Abstract

Imaging Optodes
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One of the major benefits from optical sensors with chemical recognition (optodes) is that signals can be transferred to imaging sensors. The often small-scale, non-steady-state and heterogeneous characteristics of natural environments make imaging optodes an interesting complement, or alternative, to ion-selective electrodes for reversible detection of solute concentrations. The general principle of imaging optodes is to immobilize solute specific fluorescent indicators onto/within thin-layered plastic films. The sensor film in contact with the sample is illuminated and images of the fluorescence intensities are captured with a camera.

The overall objective of this study was to develop and characterize the basic analytical performance of an imaging optode (planar fluorosensor) for continuous measurements of ammonium concentrations in complex environments like sediments and soils. The response time of the developed imaging optode was less than 4 minutes and the optode was able to reversibly sense ammonium from μM to mM concentrations using a novel phase ratiometric approach. The detection limit was $\sim 1 \times 10^{-6}$ M, i.e. about the same or even better than that of the best performing ion-selective electrodes for ammonium. In addition, the sensor was found pH independent with an enhanced selectivity to ammonium (NH_4^+:$K^+ \sim 17:1$) compared to potassium. The long-term drift in ratio was efficiently eliminated using a time correlated pixel-by pixel-procedure. The same procedure facilitated control of sensor parameters such as analytical sensitivity, limit of detection and operational lifetime at a pixel resolution.

Studies of ammonium turnover close to a root system of a tomato plant, and dissolution of long-term fertilizers in soil, exemplify the non-destructive procedure and large potential of high-resolution imaging in natural environments.

KEYWORDS: Imaging optodes, planar optodes, optode, ammonium, sensing, sensor