Development of Taste Sensor with High Selectivity and Sensitivity

Yusuke Tahara and Kiyoshi Toko
Research and Development Center for Taste and Odor Sensing
Kyushu University
Nishi-ku, Fukuoka 819-0395, Japan
e-mail: tahara@belab.ed.kyushu-u.ac.jp, toko@ed.kyushu-u.ac.jp

***Abstract*—We have developed a taste sensor for objective taste evaluations of foods, beverages and pharmaceuticals. The taste sensor is based on the potentiometric measurement system and has sensor electrodes with lipid polymer membranes as working electrodes and as reference electrode. It is desirable for the sensor to be able to evaluate not only the taste, but also the aftertaste, similar to the way humans experience it. In this study, we report relationships between sensor responses, the amount of adsorbed monosodium glutamate (MSG) onto the lipid polymer membrane and human sensory score for the evaluation of the aftertaste of umami.**

Keywords-taste sensor; lipid polymer membrane; sensory score.

I. INTRODUCTION

In food and beverage industries, it is very important to evaluate taste for development of new products, market research and quality control. The main method of taste evaluation is based on sensory tests that well-trained panelists actually perform by tasting and evaluating samples. The sensory tests have some problems, such as low objectivity and reproducibility, and the physical and psychological stress imposed on the panelists. To solve these problems, we have developed a taste sensor based on potentiometric measurement system [1]-[3]. The taste sensor has sensor electrodes which use lipid polymer membranes for the taste sensing part and output a change in the membrane potential caused by the interaction between the membrane and the taste substances. There are several kinds of membranes for evaluations of saltiness, sourness, umami, bitterness or sweetness. The surface charge density and the hydrophobicity of each membrane are designed by adjusting the sorts and amount of lipid and plasticizer on the sensor membrane, considering the basis of physicochemical properties of substances with each basic taste [4]. The taste sensor has been widely applied in manufacturing of foods and beverages such as green tea, milk, rice, soy sauce and pork [5]. Figure 1 shows a taste map of beer on the market, which is one of applications using the taste sensor for market survey.

It is desirable for the sensor to be able to evaluate not only the taste, but also the aftertaste, similar to the way humans experience it. Although the taste sensor has been used for evaluation of aftertaste [2], the interaction between the membrane of a sensor electrode for umami and umami substances for evaluating the aftertaste of umami was not investigated well. In this study, we report relationships between sensor responses, the amount of adsorbed monosodium glutamate (MSG) onto the membrane and human sensory score for the aftertaste of umami. The aftertaste of umami, which is called "kokumi", is recognized as a complicated taste, which is described in various ways, such as "mouthfulness", "thickness" and "continuity" [6][7].

II. MATERIAL AND METHOD

A. Lipid polymer membrane

The lipid polymer membrane used in the sensor electrode for umami used in this study comprises polyvinyl chloride (PVC) as the supporter constituting the membrane, trioctylmethylammonium chloride (TOMA) and phosphoric acid di(2-ethylhexyl) ester (PADE) as the lipids, and dioctyl phenylphosphonate (DOPP) as the plasticizer. Details on the preparation of the procedure can be found in a previous report [2].

B. Measurement of CPA value using taste sensor

Measurements of sample solutions using the sensor electrode for umami utilize the taste sensor (TS-5000Z, Intelligent Sensor Technology, Inc.). Monosodium glutamate (MSG) was used as kokumi substances. MSG in a reference solution consisting of 30 mM KCl and 0.3 mM tartaric acid was used as umami solutions. The change of membrane potential caused by adsorption (CPA) [1]-[3] is used as sensor outputs of the samples. The measurement procedures were performed using the same technique, following the manual.

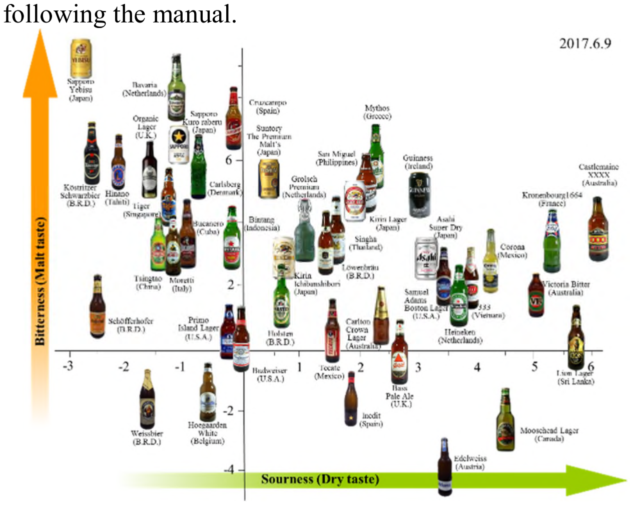

Figure 1. Taste map of beer using the taste sensor.

