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Title: A Preliminary Study of the Graphene-based Sensor for the Determination of Capsaicin

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Abstract

Chili pepper, a kind of common vegetable, is loved by the public for its unique spicy flavor. Meanwhile, it is widely used in pharmaceuticals industry as well as other fields. The detection of capsaicin in spicy food has become significant. The analysis of capsaicin is critical for the quality control, the medical effect as well as the export/import of the chili pepper. However, the existing methods for capsaicin detection based on the precision instruments and the professional standards and the traditional 'Scoville Organoleptic Test' suffer from subjectivity and tedious processes which limit the wide use in the relative enterprises.

Here we developed a novel method for the detection of capsaicin, which has the advantages of high sensitivity, easy operation, reliability and easy application. Graphene (GR) with good conductivity and excellent electrochemical properties is used for the preparation of sensor. The prepared sensor was employed to study the electron transfer behavior of capsaicin using cyclic voltammetry (CV). The responses of capsaicin with different concentrations were explored by differential pulse voltammetry (DPV), and a standard curve of peak current *versus* capsaicin concentration was obtained at the range of 0.5-80 μM. The method was successfully applied to detect capsaicin in real samples, with

13.30 mg/g for millet pepper and 27.89 mg/g for red cluster pepper. This exploration proves that series of novel sensors can be developed with nanomaterials and electrochemical method.

Introduction

1 Introduction of Capsaicin

1.1 Capsaicin

Chili pepper (Fig. 1-1) became a common dish in our life after being spread to China about 300 years ago. It is famous for the unique pungency flavor and hotness. However, some people cannot stand the stimulation of spicy, and some show special preference to the feeling of intense burning. Though different people may have different endurance and sensibility to pungency, we can find it is a special feeling different from sour, sweet, bitter and salty. Actually, capsaicinoids, the active ingredients in chili peppers, are responsible for the unique spicy feeling. Capsaicin (8-methyl-N-vanillyl-trans-6-nonenamide) (Fig. 1-2) is the most important member in capsaicinoids family (dihydrocapsaicin, nordihydrocapsaicin, norcapsaicin, homocapsaicin, nonivamide, homodihydrocapsaicin, etc.) [1] which occupies a large proportion up to 69%. Pure capsaicin is a kind of odorless waxy or crystalloid compounds which is hydrophobic and with the melting point of about 65 ~ 66 ℃.

Fig. 1-1 Capsaicin

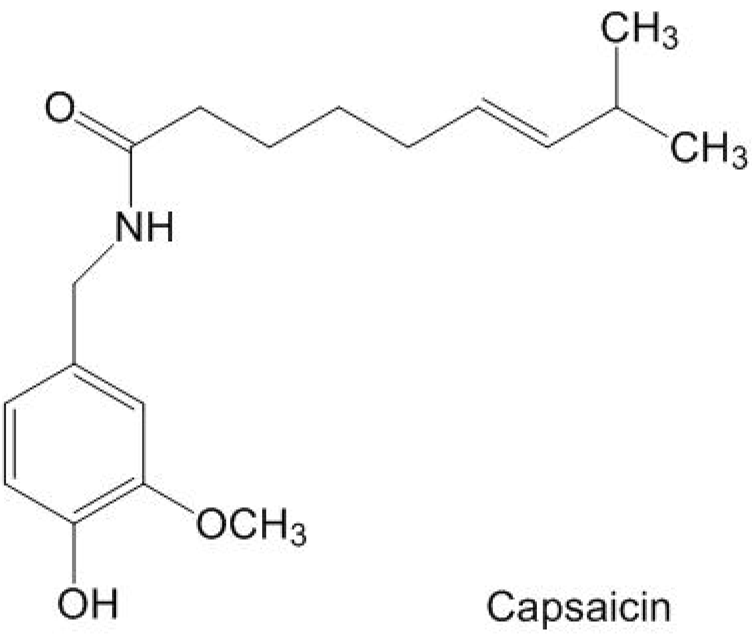

Fig. 1-2 Structure of capsaicin

1.2 Applications of capsaicin

Recently, capsaicin is being widely used in medical industry because of its biological functions such as anti-mutagenic [3] and high antioxidant power [2]. In addition, it has drawn more eyeballs as it effectively fights against obesity and cholesterol, and can be used as topical analgesic in gastrointestinal chemical hypersensitivity and post-herpetic neuralgia treatment [4].

1.3 Techniques for capsaicin detection

With the broadening applications of capsaicin in our diet and pharmaceutical industry, a simple and sensitive method for capsaicin determination is indispensable. 'The Scoville Heat Unit'（SHU）, created in 1912, is the most conventional method to measure the heat of chili peppers. It is instructed by the level of dilution of the pepper extraction using sugar solution until the volunteers cannot taste the pungency of capsaicin anymore. Capsaicin has the highest value of SHU, which is estimated to be about 15,000,000~16,000,000. The computational formula [5, 6] for capsaicin concentration to convert to SHU is shown as follows:

$$W_a = 10^{-6} \times c \times M_a \times V_b \times V / (m \times V_{cap\text{-}b})$$

$$W = W_a / 0.69$$

$$X = W \times 90\% \times (16.1 \times 10^3) + W \times 10\% (9.3 \times 10^3)$$

c： concentration of capsaicin in sample solution(μmol/L)

M_a： molar mass of capsaicin(g/mol)

V： constant volume of capsaicin sample(mL)

V_b： otal volume of BR buffer with capsaicin in it (mL)

$V_{cap\text{-}b}$： volume of sample capsaicin solution added to BR buffer m：mass of sample chili pepper(g)

W_a：mass concentration of capsaicin in chili sample(mg/g)

W：total mass of capsaicinoids in chili sample(mg/g)

0.69：conversion coefficient

X：Scoville Scale

16.1×10^3：The coefficient used to convert concentration of capsaicin or dihydrocapsaicin to Scoville Scale

9.3×10^3：The coefficient used to convert concentration of other capsaicinoids to Scoville Scale

Table 1 SHU of chili peppers and chili by-products [7]

Scoville Heat Unit(SHU)	Representatives
855,000 – 2,200,000	Komodo Dragon Chili Pepper, Trinidad Moruga Scorpion,Naga Viper pepper, Infinity Chilli, Naga Morich, Bhut jolokia (ghost pepper)
350,000 – 580,000	Red Savina habanero
100,000 – 350,000	Scotch bonnet pepper, Rocoto,Madame Jeanette, Peruvian White Habanero, Jamaican hot pepper,Wiri Wiri
50,000 – 100,000	Piri piri, Pequin pepper, Siling Labuyo, Capsicum Apache
30,000 – 50,000	Guntur chilli, Cayenne pepper, Ají pepper, Tabasco pepper, Capsicum chinense
10,000 – 30,000	Byadgi chilli, Serrano pepper, Peter pepper, Chile de árbol, Aleppo pepper,Chungyang Red Pepper, Peperoncino

