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A Flexible Enzymeless Glucose Sensor via Electrodepositing 3D Flower-like CoS onto Self-Supporting Graphene Tape Electrode

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A Flexible Enzymeless Glucose Sensor via Electrodepositing 3D Flower-like CoS onto Self-Supporting Graphene Tape Electrode

Authors

Jiang Li, Zuo-Peng Li, Yun-Feng Bai, Su-Xing Luo, Yong Guo, Ya-Yan Bao, Rong Li, Hai-Yan Liu, and Feng Feng

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(Graphene Tape Electrode Jiang Li¹** th *J. Electrochem.* 2022, 28(1), 2104211 (1 of 11)
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, Su-Xing Luo², Yong Guo¹,

Liu⁴, Feng Feng^{1*}

Datong University, Datong 037009, Shanxi,

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-Xing Luo², Yong Guo¹,

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 A Flexible Enzymeless Glucose Sensor via Electrodepositing 3D
 Flower-like CoS onto Self-Supporting Graphene Tape Electrode

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 Ya-Van BaO^1 , R **A Flexible Enzymeless Glucose Sensor via Electrodepositing 3D**
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temica 14. PERTION E-EILY)THENESS STILCOSE SENSOT VIA ENECTIOLOGY SERVENT SURVEY (SAN FOR START SURVEY).** Tang Li¹, Zuo-Peng Li¹, Yun-Feng Bai¹, Su-Xing Luc², Yong Giuo¹, Ya-Yan Bao¹, Rong Li², Thai-Yan Liu¹, Fe **Thenty Comparison of the Section Properties (Section Properties Conserts)**
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P.R. China; 2. Depa Jiang Li¹, Zuo-Peng Li¹, Yun-Feng Bai¹, Su-Xing Luo², Yong Guo¹,

Ya-Yan Bao¹, Ran-Yan Bao¹, Hai-Yan Liu⁴, Feng Feng¹

(*I. School of Chemistry and Chemistry and Chemical Engineering, Zanyi Dormas Oilege*

It is of much significance to develop a fast and de-

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 I Introduction

It is of much significance to develop a fast and de-

with high sensitivity and selectivity to glucose, and

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fromch is graphene to develop a fast and de-

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has **1** Introduction sensors^[4,8]. Glucose oxidase is a type of bio-enzyme electrode (GTE) with remarkably electrocatalytic activity toward glueose was successfully prepared by electrodeposition. Structumal
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sensitivity value of 23.3, μA (mmol -L²)^{-com² and a fow detection limit of K₃ mmol} sensitivity value of 323.3 μ A-(nmol-1.')¹-em" and a low detection limit of 8.5 μ mol-1.' (SN= 3). Moreover, the as-prepared sensor was well applied for gluocos determination in human sensor, the self-supporting, bi sor was well applied for glacose determination in human serum. Thus, the self-supporting, binder-free, low-cost sensor has good po-
tential as a promising device for practical quantitative analysis of gluoses in human seru tential as a promising device for practical quantitative analysis of glucose in human serms.
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 I Key words: flexible electrode; flower-like CoS; electrodeposition; glucose sensor
 1 Introduction

It is of much significance to develop a fast and de-

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Sensors^[4,8]. Glucose oxidase is a type of bio-enzyme

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chalcogenides have been extensively investigated as

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2 **Expe** tivity of 113.46 $\mu A \cdot (mmol \cdot L^{-1})^{-1} \cdot cm^{-2[22]}$. Further- Millipore Milli-Q UF Plus system. chalcogenides have been extensively investigated as

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2.1 Reagents and Materials

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1) by the use of tremela-like CoS with

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or and 28.44 $\mu A \cdot (mmol \cdot L^+)$ increactively⁸⁰⁸. acid (UA), dopamine (DA), ascerbic acid (AA) and

In addition, Qu e em² and 28.44 μA -(mmol-L⁺)⁻¹-em², respectively¹⁸⁾,
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In additi In addition, Qu et al. reported the CoS-decorated 3D

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Teflon tape and human blood serum samples

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2. **Apparatus** more, Sivakumar et al. also fabricated cobalt sulfide
 2.2 Apparatus and Measurements

