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TiO_2 Nanorod-based Photoelectrochemical Sensor for Alzheimer's Disease Detection

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Abstract:

In this research. TiO_2 nanorods was fabricated on FTO/glass as electrode for the immobilized of Alzheimer's disease antibody by using 3-mercaptopropionic acid (MPA). Then, cyclic voltammetry method was used to test the current response to Alzheimer's disease peptide. The result shows that biggest change of current could nearly 2 μA. The light on/off cycle of illumination by LED with different wavelength was performed in Faraday cage to evaluate the photo response. With illumination by wavelength of 470 nm could have an acceptable photocurrent, which could have less damage to bio-related spices comparing to UV illumination. 15% increases of current could be achieved by this illumination on TiO_2 nanorod. , which is proven for larger signal for Alzheimer's disease detection.

Key words: Electrochemical sensor, TiO_2 nanorod, Cyclic voltammetry, Alzheimer's disease,

Introduction

Alzheimer's disease is a degenerative brain disease and the most common cause of dementia. Lots of the people get Alzheimer's disease when they were over 65 [1]. Now a day, early detection may be the best solution to reduce the impact since no full effective medical treatment to cure Alzheimer's disease. The limitations of diagnosis are high cost and side effect. Photoelectrochemical method could be used for high current in cyclic voltammetry by illumination excitation. TiO_2 has been applied to improve the performance in semiconductor and biosensor [2]. TiO_2 nanorod could be obtained by electrochemical anodization process [3] and hydrothermal fabrication [4]. For the low limit of detection of Alzheimer's disease, TiO_2 nanorod structure with high surface area and photo response is investigate in this study.

Titanium dioxide

To prepare TiO_2 nanorod, 40 mL aqueous hydrochloric acid (HCl) solution with 18.5% in weight ratio and 1 mL Titanium(IV) isopropoxide were mixed and stirred for 5 min. A FTO (Fluorin-doped Tin Oxide) glass with area of 1.5 cm × 2.5 cm was ultrasonically cleaned in acetone, methanol, and DI water. Put the solution and FTO glass into a Teflon-line stainless steel autoclave at 150 °C for 8 hour. The SEM picture of TiO_2 nanorod is shown in Fig. 1.

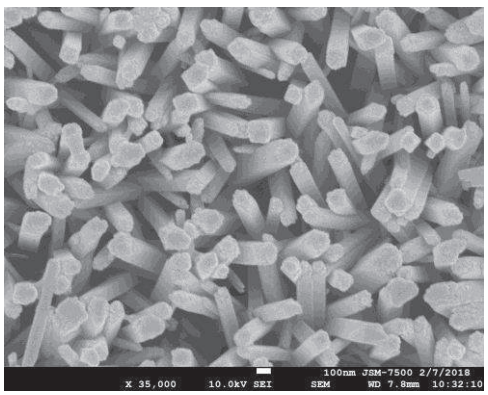

Fig. 1. SEM picture of Nanorod structure of TiO_2.

Antibody and peptide immobilization

First, sensor surface was rinsed with DI water for 5 min. Then 3-mercaptopropionic acid (MPA) worked as the linker between the TiO_2 and antibody of Alzheimer's disease [5]. The sampe is immersed in 0.15M MPA ethanol solution overnight and then rinsed with ethanol. Then drop 10 µL with concentration of 10 µg/ml Alzheimer disease antibody, Beta amyloid 1-28, (Abbiotec) on the sample surface for 12 hours at 4 °C. Then 10 µL the concentration of peptide of 20 µg/ml was dipped on the surface for 6 hours and keep it on 4 °C.

The cyclic voltammetry (C-V) method was used to investigate the current between all experiment steps for the immobilization status. The illumination with different wavelength was also applied to check the photo current increment by TiO_2 nanorod by mutli-wavelength LED light source (CoolLed, pE-4000).

Results

Amperometry method is used to investigate the photocurrent of fabricated TiO_2 nanorods under illumination of two different wavelength as shown in Fig. 2. The both 470 nm and 365 nm has photocurrent. But UV light might damage the antibody and peptide. Therefore we only use 470 nm led light for the rest experiment.

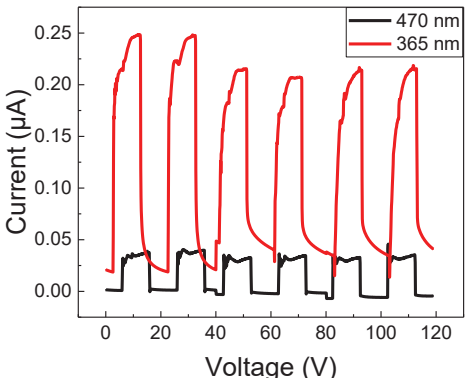

Fig. 2. The current response with and without illumination under two different wavelength.

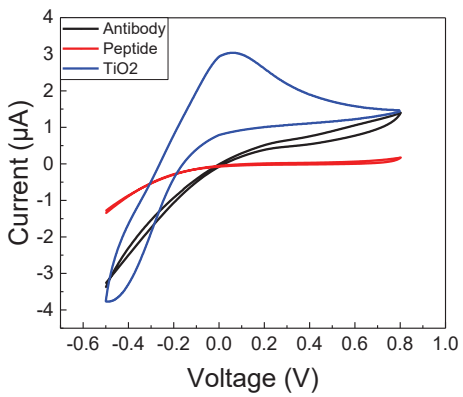

Fig. 3. The C-V response of sensor with different steps of immobilization.

For the antibody and peptide detection, cyclic voltammetry characteristics are measured in the Faraday cage to avoid the light interference. As shown in Fig. 3, photo current is decreased from the antibody and peptide attachment. Then photocurrent could be increased for 15% by the illumination with wavelength of 470 nm as shown in Fig. 4.

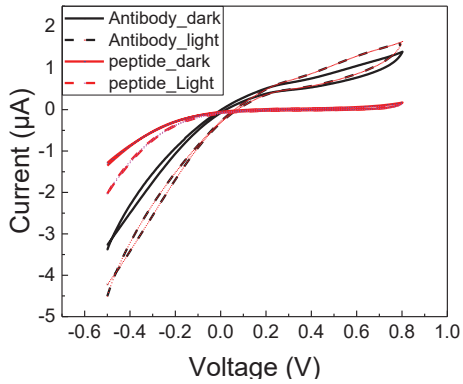

Fig. 4. The characteristics with and without illumination for sensor immobilized with antibody and peptide.

Conclusion

A photoelectrochemical sensor for Alzheimer's disease rapid screen is proposed in this study. With illumination on TiO_2 nanorods, 15% increases of photocurrent could be achieved by this illumination. which is proven for larger signal for Alzheimer's disease detection. we used high concentration peptide solution (20 ug/mL) But the concentration of the target in human CSF or blood is much less. So we still need to increase the sensitivity of the sensor.

References

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