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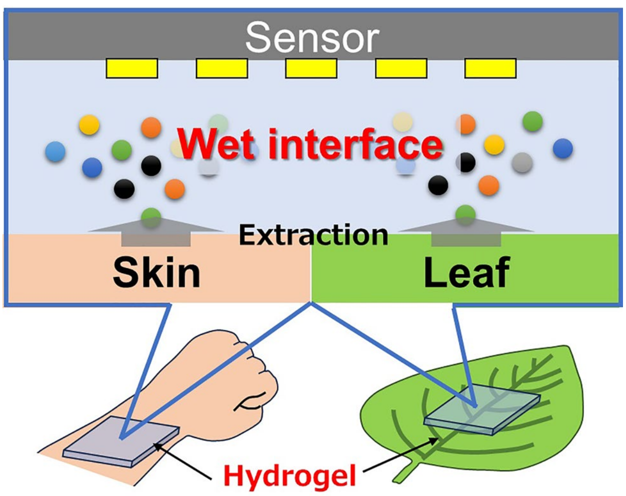
HIGHLIGHTS

Non-invasive and non-destructive chemical sensing using a wet-interfacing technique

Kuniaki Nagamine[1]



The importance of non-invasive in-vivo chemical sensing has been particularly recognized in the healthcare field since the coronavirus pandemic, where it has become common to measure the infection status by yourself using a simple immunochromatography kit. In addition, non-destructive chemical sensing methods have been proposed for plants, which are living organisms like humans, in the field of smart agriculture, with the aim of digital management of the growth and health of crops. In recent years, our research has been focusing on wet-interfacing technique [1]. This technique was established in the field of analytical chemistry that enables the extraction and detection of biological chemical components simply by bringing an aqueous solution into contact with the biological surface [2]. Based on this technique, in recent years, new non-invasive or non-destructive chemical sensors have been proposed that continuously extract and detect chemical components in human or plant bodies by connecting the sensor to the surface of these living bodies via an aqueous solution-impregnated medium (paper or gel, for example). In this highlight, we will introduce research examples of wet-interfacing technique-based chemical sensors applied for human healthcare and smart agriculture.

In humans, as it is becoming clear that sweat contains some biomarkers derived from blood, sweat components are expected as biomarkers applied to non-invasive healthcare [3]. The wet-interfacing technique-based chemical sensors, called hydrogel touchpad-based biosensors, are generally composed of a hydrogel embedding conventional chemical sensor. This type of sensor allows sweat components to be extracted into the hydrogel by simply touching the hydrogel with the human skin, followed by detecting the extracted sweat components. Since we reported on the at-rest sweat lactate sensor in 2019 [4], numerous similar sensors have been reported worldwide using different types of hydrogels and target molecules [1]. Remarkable papers are as follows: Lin et al. solved the problem of drying a hydrogel by applying a nonvolatile gel [5]. Nyein et al. [6], Zhao et al. [7], and Chen et al. [8] proposed the integration of a hydrogel into a microfluidic device to solve the problem of quantifying the amount of sweat inside a hydrogel.

In agriculture, non-destructive chemical sensing in a plant body has been attracting much attention. Optical analysis such as fluorescence [9], Raman [10], near-infrared [11, 12], and X-ray spectroscopy [13] are the representative techniques that have been developed first. On the other hand, chemical sensors for detecting residual pesticides on the surface of plant bodies [14, 15] or heavy metal in soil [16], chemical sensors destructively inserted into a plant body [17], and a device for extracting and detecting chemical components in leaves using iontophoresis [18] have been reported. Still, there are very few sensors that take into

✉ Kuniaki Nagamine
nagamine@yz.yamagata-u.ac.jp

1 Graduate School of Organic Materials Science, Yamagata University, 4-3-16 Jonan, Yonezawa, Yamagata 992-8510, Japan

account methods to non-destructively extract and detect the chemical components in a pant body. We are applying the above-mentioned hydrogel touchpad-based biosensor to non-destructive extraction and detection of chemical substances inside plant leaves. A printed potassium sensor thin film was attached to the leaf surface via a filter paper impregnated with phosphate buffer and has been successfully used for non-destructive monitoring of potassium ions in the leaf in real time [19]. In other applications, by extracting and detecting the fluorescence of chlorogenic acid using a hydrogel, a fluorescent antibacterial substance contained in infected leaves, it is possible to detect bacterial wilt in tomatoes non-destructively even before the appearance of disease symptoms [20].

As described above, chemical sensors using the wet-interfacing technique are a revolutionary technology that enables non-invasive and non-destructive detection of the health status of humans and plants. We hope that this technology, which was established in the research field of analytical chemistry, will contribute to achieving advanced future healthcare.

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