DOI 10.5162/IMCS2018/P2EM.2

Synthesis and Characterization of Electrospun 2D MoS_2 Composite Carbon Nanofibers for Determination of Vanillin

Qianwen Mei[1], Yaping Ding[1], Li Li[1], Yiljun Zhao[1], Xiaolin Shao[1], Chaolin Wang[1], Anqing, Wang[1]
[1]Department of Chemistry, Shanghai University, Shangda Raod, Baoshan District, Shanghai 200444, P.R.C
Corresponding e-mail address: wdingyp@sina.com, lilidu@shu.edu.cn

Abstract

Vanillin (Van), the main component is 3-methoxy-4-hydroxy-benzaldehyde. Vanillin is not only used in the food industry, but also widely applied in the field of medicine. A glassy carbon electrode (GCE) modified electrospun 2D molybdenum disulfide (MoS_2) nanoparticles decorated carbon nanofibers (MoS_2-CNF) were first applied for determining the amount of Van. The synthesized MoS_2-CNF were characterized by scanning electron microscopy (SEM), Energy Dispersive Spectrometer(EDS), Electrochemical impedance technique(EIS). The electrochemical detection of Van was successfully conducted in 0.1 M phosphate solution (pH 10) and showed a good linear response in the range of 0.3 to 135 μM. The proposed electrode showed a good amperometric response signal toward Van and result in the determination of real sample.

Key words: Electrospinning, molybdenum disulfide, carbon nanofibers, Vanillin

Introduction

Vanillin (Van), which is an important flavorant with full milk aroma, and is mainly exists in the seeds of vanilla. Vanillin can give people a positive and pleasant emotional experience, with anti-epilepsy and anti-anxiety effects, however, overtaking Van can lead to some undesirable consequences to their consumers. Specifically, the high dose of Van can cause potential damage to human liver and kidney[1]. Therefore, the detection of Van is significant in many field in many field as food industry, medical intermediate. Molybdenum disulfide (MoS_2) is an atomically transition-metal dichalcogenide, which has attracted widely attention, due to its thermoelectric, optical, and mechanical properties in hydrogen evolution catalyst, and for optoelectronic materials[2]. Electrospinning is a versatile technique to construct well-aligned nanofibers with average diameters in the sub-micrometer to nanometer range. Compared to other methods of preparing CNF, electrospinning is more simpler and lower in cost[3]. Electrochemical techniques have the advantages of simplicity, rapidity, high sensitivity and low cost for the analysis of compounds comparing to other detecting methods, such as ultraviolet spectrophotometry, liquid chromatography, fluorescence spectroscopy[4].

In this work, molybdenum disulfide loaded carbon nanofibers (MoS_2-CNF) were synthesized by electrospinning polymer precursor followed with successive annealing process. Extensive characterizations of MoS_2-CNF were studied by scanning electron microscopy (SEM), Energy Dispersive Spectrometer(EDS). In order to contract intrinsic properties of electrospun MoS_2-CNF for electrochemical sensing application, different thermal treatment conditions were chosen in annealing process. The obtained MoS_2-CNF were dropped on a glassy carbon electron (designate as MoS_2-CNF/GCE) and applied in sensitive detection of Van by cyclic voltammetry (CV) and current-time (I-T). The proposed electrode showed a low detection limit, high sensitivity and high stability for detection of Van.

Characterization of MoS_2-CNF

Fig.1 A is the morphology and microstructure of the prepared MoS_2-CNF investigated by SEM. As we can see from Fig.1 A the diameter about 200 nm, MoS_2-CNF nanofibers have rough surface, which had s higher surface area to volume ratio. As shown in Fig.1 B, in contrast, we synthesized a composite material that isoconcentration MoS_2 nanosheets hosted in PAN, however, due to the poor electrical conductivity of MoS_2, it causes the low electrochemical response to van. Fig.1 C showed the EDS spectrum of MoS_2-CNF. We can see from Fig.1 C, which mainly includes four elements (C, O, Mo, S). As can be seen in Fig.1 D, the diameter of high frequency semicircles of MoS_2-CNF/GCE is significantly decreased compared to bare GCE and CNF/GCE, indicating that MoS_2-CNF has the better electrical conductivity. The lower R_{ct} value a material possesses, the higher electron-transfer ability is acquired.