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in a linear range from 0.5 to 56 μ mol·L⁺ and a LOD of sive X-ray spectrometry (SEM/EDS) employed in sur-
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rials, a facile flower-like CoS-based GTE biosensor
design by direct electrodeposition was demonstrated
for sensitive glucose detection for the 电化学(*J. Electrochem.*) 2022, 28(1), 2104211 (2 of 11)
the advantages of GTE and cobalt sulfide nanomate-
nasition metal chalco-rials, a facile flower-like CoS-based GTE biosensor
ic activity, magnetic design by direct ele

2 Experimental

 e^{-1} ⁻¹ · tively. Glucose, CoSO₄ · 7H₂O, KSCN, fructose, uric $E/E^*(L \tcdot \ttext{Electrochem.})$ 2022, 28(1), 2104211 (2 of 11)

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via carityity, magnetic design by direct electrodeposition was demonstrated

via cativity, magnetic design by direct electrodeposition was demonstrated

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obtained flower-like CoS showed an outstanding

cely investigated as

electrochemical performance for glucose detection.

biliting water and
 2. Experimental

for electrochemical Scotch transparent t sulfides have **2.1 Reagents and Materials**

electrochemical Scotch transparent tape and commercial graphite

electrochemical Scotch transparent tape and commercial graphite
 $\frac{1}{2}$ (from
 1 -like CoS with China Tech 2. (1), 2104211 (2 of 11)
the advantages of GTE and cobalt sulfide nanomate-
rials, a facile flower-like CoS-based GTE biosensor
design by direct electrodeposition was demonstrated
for sensitive glucose detection for the 28(1), 2104211 (2 of 11)

the advantages of GTE and cobalt sulfide nanomate-

rials, a facile flower-like CoS-based GTE biosensor

design by direct electrodeposition was demonstrated

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the advantages of GTE and cobalt sulfide nanomate-
rials, a facile flower-like CoS-based GTE biosensor
design by direct electrodeposition was demonstrated
for sensitive glucose detection for the f $(2.28(1), 2104211 (2 \text{ of } 11))$
the advantages of GTE and cobalt sulfide nanomate-
rials, a facile flower-like CoS-based GTE biosensor
design by direct electrodeposition was demonstrated
for sensitive glucose detection for $(28(1), 2104211 (2 of 11))$
the advantages of GTE and cobalt sulfide nanomate-
rials, a facile flower-like CoS-based GTE biosensor
design by direct electrodeposition was demonstrated
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rials, a facile flower-like CoS-based GTE biosensor

design by direct electrodeposition was demonstrated

for sensitive glucose detection for the first time. The

obtaine the advantages of GTE and cobalt sulfide nanomate-
rials, a facile flower-like CoS-based GTE biosensor
design by direct electrodeposition was demonstrated
for sensitive glucose detection for the first time. The
obtained fl rials, a facile flower-like CoS-based GTE biosensor
design by direct electrodeposition was demonstrated
for sensitive glucose detection for the first time. The
obtained flower-like CoS showed an outstanding
electrochemical design by direct electrodeposition was demonstrated
for sensitive glucose detection for the first time. The
obtained flower-like CoS showed an outstanding
electrochemical performance for glucose detection.
2. Experimental for sensitive glucose detection for the first time. The
obtained flower-like CoS showed an outstanding
electrochemical performance for glucose detection.
2 **Experimental**
2.1 **Reagents and Materials**
Scotch transparent ta obtained flower-like CoS showed an outstanding
electrochemical performance for glucose detection.
2 **Experimental**
2.1 Reagents and Materials
Scotch transparent tape and commercial graphite
foil were purchased from 3M Comp electrochemical performance for glucose detection.
 2. Experimental
 2.1 Reagents and Materials