3,500 – 10,000	Guajillo pepper, 'Fresno Chili' pepper, Jalapeño, wax (e.g. Hungarian wax pepper)
1,000 – 3,500	Gochujang, Pasilla pepper, Peppadew, poblano (or ancho), Poblano verde, Rocotillo pepper
100 – 1,000	Banana pepper, Cubanelle, paprika, Pimento
0	Bell pepper

However, there have been constant doubt about ‘The Scoville Organoleptic Test’ because of its imprecision and subjectivity for the results are mostly based on feelings of tasters, most of whom are likely to be diversely sensitive to pungency. Currently, high-performance liquid chromatography (HPLC) [8, 9] was widely used in the quantitative analysis of capsaicin for its high separating rate, high sensitivity and high accuracy. In this method, the detection is conducted using a reversed phase chromatographic column with UV-absorbance detector. With widespread application of chemical instruments, various techniques for capsaicin detection emerged constantly such as gas chromatograph [10], gas-liquid chromatography and capillary electrophoresis [11].

Now, chili peppers have become an irreplaceable condiment in Chinese food. However, the pungency degrees of chili by-products on market vary from one and another with no definite concentration of capsaicinoids. Meanwhile, the precise concentration of capsaicin is essential in the medical and other fields.

The instrumental analytical methods indeed improve the accuracy and reliability in determination of capsaicin. However, some of them, like HPLC, suffer from high cost and cumbersome operation processes, which severely rise the economic cost when being applied to the market. Therefore, a simple, low-cost, sensitive and precise method for capsaicin detection would be desperately needed.

1.4 Electrochemical analysis method for capsaicin detection

In 2008, Compton *et al.* [12] firstly developed electrochemical method applied to the detection of capsaicin in different peppers using adsorptive stripping voltammetry (AdsSV), based on a multiwalled carbon nanotube modified basal plane pyrolytic graphite electrode (MWCNT-BPPGE) and demonstrated mechanism of the redox reaction capsaicin performs on the electrode (Fig. 1-3). According to their literature, the oxidation peak revealed in the first scan (dash line) (Fig. 1-4) confirmed that capsaicin is primarily oxidized at 0.69 V to convert into a carbocation intermediate which afterwards undergoes an irreversible hydrolysis of the 2-methoxy group, forming an *o*-benzoquinone unit. The pair of reversible peaks observed in the second and following scans (solid lines) are due to the reaction of catechol/benzoquinone redox couple. This method was successfully applied in practical detection of capsaicin in chili peppers and satisfactory results were obtained. However, the stability remains to be improved because the MWCNT tends to fall of from the electrode surface. Compared to the HPLC, the electrochemical analytical method is simpler, lower-cost and more facile to realize. On the basis of technique proposed by Compton group, more and more electrochemical analytical methods have been reported. Yavuz Yardim *et al.* [13] successfully detected capsaicin using boron-doped diamond electrodes in the presence of lauryl sodium sulfate in 2011. Recently, Ye *et al.* [14] has fabricated a novel capsaicin sensor based on silver (Ag) nanoparticles graphene (GR) composite (Fig. 1-5). However, the further application of this method was limited for the instability of Ag. Thus, in this study, we aim to construct an electrochemical capsaicin sensor using the more stable material, GR , as sensing nanomaterials.

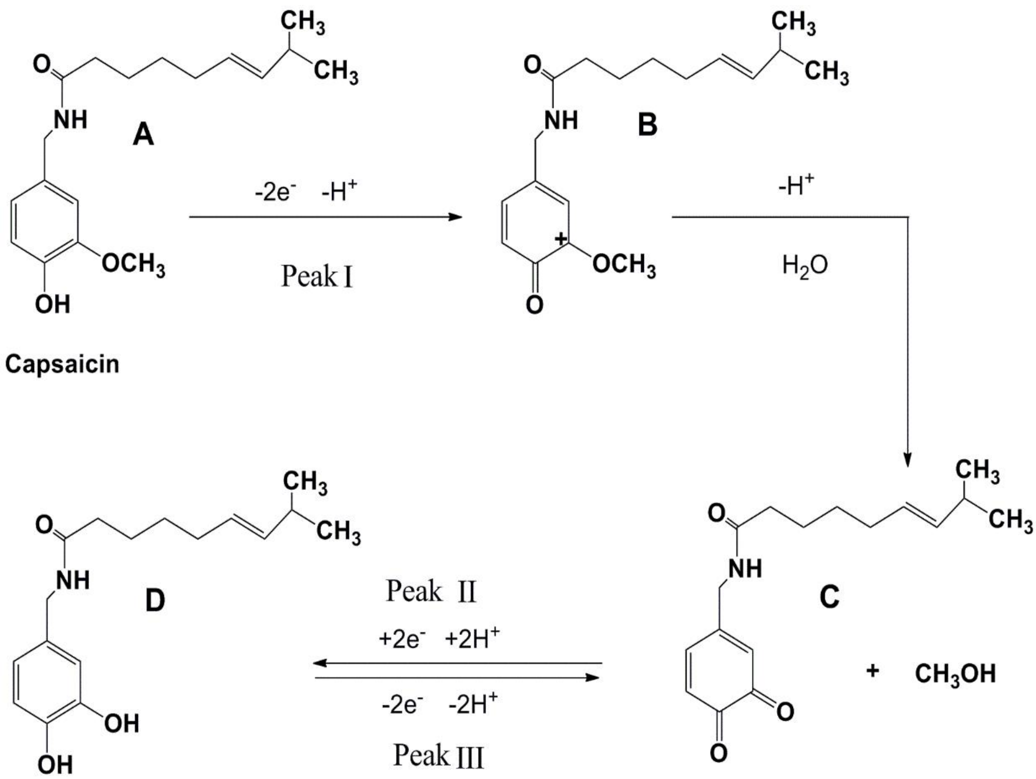

Fig. 1-3 Mechanism of the electrochemical oxidation/reduction of capsaicin.