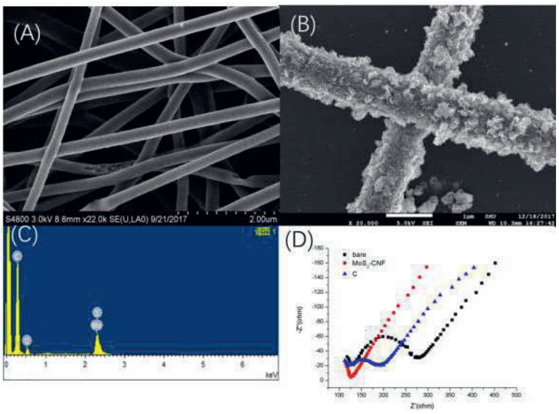

Fig.1 A SEM image of MoS_2-CNF; B SEM image of MoS_2 Nanosheets Hosted in PAN; C EDS of MoS_2-CNF; D EIS pattern of bare GCE, CNF/GCE and MoS_2-CNF /GCE

Experimental result

In order to explore the electrocatalytic of Van on MoS_2-CNF/GCE, a I-T comparison was conducted on bare GCE, CNF/GCE and MoS_2-CNF/GCE respectively in 0.1 M phosphate solution (pH 10) containing 10 μM Van. As Fig.2 showed that MoS_2-CNF/GCE has obvious electrocatalytic effect on vanillin. The bare electrode current response of vanillin was negligible, but compared with CNF/GCE, MoS_2-CNF/GCE was 5.21 times of CNF/GCE.

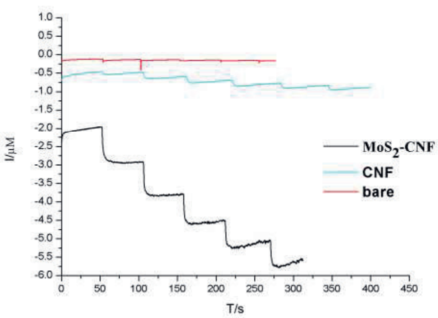

Fig.2 I-T comparison was conducted on bare GCE, CNF/GCE and MoS_2-CNF/GCE

Fig.3 A showed the I-T curve of detection of vanillin with the vanillin concentration ranging from 0.3 to 135 μM under constant stirring condition. From Fig.3 B we can clearly see that the oxidation current of vanillin increased with the concentration of vanillin increasing, the modified electrode showed a good linear response in the range of 0.3 to 135 μM. The linear regression was I_p = 1.1459 + 0.03617C (μM) (R = 0.996)

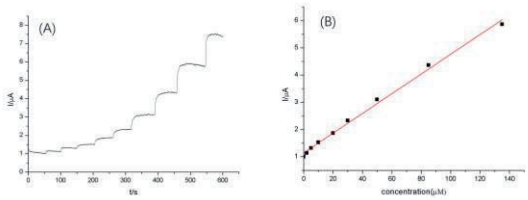

Fig.3 A I-T of Van in the concentration range from 0.3 μM to 135 μM on MoS_2-CNF/GCE; B the linear regression of Van on MoS_2-CNF/GCE.

Analysis of real sample

Tab.1: Results of real sample analysis at MoS_2-CNF/GCE (n = 3)

No.	Detected(μM)	Added(μM)	Found(μM)	Recovery
1	2.04	10	9.77	97.7%

The authors would like to thank the National Science Foundation of China (No. 21671132)

References

[1] L. Jiang, Y. Ding, Electrodeposited Nitrogen Doped Graphene/carbon Nanotubes Nanocomposite as Enhancer for Simultaneous and Sensitive Voltammetric Determination of Caffeine and Vanillin, *Analytica Chimica Acta* 833, 22-28 (2014); doi.org/10.1016/j.aca.2014.05.010

[2] Y. Xu, H. Park, Synthesis and Characterization of Electrospun PAN/2D MoS_2 Composite Nanofibers *Journal of Industrial and Engineering Chemistry* 34, 61-65 (2016); doi.org/10.1016 /j. jiec.2015.10. 030

[3] Y. Lu, Y. Ding, Electrospun Nickel Loaded Porous Carbon Nanofibers for Simultaneous Determination of Adenine and Guanine, *Electrochimica Acta* 174, 191-198 (2015); doi.org/10.1016/j.electact.2015. 05.165

[4] X. Ba, Y. Ding, Determination of L-tryptophan in the Presence of Ascorbic Acid and Dopamine Using Poly(sulfosalicylic acid) Modified Glassy Carbon Electrode, *Sensors and Actuators B: Chemical* 187, 27-32 (2013); doi: 10.1016./j.snb. 2012.09.018