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The Channel Behavior of Gramicidin D in the Self-assembled Monolayer

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Abstract: It was found for the first time that gramicidin D (GD) molecules can be incorporated into the ODM monolayer which is self-assembled on the surface of the gold electrode and form monovalent cation channels.

Keywords: Gramicidin; self-assembled monolayer; channel behavior.

Gramicidin is a linear polypeptide antibiotic consisting of 15 hydrophobic amino acids with L and D configuration. It can form ion channels in membranes which are specific for small monovalent cations[1] . Traditionally, it is thought that the bilayer or bilayer-like environment is necessary to gramicidin channel forming. All of the reported works were based on biological membranes, such as erythrocytes, mitochondria, or artificial membranes, such as bilayer lipid membrane (BLM), liposome and so on. Only one paper reported the incorporation of gramicidin into solid substrate supported BLM and the channel behavior[2]. However, the gramicidin channel behavior based on the monolayer has not been mentioned in literatures. In this paper, it is found that gramicidin can form ion channel on self-assembled monolayer.

A potentiostat and a three electrode electrochemical cell were used in the experiments. The working electrode was a bare gold electrode or the gold electrode modified with octodecyl mercaptan (ODM) monolayer using the self assemble method. The counter electrode was a Pt wire. A saturated calomel electrode served as the reference electrode. The electrolyte is the 2 ml 1 mol/L KCl solution. The cyclic voltammograms of 2 mmol/L $K_3[Fe(CN)_6]$ at the bare and the ODM-modified gold electrodes demonstrated that the pinhole fraction of the surface of the ODM-modified electrode was very small indicating that the interaction between inorganic ions and the gold substrate was efficiently barriered by the ODM self-assembled monolayer.

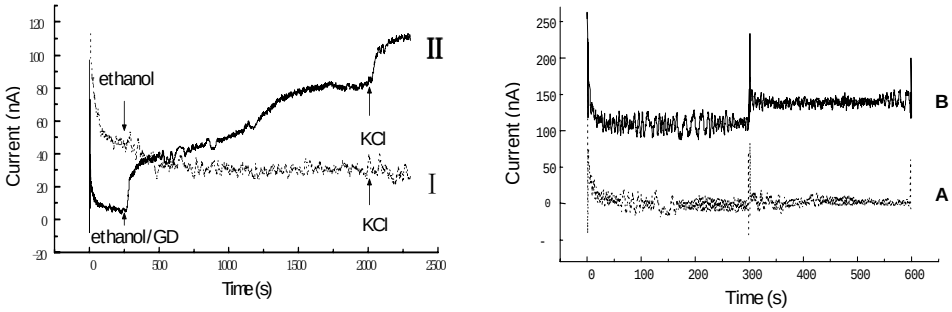
Figure 1 shows the current change with time for the ODM-modified gold electrode at 50 mV. It can be seen from **Figure 1**, Curve I that there is no obvious change in the current after adding 0.2 ml ethanol at 250s and 1 ml saturated KCl solution at 2000s into the electrolyte. However, when 0.2 ml ethanol with 55.9 μmol/L gramicidin D (GD) is added at 250s , the current rapidly increases and then gradually reaches a stable value at about 1750s. When 1 ml saturated KCl is added at 2000s, the current increases again (**Figure 1**, Curve II). The sole difference between Curve I and II is whether GD is added into the solution.

Thus, the current change in Curve II can only be attributed to GD. The most possible explanation is that GD molecules can be spontaneously incorporated into the ODM monolayer and form monovalent cation channels resulting in the cation permeability and then the current increases. The gradual increase in the current means that the incorporation of the GD molecules into the ODM monolayer is a slow process.

After the two ODM-modified electrodes were used in the experiments for **Figure 1**, Curve I and II, they were rinsed with distilled water and then placed in the 1 mol/L KCl solution without gramicidin D. When 50 mV potential is applied to the two electrodes, respectively, the current for the electrode used for **Figure 1**, Curve II (**Figure 2**, Curve B) is obviously larger than that for the electrode used for **Figure 1**, Curve I (**Figure 2**, Curve A). Furthermore, when the electrode potential changes to 100 mV, there is almost no current change for the electrode used for **Figure 1**, Curve I (**Figure 2**, Curve A), while the current obviously increases for the electrode used for **Figure 1**, Curve II (**Figure 2**, Curve B). It further demonstrates that gramicidin D molecules have incorporated into the ODM monolayer and form the monovalent cation channels.

Figure 1. The change in the current with time for the ODM-modified gole electrode at 50 mV after adding ethanol without (**I**) and with gramicidin D (**II**) at 250s and the saturated Kcl solution at 2000s into the electrolyte.

Figure 2. The change in the current with time for the ODM-modified gold electrode after using for **Figure 1.** Curve I (A) and for **Figure 1**, Curve II (B) in the 1 mol/L solution. The electrode potential: 50mV from 0 to 300s and 100mV from 300 to 600s.



In summary, it can be concluded from the results mentioned above that gramicidin D molecules can be incorporated into the ODM monolayer which is self-assembled on the surface of the gold electrode and form monovalent cation channels. In order to understand more clearly the mechanism for forming the ion channels in the ODM monolayer self-assembled on the substrate, further study is underway in our group.

References

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