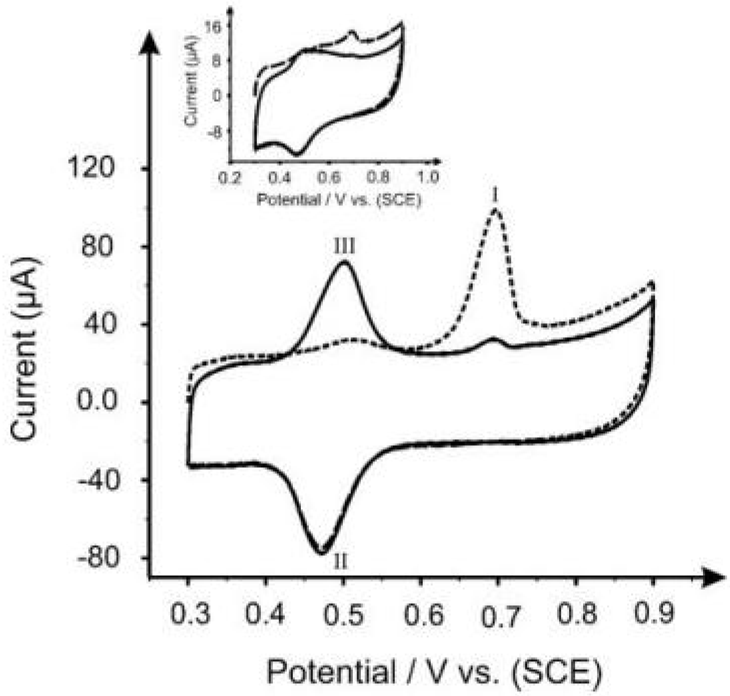

Fig. 1-4 CV signals of 100 μM capsaicin in BR buffer solution (pH 1.0) at the MWCNT-BPPGE with a scan rate of 100 mV s^{-1}.

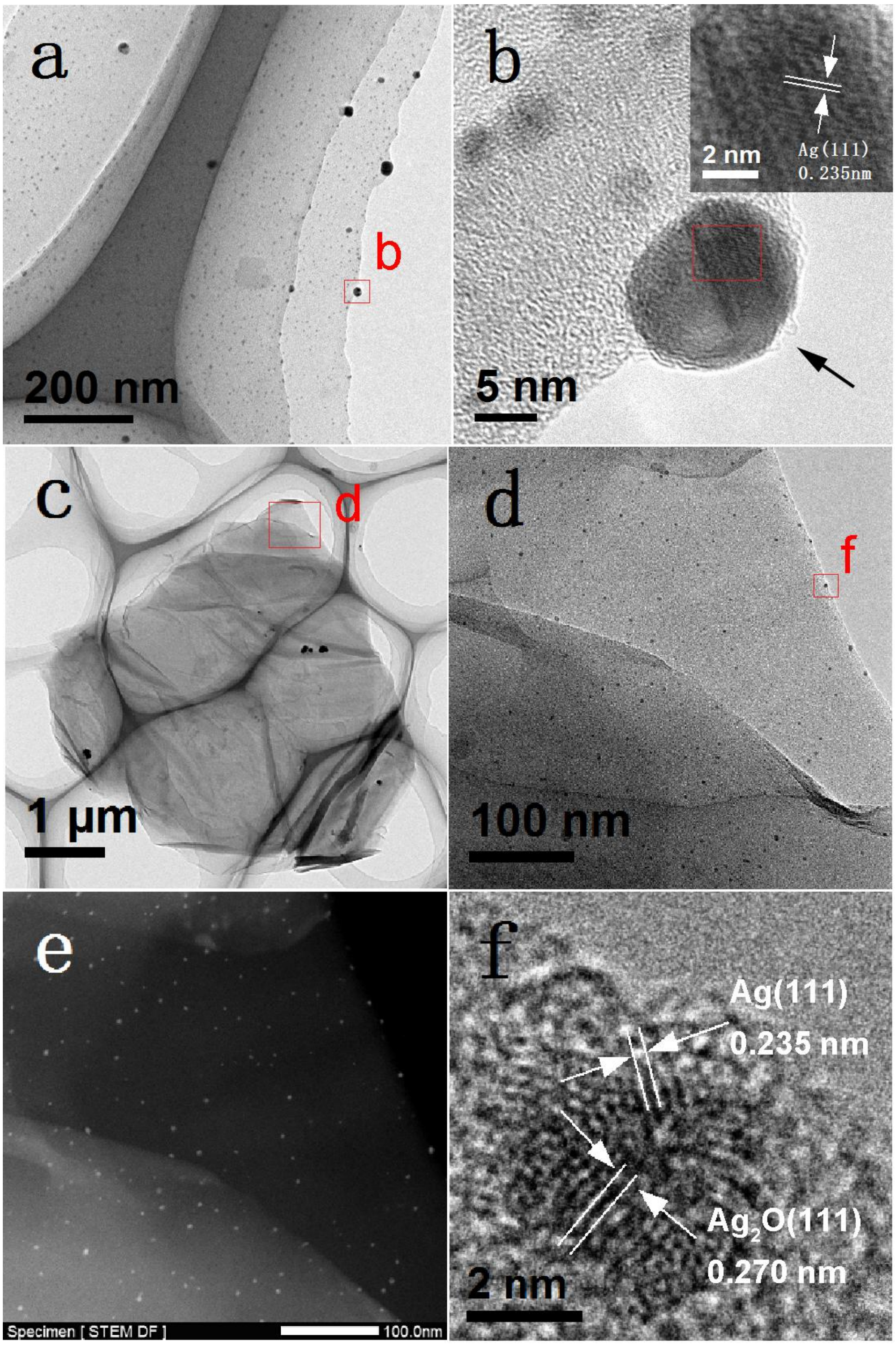

Fig. 1-5 (a) TEM image of AgNPs; (b) A partial magnification of (a) shows the HRTEM of AgNPs; (c) TEM image of Ag/Ag_2O-PSS-rGO; (d) Partial magnification of c; (e) STEM of image d; (f) Partial of d shows the HRTEM of a Ag/Ag_2O nanoparticle.

