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Enhanced Analysis of Key Marine Nutrients in High-Salinity Seawater Using Ion Chromatography

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Extended Abstract

Objective: Accurate measurement of inorganic ions such as nitrite-N, nitrate-N, phosphate-P, and ammonium in seawater is essential for a comprehensive understanding of marine nutrient cycles, effective water quality assessment, and the detection of environmental pollution. The high salinity of seawater introduces significant analytical challenges that can complicate ion measurement. This study aims to introduce and validate a novel analytical method using the Dionex ICS-6000 Ion Chromatography system. The primary objective is to address the analytical difficulties posed by seawater's high salt content, thereby improving sensitivity and resolution for the simultaneous measurement of these critical ions.

Scope: This research focuses on the development and validation of an ion chromatography method specifically designed for seawater analysis. The Dionex ICS-6000 system was selected due to its advanced capabilities in sensitivity and resolution, which are necessary for handling the challenges associated with seawater's elevated salinity. The study encompasses a detailed evaluation of the method's performance across several critical parameters, including specificity, linearity, detection limits, precision, accuracy, and measurement uncertainty. The overarching goal is to establish a reliable and effective approach for quantifying marine nutrients at low concentrations, adhering to stringent environmental regulatory standards.

Results: The newly developed ion chromatography method demonstrated notable advancements in the accurate measurement of nitrite-N, nitrate-N, phosphate-P, and ammonium in seawater. The key findings of the study are outlined below:

1. **Specificity and Linearity:** The Dionex ICS-6000 system displayed high specificity for the target ions. The system's response was linear across the range of concentrations tested, meeting the criteria for environmental monitoring. Coefficients of determination (R^2) for all target ions were ≥ 0.99, indicating excellent linearity. Additionally, the deviation of back-calculated concentrations from expected values was $\leq \pm 20\%$, ensuring reliable quantification throughout the measurement range.
2. **Detection Limits:** The method achieved low detection limits, crucial for precise measurement of ions at trace levels commonly found in marine environments. The detection limits obtained were:
   - Nitrite-N: 0.035 mg/L
   - Nitrate-N: 0.095 mg/L
   - Phosphate-P: 0.089 mg/L These limits highlight the method's sensitivity and capability to detect very low concentrations of these ions in seawater, which is critical for accurate environmental monitoring.

3. **Precision and Accuracy:** The method demonstrated high precision and accuracy. Average percent recovery of the ions ranged between 70% and 130%, indicating effective detection and quantification of the target ions. Precision,

expressed as percent relative standard deviation (% RSD), was ≤ 20%, reflecting consistent and reproducible results across multiple analytical runs and replicates.

4. **Measurement Uncertainty:** A thorough assessment of measurement uncertainty was conducted to ensure the reliability and reproducibility of the data. Both Type A and Type B evaluations were employed to calculate expanded uncertainty, with a coverage factor of 2 at a 95% confidence level. This comprehensive analysis of measurement uncertainty reinforces the robustness and dependability of the method.

Overall, the approach successfully addresses the challenges posed by seawater salinity, offering a robust tool for researchers and environmental scientists. This technique enables accurate and comprehensive assessments of marine water quality, thereby supporting the protection and management of marine ecosystems in compliance with environmental regulations.

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