™ ICS-4000 HPIC™ System.

With minimal investment, maintenance cost, and superior ease of use, the QD seamlessly fills the gap between the suppressed conductivity detector and mass spectrometry.



Figure 6. The Thermo Scientific Dionex Conductivity and QD Charge Detectors.

References

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