2 Introduction of GR

2.1 Structure and properties of GR

GR is a kind of two dimensional (2D) crystal consists of a single layer of carbon atoms, which is firstly exfoliated from graphite. The six-membered carbon rings construct the 2D periodic honeycomb lattice framework of GR. In GR, the C-C σ bonds build up the strong connection of the adjacent sp^2 hybrid carbon atoms. The remaining electrons in p orbitals of these sp^2 hybrid carbon atoms construct a π great bond, where the electrons are able to move freely. Thanks to the unique structure, GR possesses the advantages of outstanding rigidity, high thermal and electric conductivity and excellent electrochemical activity. Within the knowledge of human being, GR is the thinnest material discovered. GR is considered as the primary unit of other carbon allotrope, since it can be transformed into zero-dimensional Fullerene, or be curled into one-dimensional carbon nanotubes, or be accumulated into three-dimensional graphite. What`s more, GR is a kind of semiconductor with zero bandgap, which makes the transmission rate of electrons much greater than that of other semiconductors.

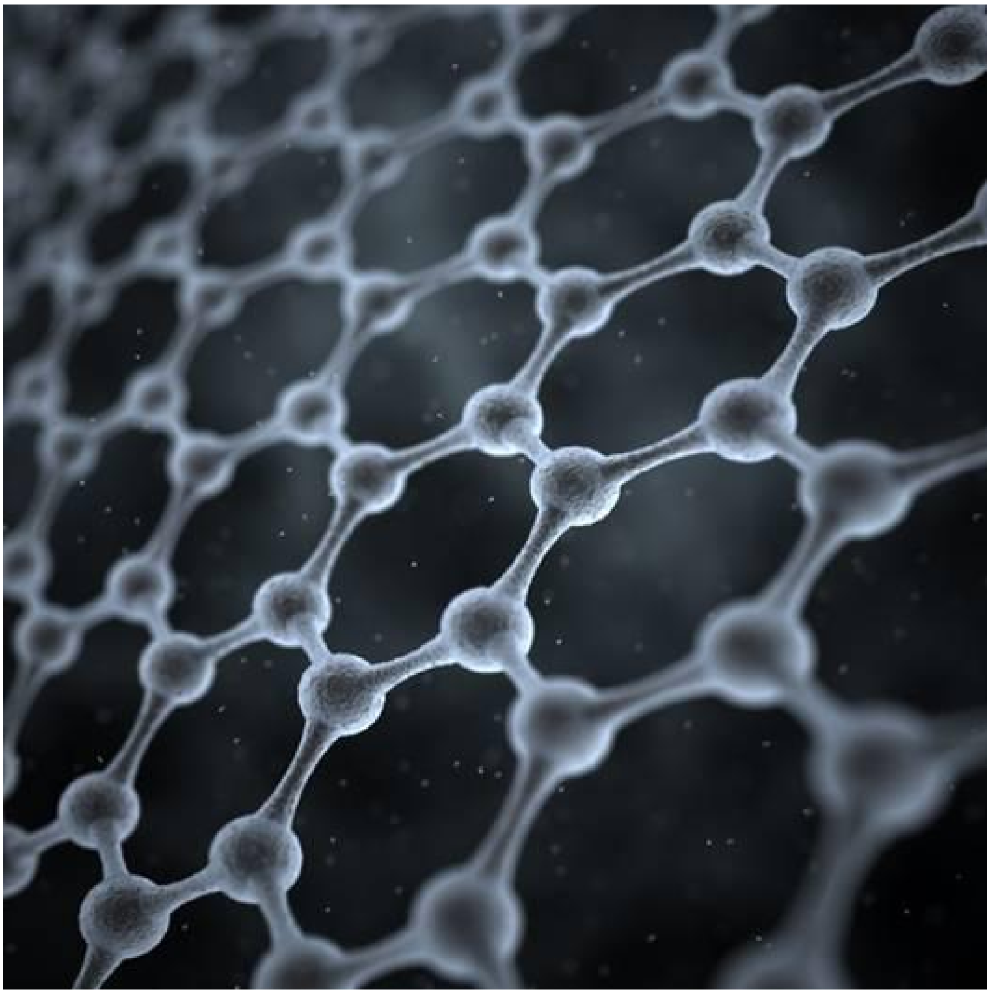

Fig. 1-6 Graphene

2.2 Synthesis of GR

In the University of Manchester, GR was separated from graphite for the first time in 2004 by Geim A.K. and Novoselov K.S. [15], who also proved the existence of isolated GR. Because of the outstanding properties, GR has been a potential material in many fields. Numerous efforts have been undertaken towards the large scales fabrication of high quality GR these years. To date, there are two classes of methods for GR synthesizing, including the mechanical method and chemical approach. The mechanical method consists of the thermal cracking of SiC, the mechanical exfoliation of graphite and the oriented growth method, while the chemical method includes the reduction approach and chemical exfoliation.

2.3 Application of GR

Benefiting from the large specific surface area and high chemical activity, GR modified electrode has been successfully applied to electroanalysis. There are various methods for constructing a modified electrode, in which the drop coating approach and polymer embedding method are used most widely. The GR largely improves the electron transfer rate of the detected molecule on the electrode surface and enhances the sensing performance of such chemical sensors. With the help of surfactant, it is easy to disperse GR into the aqueous solution. Such strategy not only remains the original properties of GR, but also provides it with some novel electrochemical properties, which make it a potential material used widely. So far, quantities of studies demonstrated that GR can triumphantly be used in electrochemical analysis. GR based electrochemical sensors have the advantages of low detection limit, high sensitivity and good reproducibility. In 2008, GR thin film was applied as an electrochemical sensor by Papakonstantinou *et al* [16] using potassium ferricyanide as the molecular probe. Their study showed that, the GR thin film can efficiently improve the electron transfer. The prepared sensor was successfully used for the simultaneous determination of dopamine

(DA), ascorbic acid (AA) and uric acid (UA). Shan and his coworker [17] developed the ionic liquid functionalized GR modified glassy carbon electrode (GCE), which greatly improves the stability of the electrode. The enhanced detected current largely improves its sensitivity for the determination of DADH. Kang *et al.* [18] successfully developed the glucose sensor based on glucose oxidase immobilized GR. All the studies prove that GR is an outstanding material for constructing high performance electrochemical sensors.