Scotch transparent tape and commercial graphite

foil were purchased from 3M Company and North

China Technology Metal Ma **Experimental**
 I Reagents and Materials

Scotch transparent tape and commercial graphite

1 were purchased from 3M Company and North

ina Technology Metal Material Company, respec-

ely. Glucose, CoSO₄·7H₂O, KSCN, f **2.1 Reagents and Materials**
Scotch transparent tape and commercial graphite
foil were purchased from 3M Company and North
China Technology Metal Material Company, respec-
tively. Glucose, $CoSO_4 \cdot 7H_2O$, KSCN, fructose, Scotch transparent tape and commercial graphite
foil were purchased from 3M Company and North
China Technology Metal Material Company, respec-
tively. Glucose, $CoSO_4 \cdot 7H_2O$, KSCN, fructose, uric
acid (UA), dopamine (DA) foil were purchased from 3M Company and North
China Technology Metal Material Company, respec-
tively. Glucose, CoSO₄·7H₂O, KSCN, fructose, uric
acid (UA), dopamine (DA), ascorbic acid (AA) and
other reagents were purc China Technology Metal Material Company, respectively. Glucose, CoSO₄ · 7H₂O, KSCN, fructose, uric acid (UA), dopamine (DA), ascorbic acid (AA) and other reagents were purchased from Aladdin Ltd. Teflon tape and human tively. Glucose, CoSO₄ · 7H₂O, KSCN, fructose, uric
acid (UA), dopamine (DA), ascorbic acid (AA) and
other reagents were purchased from Aladdin Ltd.
Teflon tape and human blood serum samples were
obtained from Chukoh C acid (UA), dopamine (DA), ascorbic acid (AA) and
other reagents were purchased from Aladdin Ltd.
Teflon tape and human blood serum samples were
obtained from Chukoh Chemical Industries, Ltd., and
Sangon Biotech Co., Ltd. (other reagents were purchased from Aladdin Ltd.
Teflon tape and human blood serum samples were
obtained from Chukoh Chemical Industries, Ltd., and
Sangon Biotech Co., Ltd. (Shanghai, China). All chem-
icals were used witho

flon tape and human blood serum samples were
tained from Chukoh Chemical Industries, Ltd., and
ngon Biotech Co., Ltd. (Shanghai, China). All chem-
ls were used without further purification unless
rerwise indicated. Deioniz obtained from Chukoh Chemical Industries, Ltd., and
Sangon Biotech Co., Ltd. (Shanghai, China). All chemicals were used without further purification unless
otherwise indicated. Deionized-water was used
throughout the study Sangon Biotech Co., Ltd. (Shanghai, China). All chemicals were used without further purification unless
otherwise indicated. Deionized-water was used
throughout the study. Water was deionized with the
Millipore Milli-Q UF

icals were used without further purification unless
otherwise indicated. Deionized-water was used
throughout the study. Water was deionized with the
Millipore Milli-Q UF Plus system.
2.2 **Apparatus and Measurements**
Scanni otherwise indicated. Deionized-water was used
throughout the study. Water was deionized with the
Millipore Milli-Q UF Plus system.
2.2 Apparatus and Measurements
Scanning electron microscopy and energy disper-
sive X-ray s throughout the study. Water was deionized with the
Millipore Milli-Q UF Plus system.
 2.2 Apparatus and Measurements

Scanning electron microscopy and energy disper-

sive X-ray spectrometry (SEM/EDS) employed in sur-
 Millipore Milli-Q UF Plus system.
 2.2 Apparatus and Measurements

Scanning electron microscopy and energy disper-

sive X-ray spectrometry (SEM/EDS) employed in sur-

face morphologic and elemental characterizations by **2.2 Apparatus and Measurements**
Scanning electron microscopy and energy disper-
sive X-ray spectrometry (SEM/EDS) employed in sur-
face morphologic and elemental characterizations by
field-emission scanning electron micr **Example 18 All solution**

solution. The complement of the commental characterizations by

tron microscopy (SEM,

accelerating voltage of

ectroscopic (XPS) mea-

by ESCALAB 250Xi

eter.

were conducted by the

mical works Scanning electron microscopy and energy disper-
sive X-ray spectrometry (SEM/EDS) employed in sur-
face morphologic and elemental characterizations by
field-emission scanning electron microscopy (SEM,
FEI Quanta 650 FEG) ex X-ray spectrometry (SEM/EDS) employed in sur-
ce morphologic and elemental characterizations by
eld-emission scanning electron microscopy (SEM,
El Quanta 650 FEG) at an accelerating voltage of
kV. X-ray photoelectron s face morphologic and elemental characterizations by
field-emission scanning electron microscopy (SEM,
FEI Quanta 650 FEG) at an accelerating voltage of
20 kV. X-ray photoelectron spectroscopic (XPS) mea-
surements were pe field-emission scanning electron microscopy (SEM,
FEI Quanta 650 FEG) at an accelerating voltage of
20 kV. X-ray photoelectron spectroscopic (XPS) mea-
surements were performed by ESCALAB 250Xi
X-ray photoelectron spectro FEI Quanta 650 FEG) at an accelerating voltage of 20 kV. X-ray photoelectron spectroscopic (XPS) measurements were performed by ESCALAB 250Xi X-ray photoelectron spectrometer.
The electrochemical tests were conducted by t

