Online Monitoring of Human Body Odor for the Improvement of Athlete's Health status.

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***Abstract*— Monitoring body odor represents an emerging development in area of sports performance and training. In this work, we have developed a nano-composite polymer gas sensor array for the detection of human body odor. The sensors exhibit electrical changes when interacting with VOCs emitted from the body. We proposed the use of these sensors together with artificial intelligence to track the body odor for improvement of the athletes' health status.**

Keywords*— *Body odor, Gas sensor array, Health status, Augmented sports.

I. INTRODUCTION

People usually release sweat under hot temperature, after exercising or when they become stressed or anxious. Especially, athletes under a sports training program usually release sweat more than an average person. Thus, the amount of sweat produced is determined by gender, genetics, age, environmental conditions, and fitness level [1]. However, sweat usually does not have a smell, but the bacteria on the skin break it down into aromatic fatty acids and chemicals that cause the unpleasant odor. That smell caused by the breakdown of amino acids and metabolism may indicate health status, which is correlated to the nutrition [2], stress and muscle fatigue [3] of the athlete. In some case, a change in body odor can be an underlying sign of a medical disorder. For instance, people who experience a fruity body odor may be suffering from diabetes while an ammonia odor may indicate kidney or liver diseases. If a human has a cold sweat, this may be corresponding to pain, anxiety or illness [4].

Fig 1. The concept of gas sensor arrays with sports applications for the athlete's performance and health status monitoring.

In this study, we proposed a novel concept to use a gas sensor array for monitoring the volatile organic compounds (VOCs) contained in the human body odor as shown in Fig 1. We have demonstrated a possibility for sports application by testing with the human body odor collected in cotton pads together with a pattern recognition based on principal component as shown in Fig 2.

II. EXPERIMENTAL

A. Materials

Carboxylic functionalized single-walled carbon nanotube (SWNT-COOH) (90 wt%) and four different types of polymers, namely, poly (styrenecomaleic acid) partial isobutyl/methyl mixed ester (PSE), and poly vinylpyrrolidon (PVP), poly (4-styrenesulfonic acid) solution, and polyvinyl alcohol (PVA) were selected as precursor chemical for fabrication of gas sensors.

B. Fabrication and Measurement

The sensing materials to create the four gas sensors namely, PSE-COOH, PVP-COOH, Poly 4-styrenesulfonic-COOH, and PVA-COOH have been fabricated according to the previous work [5] Firstly, Preparation of the composite solutions by dissolving each polymer in the proper solvent and then sonicated for obtained the homogeneous solution of mixture. After that, added the functionalized SWCNTs, stirred and then sonicated continuously. Polymer/f-SWCNTs solution was deposited over the interdigitated finger electrode structure (IDEs) by spin-coating technique. These sensors respond differently to various VOCs contained in the sample odor with a change in their electrical conductivity, thereby generating a unique pattern. Pattern recognition or artificial intelligence algorithm can be used to learn and classify the data.

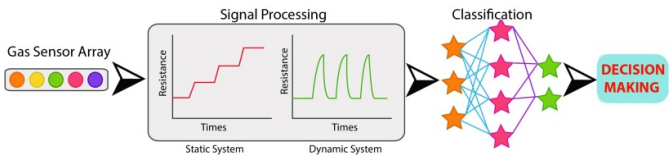

Fig 2. Schematic of data processing analysis.

III. Results and Discussion

A. VOCs Detection of Body Odor

The VOCs released from a human body can provide precious information on health status. These VOCs consist of a wide range of functional groups such as acid, ammonia / amines, alcohols, ketone, etc. [6]. We tested the 6 volatiles that found particularly in the human body odor, our gas sensors show specificity and sensitivity to the functional group contained in the body odor. The PSE-COOH and Poly 4-styrenesulfonic-COOH sensors show higher response toward the amine odors (TMA and ammonia). In addition, the PVP-COOH yields specific response to water and methanol. The working principle of these sensors is based on the swelling capability of the polymer and electron-donating capability of analytic gases into carbon nanotubes [7]. The specification of sensors can detect the VOCs and recognize the different odor by functional group and structure of polymer. The correlation of the sensor response to the body odor can refer to the performance or health status of an athlete. The odor strength has changed due to the amount of sweat that occurs from activities in each day. As a result, these sensors are appropriate to detect and evaluate the human body odor for sports training.

B. Body Odor Monitoring of Player's Activities

To simplify the results of 3 volunteer's body odor who have the same background (3 Healthy men have 27-30 years old), the principal component analysis (PCA) was introduced to classify all data sets and provide comprehensible visualization as shown in Fig. 4, where PCA clearly illustrates the clustering of 4 different odor patterns during the passage of time by using the factors as Min-Max value and slope. It was found that 4 types of odor patterns are clearly distinguished, whereas the body odor data show an obvious progressive direction of body odor after wearing the device for 0, 3, 6 and 9 hours, respectively. In addition, we can observe recovering of the underarm odor of the volunteer. This result provides a straightforward understanding about the relationship between the observed signals and changing of the human odors related to different activity times.

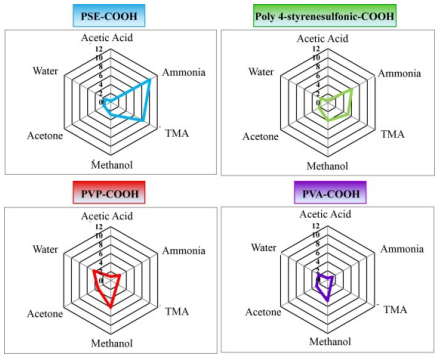

Fig 3. Radar plot of sensing response of four sensors when exposed to volatiles that contains in body odor with a concentration of 25 ppm.

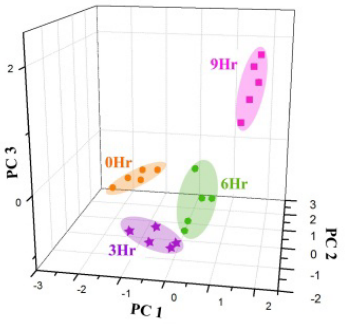

Fig 4. 3D PCA performed on human body odor of 3 volunteer's, obtained during the daily activities of a volunteer.

IV. Conclusion

This paper demonstrates a technology to detect body odor of an athlete based on a gas sensor array and a pattern recognition algorithm. It was shown that the technology has a capability to track changes in the human body during sports activities. Considering that the body odor could be used as an indicator for sports performance and health status, it is well expected that our technology could play a pivotal role in daily life monitoring and athletic training, as well as to help them know health status early.

Acknowledgments

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