Capsaicin determination based on electrochemical method

1 Principle and electrochemical method

Cyclic Voltammetry (CV) is a conventional method for electrochemical study. This method controls scan rate of the electrode potential and scans using triangular wave for one or more times during the operating time. The potential range equips the electrode surface with oxidation reaction or reduction reaction, in the same time, the current *vs.* potential curve is recorded. The electrode is a kind of conductor or semiconductor that work as a heterogeneous system for connecting the electrolyte. Electrochemical reaction always takes place on the electrode, which is used for electric energy output or input of the electrochemical system. Electrochemical system can be divided into two-electrode system and three-electrode system in general, and the latter one is studied the most. The three electrodes are working electrode, reference electrode and auxiliary electrode. Another name of the working electrode is study electrode, which is used to study the reaction on the electrode surface. The reference electrode is an electrode that is closed to an ideal non-polarization material with a known potential. The reference electrode is used to determine the potential of the study electrode (relative to the reference electrode) and there is nearly no current passing through it. The auxiliary electrode, also known as the counter electrode, constructs the circuit with working electrode for the conduction of current, and makes the studying reaction take place on the electrode surface. In the present work, CV and different pulse voltammetry (DPV) were applied to the determination of capsaicin using the GR modified electrode, Ag|AgCl electrode and Pt electrode as the working electrode, reference electrode and counter electrode respectively.

2 Experimental

2.1 Instruments and reagents

Table 1 Instruments and accesaries

Instrument	Type	Manufacturer
Electrochemical workstation	CHI660D	Shanghai Chenhua instrument co., LTD
Ultrasonic cleaner	KQ2200E	Kunshan ultrasonic instrument co., LTD
Pipette #1	100-1000 μL	Thermo scientific, America
Pipette #2	10-100 μL	Thermo scientific, America
pH meter	PHS-3	Ray magnetic instrument, Shanghai
Thermostatic oil bath	DF-101S	Yuhua instrument co., LTD in China
Infrared lamp	220W	CongYuan instrument co., LTD
Drying oven	DHG-9053A	Shenxianwen instrument co., LTD
Ag|AgCl Reference	3.0M KCl	Ingsens sensing technology co., LTD
GCE	3mm	Ingsens sensing technology co., LTD

Table 2 Reagents

Reagents	Grade	Manufacturer
HAC	AR	Sigma-Aldrich (Shanghai)
H_3PO_4	AR	Sigma-Aldrich (Shanghai)
Capsaicin（99.5%）	AR	Sigma-Aldrich (Shanghai)
H_3BO_3	AR	Sigma-Aldrich (Shanghai)
C powder	Flake graphite	Guangfu Institute of Superfine Chemical Industry, Tianjin
H_2SO_4（98%）	AR	Guanghua technology co., LTD
HCl（36-38%）	AR	Guanghua technology co., LTD
HNO_3	AR	Guanghua technology co., LTD
$N_2H_4.H_2O$	AR	Ghemical reagent factory, Guangzhou
C_2H_5OH	AR	Guanghua technology co., LTD
$KMnO_4$	AR	Guanghua technology co., LTD
H_2O_2（30%）	AR	Guoyao chemical reagent co., LTD

2.2 Preparation of solutions

We prepared BR buffer solution (0.06 M)by mixing 0.7419g boric acid, 0.7260g acetic acid and 1.1760g phosphoric acid. The pH of BR buffer was adjusted by 0.10 M NaOH solution. For preparation of capsaicin stock solution, 0.3054 mg capsaicin was dissolved in 50/50 V/V water/ethanol to make a final volume of 10 mL (1.0 mM).We bought different kinds of chili peppers from a local market. 8 g of each chili was shattered with mortar and added into an ethanol solution. Then the mixture was sonicated by a JY92-2D Ultrasonic Cell Disrupter (Ningbo Scientz Biotechnology Co. Ltd, China) for 40 min. The supernatant liquid was collected by filtration, after which it was diluted to 50 mL. The real sample solutions were used for later experiments.

2.3 Preparation of GR

GR was compounded as the following shows: firstly, 60 mg graphite oxide (GO) powder was scattered in 100 mL deionized water by ultrasonication for 1 h. The unexfoliated GO was removed by centrifugal separation. Then, 200 mL ammonium hydroxide and 20 mL hydrazine monohydrate were added to the GO dispersion and then stirred for 15 min. The mixture was treated at 90 °C under intense stirring for 3 h. Lastly, the excessive hydrazine monohydrate and hydrazine monohydrate were removed by washing with deionized water and centrifuging. The finished graphene was freeze-dried under vacuum for 24 h.

2.4 Preparation of the modified electrode

Prior to the electrochemical experiments, bare GCE (3 mm in diameter) was carefully polished with 0.3 alumina slurries in turn to obtain a mirror-like surface. After 3 min of ultra-sonication in ethanol and water successively, the electrode was rinsed with water and then dried. 1 mg as-prepared graphene was dispersed in 1 mL DMF. Then, a sample of 3 μL GR dispersion (1.0 mg mL^{-1}) was cast on the surface of the GCE(described as GR/GCE)and dried under an infrared lamp.

3 Results and discussions

3.1 Properties of bare GCE and GR/GCE

The responses of 50 μM capsaicin obtained at bare GCE and GR/GCE are depicted in Fig. 2.1. It is clear that the CV signal obtained on a bare GCE (red line) shows a pair of quite weak redox peaks while there are no responses for BR (black line) under the same conditions. Compared with the bare GCE, CV signals on the GR/GCE (blue line) shows sharper outlines. The decrease of peak potential difference (ΔE_p) on GR/GCE manifests the better electrochemical reversibility of capsaicin in the presence of graphene. The above fact demonstrates that GR/GCE could be employed in capsaicin determination in BR buffer (pH 1.5).

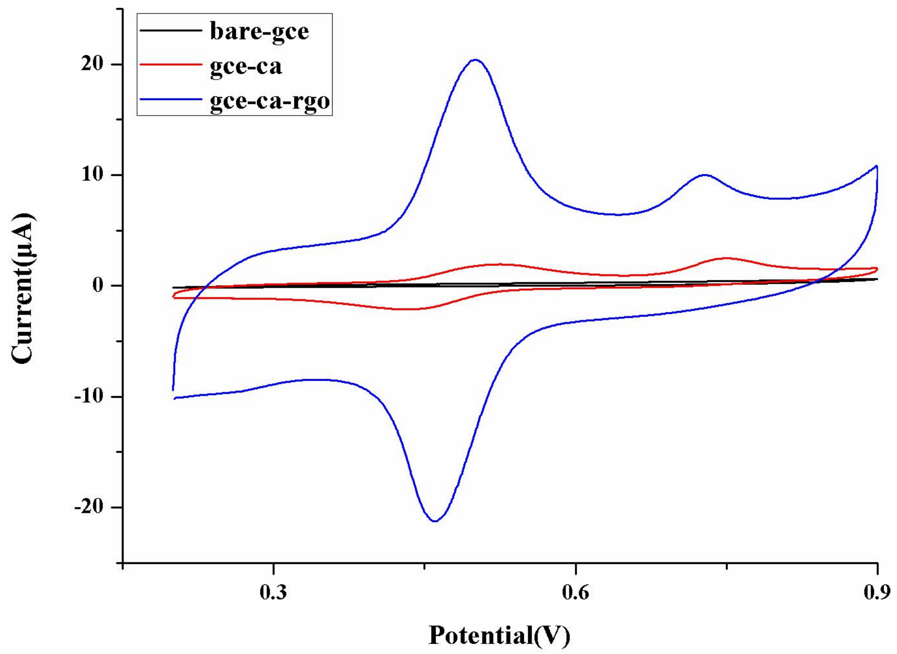

Fig. 2-1 CV signals of 0 μM (black line) and 50 μM capsaicin in 0.06 M BR buffer solution (pH 1.5) at bare GCE (red line) and GR/GCE (blue line).

