Detection of Cocoyl Sarcosine utilizing an Extended Gate-Type Organic Field-Effect Transistor with Copper(II)-Dipicolylamine Complex

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Abstract

Herein, we report a chemical sensor utilizing an easily manufactured organic transistor for the cocoyl sarcosine (CS) detection. An extended gate-type organic field-effect transistor (EG-OFET), with separated operation and detection portions, was employed. The extended gate gold electrode was modified with a self-assembled monolayer of dipicolylamine copper(II) complex (Cu(II)-dpa) that shows a binding affinity to CS. The EG-OFET exhibited changes in transistor characteristics with increasing CS concentration.

1. Introduction

Cocoyl sarcosine (CS) may act on other ingredients to penetrate through the skin, and CS derivatives are a subject of concern owing to their potential toxicity.[1)] However, there is almost no report to date regarding on-site CS detection. In this regard, an extended gate-type organic field-effect transistor (EG-OFET) has attracted broad attention as it can realize the simple and fast detection of the target in aqueous media.[2)] Toward the CS detection, the extended gate gold electrode was modified with a self-assembled monolayer (SAM) of copper(II)-dipicolylamine complex[3)] (Cu(II)-dpa) with a binding affinity to CS. Herein, we report CS detection based on the EG-OFET.

2. Experimental section

The EG-OFET sensor consisted of an operation part and a sensing part to detect analytes in aqueous media (Fig.1). The OFET can be operated at a low drive voltage (< |3|V) owing to the double dielectric layer composed of aluminum oxide (AlO_x) and tetradecylphosphonic acid (TDPA). Furthermore, a π-conjugated polymer (PBTTT) and a fluoropolymer (*i.e.* CYTOP™) were used as an active layer and a passivation layer, respectively. The extended gate electrode was immersed in a methanol solution of dpa (10 mM) for 1 h at 25 ºC and then in a HEPES buffer solution (10 mM, pH 7.4 at 25 ºC) containing $Cu(ClO_4)_2$ (1 mM) to prepare the electrode modified with a Cu(II)-dpa complex.

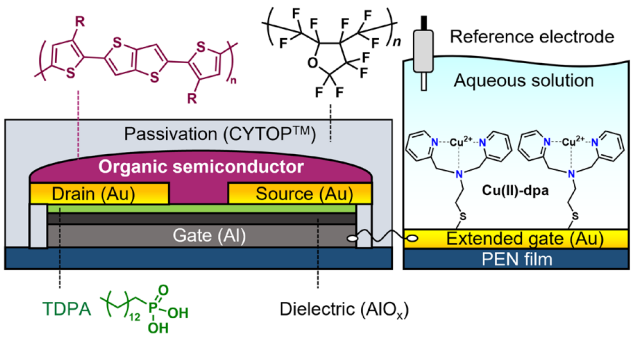

Fig.1 Schematic illustration of the EG-OFET sensor for cocoyl sarcosine (CS) detection.

3. Results and discussion

The modified electrode was analyzed using different characterization techniques. Photoelectron yield spectroscopy (PYS) performed in air and wettability measurements confirmed the adsorption of the organic compound (*i.e.,* dpa) on the extended gate gold electrode. The work function shift and the Cu 2*p* peak were observed in PYS and X-ray photoelectron spectroscopy (XPS), respectively (Fig.2(A)). In addition, cyclic voltammetry (CV) measurements confirmed the redox peaks derived from the copper ion. These results confirm the coordination of Cu(II) with dpa. The density of dpa calculated by linear sweep voltammetry (LSV) with four repetitions was $(1.1\pm0.1)\times10^{-9}$ mol/cm^2, which indicates high density and uniformity of dpa. Moreover, the transfer characteristics (V_{GS}-I_{DS}) of the EG-OFET sensor functionalized with the Cu(II)-dpa derivative changed with increasing CS concentration (Fig.2(B)), suggesting that the carboxy group of CS bound to the Cu(II)-dpa derivative. Furthermore, the limit of detection (LoD) was estimated as 0.064 ppm by titration isotherm results (Fig.2(C)).

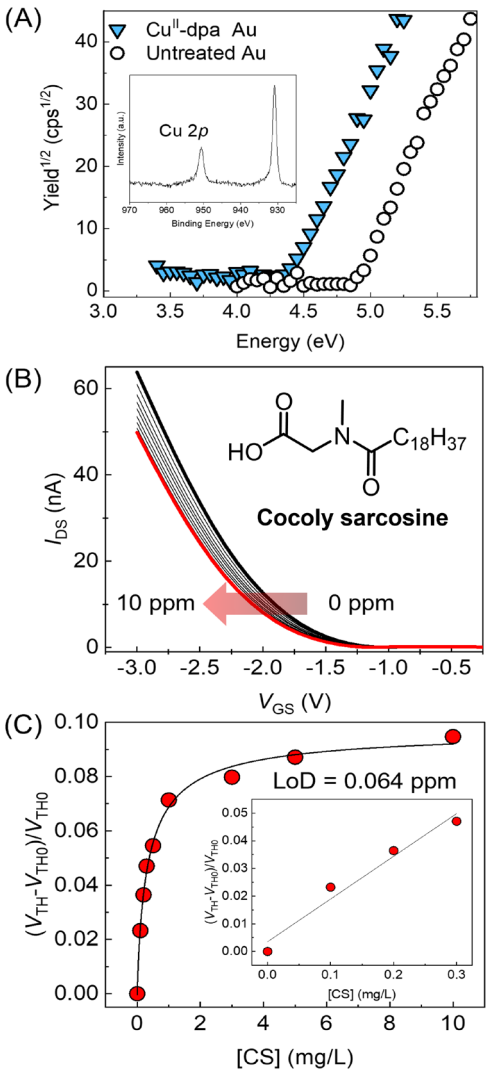

Fig.2 (A) PYS measurement of the untreated Au (white circle) and the Cu(II)-dpa modified Au electrode (blue inverted triangle). Inset: Cu 2*p* peak shown in XPS spectrum. (B) Transfer characteristics (I_{DS}-V_{GS}) and (C) Titration isotherm upon the addition of CS in water. [CS] = 0−10 mg/L. Inset shows the lower end titration.

4. Conclusions

We demonstrated CS detection in water by the Cu(II)-dpa functionalized EG-OFET. The modified electrode was characterized by PYS, XPS, wettability measurements, and LSV. The transfer characteristics of the fabricated EG-OFET varied with increasing CS concentration (LoD: 0.064 ppm).

Acknowledgments

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