3D microelectrode chip helps soil nutrient analysis

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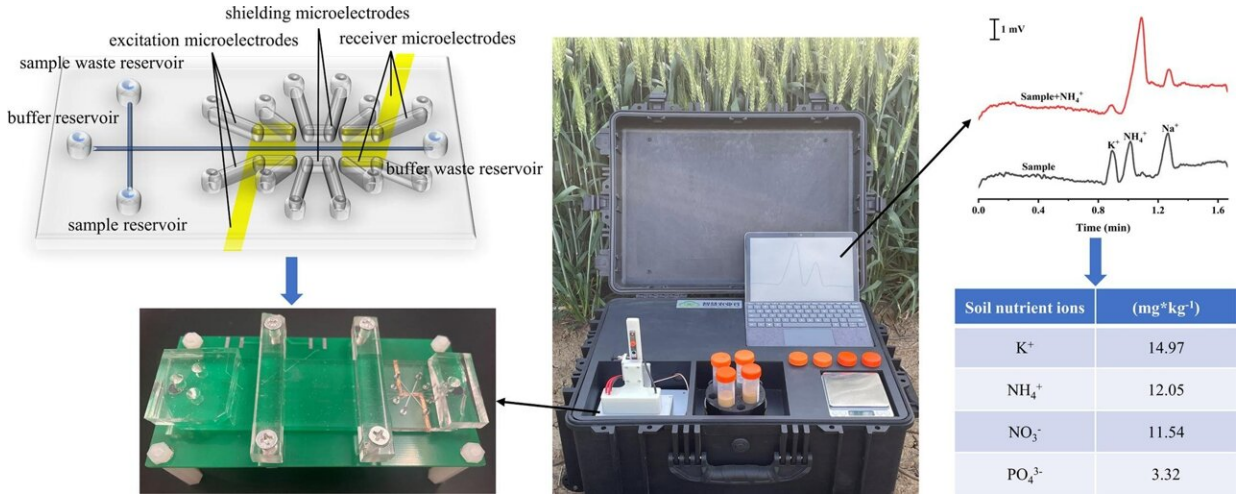

Soil nutrient ions	(mg*kg^{-1})
K^+	14.97
NH_4^+	12.05
NO_3^-	11.54
PO_4^{3-}	3.32

Schematic diagram of C^4D microfluidic chip integrated 3D microelectrodes. Credit: Chen Xiangfei

Researchers have developed a novel microfluidic chip with capacitively coupled contactless conductivity detection (C^4D) integrated 3D microelectrodes to rapidly and quantitatively determine abundant nutrient ions in soil.

"Farmers can use this chip to make sure their crops are getting all the nutrients they need to grow healthy and strong," said Prof. Wang.

The results were published in *Computers and Electronics in Agriculture*.

Nutrients such as nitrogen, phosphorus, and potassium are essential for plant growth and agricultural production. Therefore, rapid and accurate determination of these nutrients in the field is critical to guide precise fertilization practices. Compared to traditional C^4D microfluidic chips, the integration of 3D microelectrodes increases wall capacitance and improves signal response, while also being cost-effective and easy to fabricate.

In this study, the researchers, led by Prof. Wang Rujing and Assoc. Prof. Chen Xiangyu from the Hefei Institutes of Physical Science of the Chinese Academy of Sciences, together with Prof. Hong Yan's research group from Anhui University of Science and Technology, used the micro-electro-mechanical system to develop a C^4D microfluidic chip with integrated 3D microelectrodes, including a cross-over electrophoretic channel and a 3D channel. And they constructed 3D microelectrodes through a unique design with a single photolithography process.

This 3D microelectrode system is composed of a sidewall electrode and a bottom electrode, where the sidewall electrode is realized by injecting liquid gallium into the electrode channel.

With this novel microfluidic chip, the on-site determination limits of ions such as K^+, NH_4^+, NO_3^- and PO_4^{3-} were less than 0.1 mg/L, with a relative standard deviation of less than 5% between multiple determinations. In addition, the chip achieved high resolution in the separation of K^+ and NH_4^+ in soil samples.

The introduction of a new 3D microelectrode configuration scheme with excellent performance and low cost into the C^4D microfluidic chip enables the on-site determination of abundant soil nutrient ions with multi-index, high sensitivity, and stability.

"Our findings will effectively solve the need for rapid on-site

determination of soil nutrients in farms," said Assoc. Prof. Chen.

More information: Yan Hong et al, A novel capacitively coupled contactless conductivity detection (C^4D) microfluidic chip integrated 3D microelectrodes for on-site determination of soil nutrients, *Computers and Electronics in Agriculture* (2024). DOI: 10.1016/j.compag.2024.108829

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