3.2 Electrochemical response of capsaicin at the GR/GCE

Fig. 2.2 shows the CV signals of successive scans of 50 μM capsaicin in BR buffer solution (pH 1.5) at the scan rate of 100 mV s^{-1}. It manifests that capsaicin is oxidized at the first scan to form a carbocation intermediate (peak I), followed by an irreversible hydrolysis process of the 2-methoxy group in capsaicin, generating an *o*-benzoquinone group. Then, the *o*-benzoquinone group participates in a cyclic oxidation-reduction with catechol, results in the peak II and peak III observed at the second scan (dotted line).

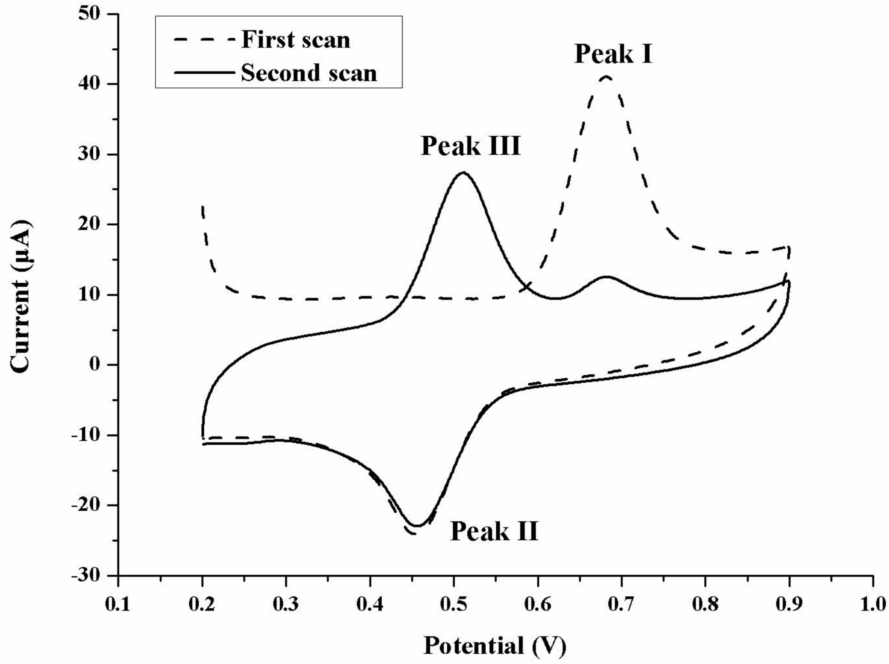

Fig. 2-2 Two continuous CV scans including the first scan (dotted line) and the second scan (solid lines) of 50 μM capsaicin at the GR/GCE in 0.06 M BR buffer (pH 1.5); Scan rate, 100 mV s^{-1}.

3.3 Influence of pH

The influence of pH was probed into in the BR buffer solution with pH range of 1.5 - 9.5 at the GR/GCE. As reflected in Fig. 2.3, with the increase of pH, the peak currents of the second scan decrease gradually because the phenolic moiety in capsaicin deprotonates partially. Therefore, pH 1.5 was chosen as the optimal pH value. The redox peak potentials are found to move linearly to more negative values (Fig. 2.4) with the regression equation of $E_p = -0.0565\ pH + 0.58175$ (R^2 = 0.9993). Besides, the slopes of E_p versus pH appear to be -56.50 mV/pH, being closed to the ideal value of -59 mV/pH (25 °C) suggested by the Nernst equation, which suggests that the electrode reaction of capsaicin of the second scan involves a $2H^{+} \sim 2e^{-}$ process, according with the anterior mechanism[12-14].

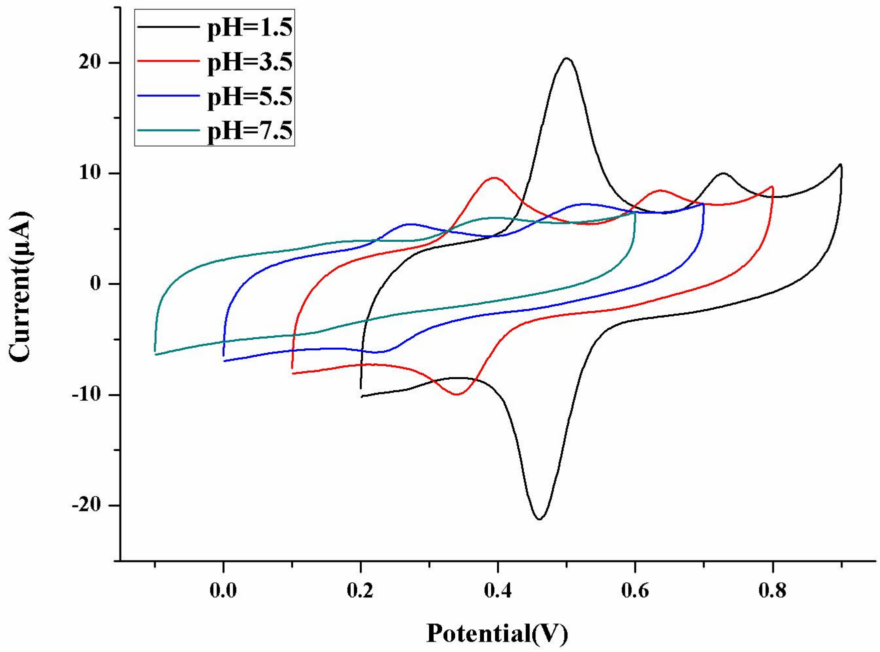

Fig. 2-3 CV signals of 50 μM capsaicin in 0.06 M BR buffer solution with different pH values (pH 1.5, 3.5, 5.5, 7.5) at the GR/GCE; Scan rate, 100 mV s^{-1}.

