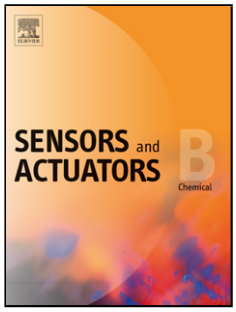

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Digital microfluidic chip technology for water permeability measurements on single isolated plant protoplasts

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Abstract

Dynamic follow up and analysis of isolated single cells that display non-adhering behaviour is hindered by the fact that they float in the suspension medium and thus requires the implementation of systems that physically entrap the cells for successful analysis. We describe the potential of digital microfluidic (DMF) chip technology for conducting analysis of cells in suspension at the single cell resolution. More specifically, we demonstrate the use of DMF technology for the analysis of a group of single individual protoplasts from *Arabidopsis thaliana* plants that are labelled with magnetic particles and are immobilized on the DMF chip by magnetic forces. By transporting droplets with different osmotic conditions to the site where the cells are trapped, we challenge the cells and monitor their responses dynamically with a camera. The use of DMF technology for performing water potential measurements has the following advantages: (i) solid particles such as cells and magnetic beads are manipulated on the chip without the risk of clogging channels, (ii) low shear stress during droplet unit operations like mixing and transport that characterize DMF are particularly suited for analysis of delicate cells types that lack cell walls such as protoplasts, (iii) the throughput of the analysis is strongly increased as multiple protoplasts are analysed simultaneously, in contrast with the traditional methods that can handle and challenge only one cell at a time. We show that the DMF analysis platform is effective in creating the steep osmotic gradients required for calculation of water permeability coefficients (*P*) as the values found are comparable with previously reported ones thus validating the suitability of the technology for such studies. This work illustrates a proof of concept for the applicability of DMF as an unparalleled and promising system for implementing single cells studies on non-adhering cells in an automated way.

Keywords: Digital microfluidic chip; Water permeability coefficient; Protoplasts; Magnetic cell immobilization; Single cell analysis; Lab-on-a-chip

1. Introduction

Absorption of water molecules and solutes from the environment and their transport in plants represents one of the