

Electropolymerization of porphyrinoids on LIG as EGFET-based sensor array for ascorbic acid detection

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Summary:

Laser-induced graphene was obtained from polyimide films by lasing with a commercial CO₂ laser. Then porphyrinoids were electrosynthesized on the electrodes using cyclic voltammetry. These electrodes were employed as working electrodes in an extended gated field-effect transistor configuration. The array exhibits excellent sensitivity towards ascorbic acid and dopamine. Furthermore, artificial tears were tested with and without ascorbic acid as real samples.

Keywords: EGFET, laser-induced graphene, ascorbic acid, porphyrinoids, electrosynthesis.

1. Introduction:

L-ascorbic acid is a well-known water-soluble antioxidant present in many biological systems, and there are several ways to detect it [1]. ChemFET sensors are one of the recent interests in biological applications. Extended gate field effect transistor (EGFET) is quite modified from ion sensitive-FET sensors where the transducer is away from the electrolytic solution which gives the device long-term stability. Because MOSFETs are reusable in this technique, but the working electrode needs to be replaced, we need to pay attention to developing sensing materials. Preparation of electrodes is always a crucial part of the development of I sensors, where laser-induced graphene (LIG) is an easy method to obtain highly conductive graphene. Porphyrinoids are excellent ionophores materials that have been exploited in potentiometric sensors [2]. In this work, we electrosynthesized the porphyrinoids on laser-induced graphene (LIG) and used a sensor array using the EGFET technique to detect ascorbic acid in artificial tears.

2. Materials and methods:

A 125 μM polyimide sheet was lasered to produce LIG. The polyimide was cleaned with ethanol before laser illumination. Double lasing was performed with laser power of 10 W/cm², at a rate of 20 cm/s and a resolution of 1000 PPI. The LIG obtained was used to electrosynthesis porphyrinoids in 0.1M TBAC. Elec-

tropolymerization was carried out as reported in our previous work [3]. This forms a sensor array consisting of 8 sensors: LIG, LIG/Cu(NH₂)₃TPC, LIG/ Cu(NH₂)₃TPC_LUT, LIG/ Co-PPH₃(NH₂)₃TPC, LIG/ Mn-Cl(NH₂)₃TPC, LIG/ Cu-5,10(NH₂)₂TPP, LIG/ 5,15(NH₂)₂TPP and LIG/ 5,10(NH₂)₂TPP (left to right). Each electrode was connected to the gate terminal and a saturated calomel electrode was used to bias the gate as shown in Fig. 1. 100 μl of artificial tears (purchased from a pharmacy) were tested as a real sample in 1X PBS at.

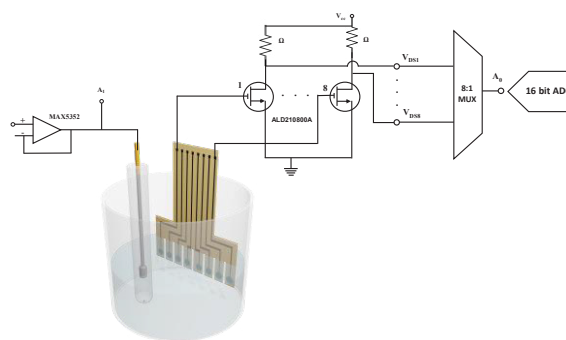


Figure 1. Schematic of the experimental setup.

3. Result and discussion:

Fig. 3 shows the principal component analysis (PCA) of the sensor array. The sensor was evaluated with ascorbic acid, dopamine, and artificial tears with and without ascorbic acid. The score plot shows the residual of the

repeated measurements. Fig 2 a) represents the scope plot of the sensor array based on ascorbic acid, dopamine, the mixture of dopamine and ascorbic, and synthetic tears with and without ascorbic acid. Both PC1 and PC2 correspond to 97.77% of the total variance. The measurements were repeated twice with a two-sensor replica. Fig 3 b) Load plots indicate the execution of the sensor array where the sensor projects in different directions. It is noteworthy that Cu-5,10(NH₂)₂TPP is projected in the opposite direction with respect to the bare LIG electrode. On the other hand, LIG/ Cu₃(NH₂)₃TPC_LUT doesn't provide any information with respect to LIG. It is noticed that LIG contributes a lot more towards dopamine than electrosynthesized sensors.

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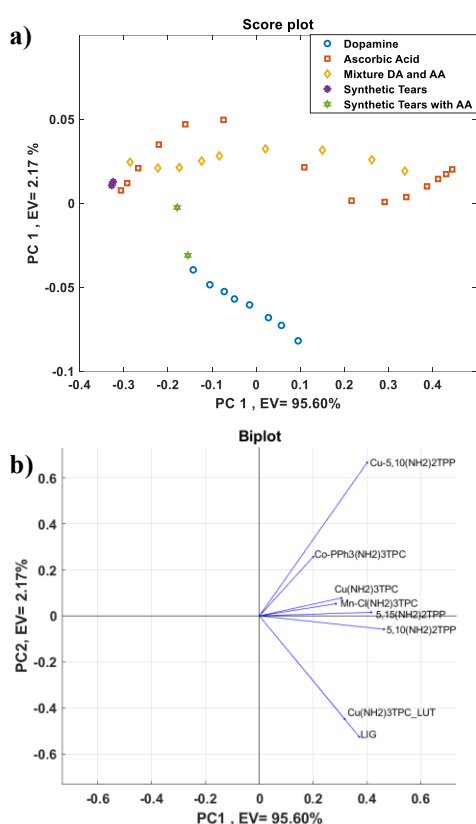


Fig 2. PCA of sensor array a) score plot based on ascorbic acid, dopamine, a mixture of dopamine and ascorbic, synthetic tears with and without ascorbic acid, b) biplot.

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