# Wearable microfluidic sweat pH sensor

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## I. Introduction

Skin interfaced wearable devices consisting of microfluidic channels, electrochemical and calorimetric assays utilize the sweat as analyte and therefore offer noninvasive and real time physiological information [1]– [3]. The biomarkers present in the sweat could be effectively used for comprehending various disorders such as diabetes, cystic fibrosis, and stress as well as monitoring of drugs, pH, and electrolytes [2][4].

Major challenges of most of these microfluidic wearable technologies are related to 1) the contamination of old and new sweats, 2) stability of biosensing methods[5], and 3) variation of sweat pH during the sensing of biomarkers.

Cortisol is the principal biomarker present in the sweat which is directly correlated to stress. Hence real time monitoring of stress could be achieved by measuring the cortisol in the sweat. The real time or longitudinal measurement of stress in diseases like concussion is much needed as stress in these patients can lead to significant health issues and as well as it can be life threatening to them [6].

One technical challenge of accurate detection of cortisol using biosensors is the dependency of the sensors to pH of solution. Therefore, it is crucial to measure pattern concentration of cortisol. Here we developed simple, low-cost wearable microfluidic chip that measures the sweat pH in real time. This sensor can be easily integrated with cortisol sensors embedded within microfluidic chips.

## II. DESIGN AND FABRICATION

The wearable microfluidic patch is fabricated from inexpensive pressure sensitive adhesives, and thin hydrophilic and hydrophobic sheets. The digital laser cutter is used to fabricate the patch layers. The commercially available highly sensitive pH strips are embedded within microfluidic chips to measure the variation in pH from 4.2 to 7 during the exercise condition (Fig. 1).

The wearable microfluidic patch contains 6 pH sensors. The subject will use slow running or jogging to generate sweat. It usually takes 6 to 10 minutes to generate sweat on the skin. Thereafter, in less than 15 minutes, the first pH was covered with sweat. Later, the sweat was subsequently absorbed by other pH strips. For all 6 pH sensors, it took from 30 to 40 minutes to collect and sense the pH depending on the subject.

Once the wearable microfluidic patch completely covers the sweat, it is detached from the forehead and digital imaging of the optical sensor is analyzed by a python program to read the variation in the sweat pH during the exercise time from 10 to 40-minute interval. The detailed results of the sequential pH variation will be presented in the complete version of the article.

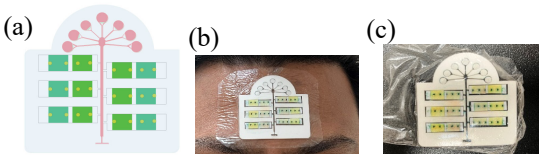


Fig. 1 (a) Schematics of wearable microfluidic pH patch (b) Wearable microfluidic pH sensing chip attached on the forehead (c) The chip detached from the forehead for analyzing in python program for pH variation.

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