C. *Measurement of the amount of adsorbed MSG*

The amount of MSG was measured by an enzymatic method (L-glutamate kit, Yamasa Co., Japan) and a spectrophotometer (UV-1800, Shimadzu Corporation). First, 5 ml of MSG solution with a known concentration was added dropwise onto a petri dish on which a lipid polymer membrane had been formed, and left to stand for 30 s to allow MSG molecules in the solution to be adsorbed onto the membrane. After 30 s, 3 ml of the MSG solution was taken from the petri dish to measure the absorbance of the solution. The concentration of MSG in the measured solution was calculated from the measured absorbance and calibration curve. The difference between the concentration of the MSG solution added dropwise and that of the MSG solution calculated from the absorbance was defined as the amount of adsorbed MSG.

D. *Sensory test of aftertaste of umami*

Five well-trained panelists (2 male and 3 female healthy adults) evaluated the following. The panelists drank each MSG solutions. Then, they were instructed to answer questions about the taste (kokumi) at 20 s after drinking.

III. Results and Discussion

Figure 2 shows the CPA response values to MSG solutions using the sensor electrode for umami. The CPA values increased with increasing MSG concentration from 30 to 300 mM. Figure 3 shows the amount of adsorbed MSG onto the membrane. The amount of adsorbed MSG increased with increasing MSG concentration from 30 to 300 mM. These results indicate that the CPA is generated when a taste substance adsorbs onto the surface of the lipid polymer membrane and the electrical charge density of the membrane surface changes. In order to confirm that the aftertaste of MSG shows kokumi, a sensory test was conducted. The well-trained panelists evaluated the aftertaste of the MSG solution (10, 100 and 300 mM). They all answered that MSG solution showed kokumi at 20 s after drinking the MSG solution and the intensity of kokumi increased with increasing MSG concentration.

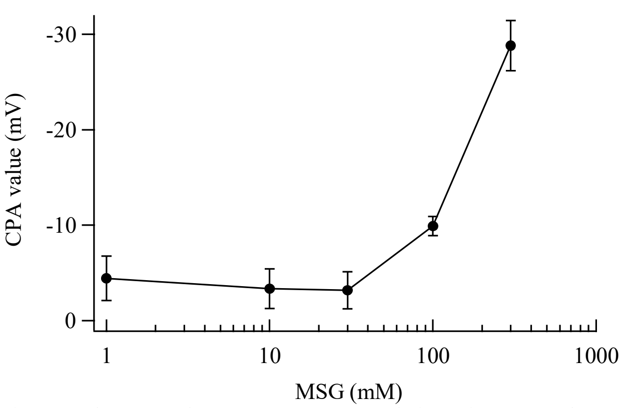

Figure 2. The CPA values response to MSG solution using sensor electrode for umami.

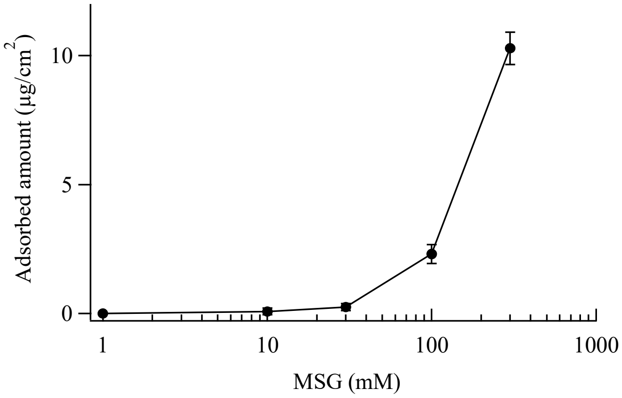

Figure 3. The amount of adsorbed MSG onto the membrane.

In conclusion, the CPA value by the sensor electrode for umami showed a good agreement with kokumi by sensory score. It was suggested that kokumi by MSG could be evaluated by the sensor electrode for umami.

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