Electrified Liquid-Liquid Interfaces for Direct Electroanalysis of Nitrate in Cyanobacterial growth

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Nitrate (NO_3^-) is an essential nutrient of biosphere, pivotal in agricultural productivity and healthy vegetation of aquatic ecosystem. However, excessive nitrate accumulation in water bodies due to agricultural runoff, industrial discharge, and wastewater contamination leads to severe environmental consequences, including eutrophication, harmful algal blooms, and hypoxic zones [1]. These disruptions threaten aquatic biodiversity, compromise water quality, and pose risks to human health, such as methemoglobinemia (blue baby syndrome) [2]. Therefore, accurate and efficient nitrate monitoring is critical for environmental protection and sustainable water management. In this study, we developed an electrochemical sensing strategy based on the electrified liquid-liquid interface (eLLI) coupled with voltammetry to enable onsite and periodic nitrate monitoring in cyanobacteria growth medium. At eLLI the nitrate detection is governed by its interfacial ion transfer behaviour rather than its redox activity. Unlike conventional spectroscopic or chromatographic methods that require sophisticated instrumentation, the eLLI-based approach offers a simpler, portable, and real-time detection technique [3]. The sensor demonstrated a linear detection range from 20 to 500 µM with detection and quantification limits of 1.5 and 14.6 µM, respectively, ensuring high sensitivity and reliability. Given the complexity of natural aquatic environments, we systematically investigated the influence of chloride ions and other competing anions present in the algae growth medium. In particular, the simple in-situ chemical precipitation strategy was found to be powerful to eliminate chloride interference and improving sensor accuracy. The validated eLLI-based sensor was successfully applied to Z8 medium, a standard nutrient solution for *Microcystis aeruginosa* cyanobacteria cultures. The results demonstrated the sensor's robustness for periodic nitrate monitoring, making it a promising tool for environmental water analysis and algal research [4]. A schematic illustration of nitrate sensing is given in Fig. 1.

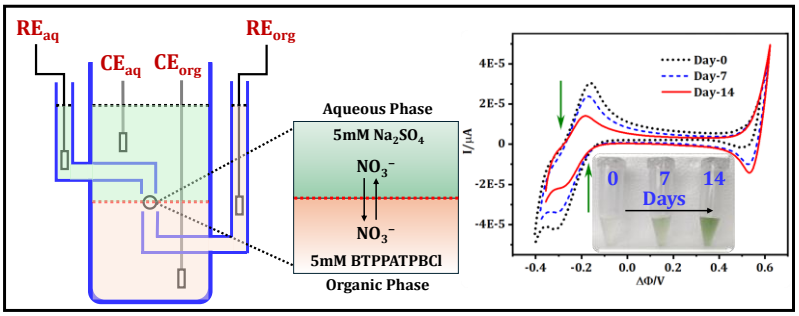

Figure 1: Schematic representation of the electrochemical cell (left) along with cycling voltammograms recorded in the algae growing medium.

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