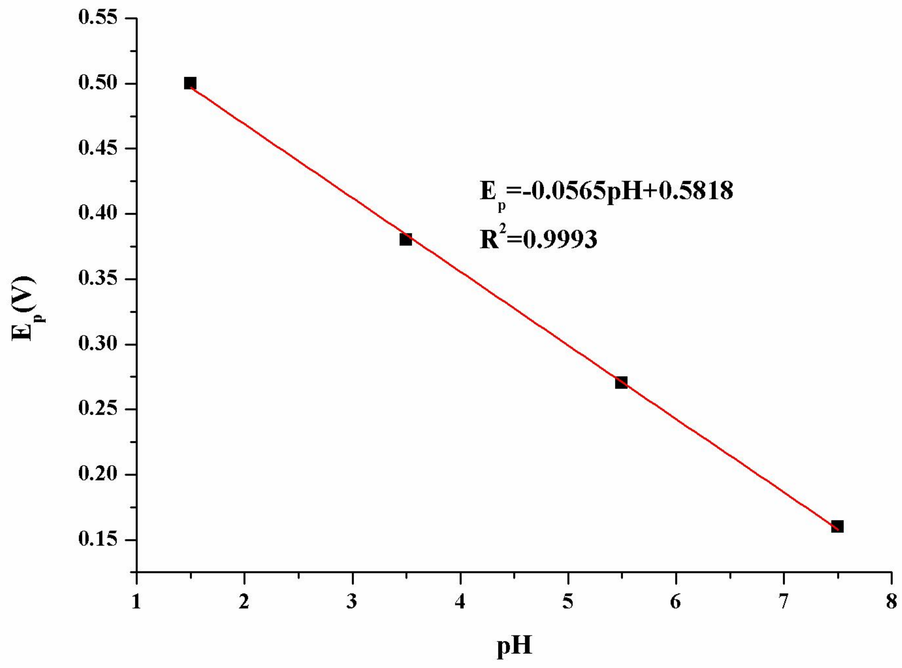

Fig. 2-4 Capsaicin oxidation peak potentials (vs. Ag|AgCl) versus pH values.

3.4 Electrochemical determination of capsaicin by DPV

Fig. 2.5 shows the DPV curves of continuous additions of capsaicin at the GR/GCE in BR buffer solution (pH 1.5). The oxidation peak current increases linearly within the concentration scope of 0.30 - 30 μM. The regression equation is $I_{pa}\ (\mu A) = 0.2005\ c\ (\mu M) + 0.08658$ (R^2 = 0.997) as shown in Fig. 2-6. The capsaicin concentration could be calculated using this formula if the I_{pa} is within the range of 0.04972-5.809 μA.

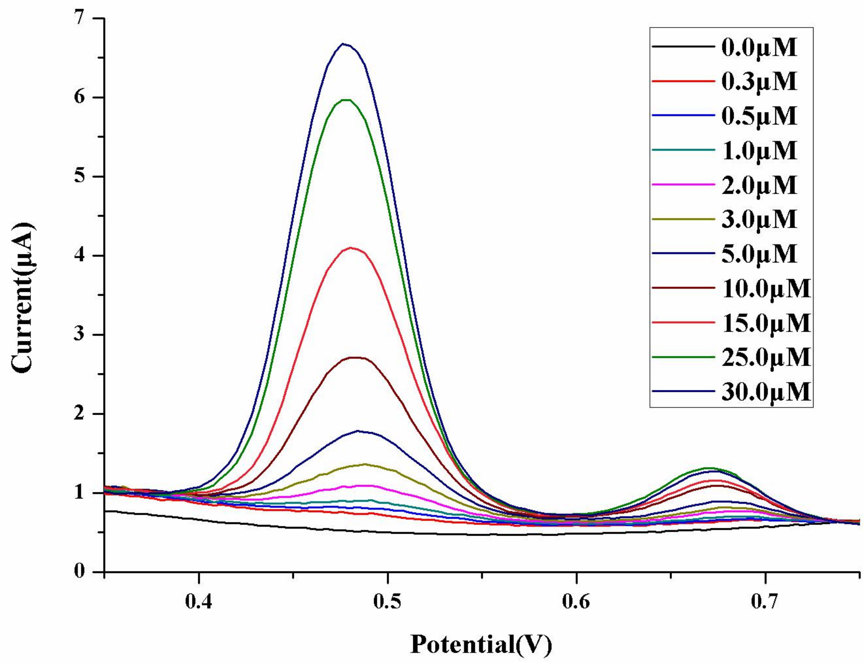

Fig. 2-5 DPV responses of capsaicin in 0.06 M BR buffer solution (pH 1.5) with different concentrations at the GR/GCE with the scan rate at 100 mV s^{-1}.

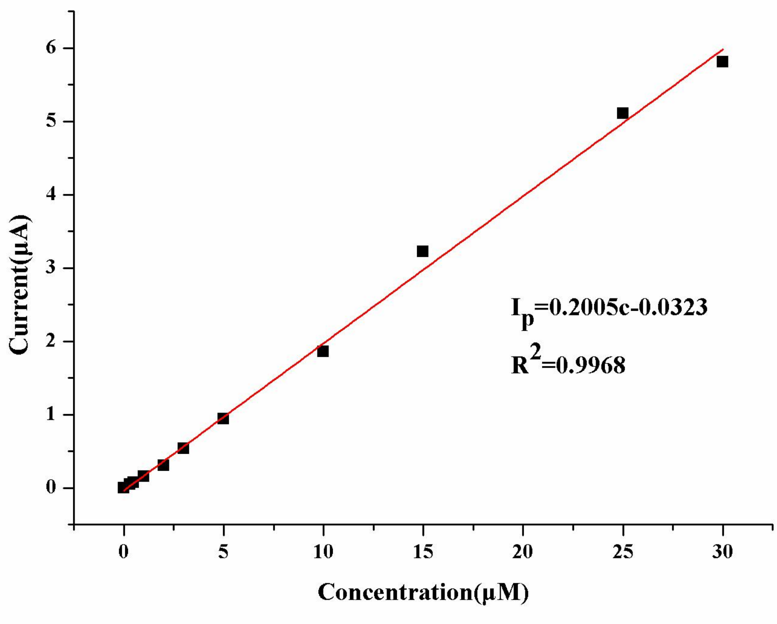

Fig. 2-6 The standard curve of capsaicin.

3.5 Detection of capsaicin in chili peppers

The quantification of capsaicin in practical samples(Fig. 2-7) was implemented in BR buffer solution with pH 1.5at the GR/GCE. An suitable volume of extracting solution was mixed into 10 mL BR buffer solution and then determinated by performing DPV for 3 times. The capsaicin concentration was counted based on the average of three determinations of peak current. The calculated concentration of capsaicin was finally converted to SHU according to the computational formula and the results were summarized in Table 2.

Table 2 SHU of capsaicin in real chili peppers

Real Sample	**Capsaicin Dosage in the Solution**	**Peak Current**	**Capsaicin Content**	**SHU**
Pod pepper	50μL	1.594μA	27.89mg/g	418350
Millet pepper (from Hainan)	100μL	1.524μA	13.30mg/g	199500
Millet pepper (from Jiangxi)	50μL	0.949μA	0.3623mg/g	8096
Sauce of pod pepper	50μL	1.549μA	0.1892mg/g	4229
Chunguang sauce of bell pepper	50μL	1.013μA	0.0619mg/g	1383
Big red pepper	1mL	0.672μA	0.0128mg/g	287
Round green pepper	1mL	0.594μA	0.0036mg/g	81

Fig 2-7 Pod pepper (left) and Millet pepper (Right)

Conclusions

As the source of pungency, flavor and hotness in peppers, capsaicin was widely used in the usage of delicacy in our diet pharmaceutical industry for its anti-bacteria, anti-carcinogenic and high antioxidant power. GR, with large specific surface area and good conductivity, has attracted enormous attention in electrochemical analysis field in recent years.

In this study, a graphene-based electrochemical sensor for sensitive capsaicin detection was developed. The oxidation peak current increases linearly within the concentration range of 0.30 - 30 μM. The regression equation is $I_{pa}\ (\mu A) = 0.2005\ c\ (\mu M) + 0.08658$ ($R^2 = 0.997$). In addition, the as prepared sensor has been also applied in practical detection of capsaicin in chili peppers. The simple fabrication process of the sensor implies a potential application for the instant detection of other biological molecules or heavy metals in the future.

As a novel nanomaterial, GR is widely used in electroanalytical field.

The graphene-based electrochemical capsaicin sensor is promising in the practical food test for its high sensitivity and low cost. In 2016, Jean-Pierre Sauvage, Sir J.Fraser Stoddart and Bernard L. Feringa got the Nobel Prize for their attribution of ‘the design and synthesis of molecular machines’, which give a clue for us to employ “the molecular nanorobot” as sensing nanomaterials in sensor development. However, this remains to be further researched in the future.

In conclusion, we have realized the importance of cooperation and managed some of the research method as well as experimental skills through this study, which is conducive to the further study in the future.

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Resume (Team Members)

Name: Zhang Luyue

Gender: Female

Birthday: May 2nd, 2000

School:

September 2006 to June 2012, Shuiyin Road Primary School

September 2012 to June 2015, Middle School Affiliated to Guangzhou University (Junior)

September, 2015 until now Middle School Affiliated to Guangzhou University (Senior)

Experience & Distinction:

Have been studying in Mathematical Class A.

Did great academically, thus helicoptered to the present high school.

Have been ranking top six in school since senior high, and ranked the 5th in the final examination of Yuexiu District.

Actively take part in various extra-curriculum activities related to scientific research.

Win the 1st prize in Guangzhou Youth Science and Technology Innovation Talents- Qian Shi Wan Miao Project

Win award in Guangdong Kaixin Cup Astronomy Olympics.

Selected to be in Star of Science and Technology Special Training Camp in 2015. (Department of life science in Sun Yat-sen University)

Interests&Hobbies:

Very fond of math, physics, chemistry, astronomy, medical science and literature, love to explore the mechanism and principle of things happen in daily life.

Fell in love with Chinese medicine lately, desire to use modern technologies to explain Chinese medicine, and if lucky, hope to complete or improve it.

Often practise Chinese calligraphy/ painting/ Ping Pong/ piano/ ukelele.

Fancy yoga/ basketball/ jogging.

Name: Zheng Yuning

Gender: Female

Birthday: February 25th, 2000

School:

September 2006 to June 2012, Guangzhou Fineland Experimental School

September 2012 to June 2015, The Middle School Affiliated to Guangzhou University (Junior)

September 2015 until now, The Middle School Affiliated to Guangzhou University (Senior)

Experience&Distinctions:

Be interested in Mathematics, Chemistry and Medical science.

Now studying at the Mathematical A class.

Have an excellent academic performance.

Helicopter to Senior High School.

High school entrance examination results ranked first in the present school.

Science total score stabilizes at the top five in the Grade.

Take an active part in all kinds of scientific research activities for students.

Won second prize at the 18th Loo-Keng Hua Gold Cup Mathematics Competition.

Won second prize at the China Mathematics Competition in 2014.

Won the silver award at the Hope Cup Mathematics Competition twice.

Interests&Hobbies:

Besides subjects like Mathematics, Chemistry and Biology, love to discover the mechanism of reactions of human body, especially mental reactions. Want to study Psychiatry and Pharmacology.

Eager to learn different languages. Have preliminarily learned French, Italian, Spanish and German.

Enjoy writing modern poems, playing Chinese Zither, singing Jazz, practising Copperplate cursive script and playing table tennis.

Resume (Mentors)

Name: Li Xuan

Subject: Chemistry

Experience & Distinctions:

Senior chemistry teacher, teaching key classes for years. Have been praepostor and class teacher for years. Win awards named "Outstanding Class Teacher in Guangzhou""The 1st term of Core Teacher of Middle School Affiliated to Guangzhou University ""Famous Class Teacher in Guangzhou",etc.

A member of the Guangzhou chemistry central group in early phase. Have been the leader of unified examination.

Have rich teaching experience and train a lot of outstanding young teacher.

Name: Ding Xing

Guiding Subject: Chemistry

Graduate University: Beijing Normal University

Distinctions:

High school high-ranking Chemistry teacher.

Cultivation object of Backbone Teacher in Guangzhou.

Appointed educational researcher of the Guangzhou Chemistry Educational Research Group.

Excellent Chemistry Competition counselor of Guangdong Province.

Guiding Experience:

Students under his guidance won three second prizes and two third prizes at the China Chemistry Olympic Competiton, twelve first prizes at the Guangdong Chemistry Competition and numerous first prizes at the Guangzhou Chemistry Competition.