the as-pretreated map and state and the price of the price of the state of graphite and state of the price of the pri **EVALUATE 1999**
 EVALUATE 12 h. Thirdly, an above EVALUATION EXAMORET SECTION CONTROLLATE SECTION CONTROLLATE SECTIONS (SUPPOSE THE SECTION CONTROLLATE SUPPOSE THE SUPPOSE CONTROLLATE By exconometry and ultrapure vater for 15 min, dualle layer capacitance in 1 mol \cdot then the scotter of the sc **EVALUATION**
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 EXALUATE: The area of GF11) $2.28(1)$, 2104211 (3 of 11)

they were polished using abrasive paper (grit 2000 and min to electrodeposit CoS, whose electrochemical

5000). Secondly, after respective ultras **EVALUATION**
 EVALUATION \pm //2 *Electrochem.*) 2022, 28(1), 2104211 (3 of 11)
they were polished using abrasive paper (grit 2000 and min to electrodeposit CoS, whose electrochemical
5000). Secondly, after respective ultrasonic washing active ar **EVALUATION**
 EVALUATION Exposed to the electrology of the electrodenal solution
 Exposed to the electrology of the electrodenal solution was controlled by accelens electrology. Secondly, after respective ultrasonic was inglue and by accelens **Example 1.** The expression of the expression of the extraordinate mass of the conduction of the separation of th th $(2\frac{16}{16}\times 16R_{\text{C}}\times R_{\text{C}}\times R_{\text$ by were polished using abrasive paper (grit 2000 and min to electrocheposit CoS, whose electrochemical

00). Scoondly, after respective ultrasonic washing active area was calculated to be 6.69 cm² using the

acetone, et they were polished using abrasive paper (grit 2000 and min to electrodeposit CoS, whose electrochemical
5000). Secondig, after respective turbanoic washing active area was calculated to be 6.69 cm³ using the
by sectone, 5000). Secondly, after respective ultrasonic washing active area was calculated to be 6.69 cm³ using the by accords, chanal, and turbureuve water for 15 min, double layer equactione in 1 mol - L¹ NaOH. The phear cost

without graphite were sheared off to obtain the 3D

porous self-standing flexible GTE. The area of GTEs

porous self-standing flexible GTE. The area of GTEs

reposed to the electrolyte solution was controlled by

the typi

 $\# \# \# (J. Electron) \ge 222, 28(1), 2104211 (3 of 11)$
they were polished using abrasive paper (grit 2000 and min to electrodeposit CoS, whose electrochemical
5000). Secondly, after respective ultrasonic washing active area was calcul then the method using abrasive paper (grit 2000 and a min to electrodeposit CoS, whose electrochemical 5000). Secondly, after respective ultrasonic washing active area was calculated to be 6.69 cm² using the by acctone, the $\frac{4}{5}$ $\ell_{\infty}^{\frac{16}{5}}$ (*L Electrochem.*) 2022, 28(1), 2104211 (3 of 11)
they were polished using abrasive paper (grit 2000 and min to electrodeposit CoS, whose electrochemical
5000). Secondly, after respectiv $28(1), 2104211 (3 of 11)$
min to electrodeposit CoS, whose electrochemical
active area was calculated to be 6.69 cm² using the
double layer capacitance in 1 mol·L⁻¹ NaOH. The
as-prepared sensor was washed with copious de $28(1)$, 2104211 (3 of 11)
min to electrodeposit CoS, whose electrochemical
active area was calculated to be 6.69 cm² using the
double layer capacitance in 1 mol \cdot L⁻¹ NaOH. The
as-prepared sensor was washed with behemical

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picted in $28(1)$, 2104211 (3 of 11)
min to electrodeposit CoS, whose electrochemical
active area was calculated to be 6.69 cm² using the
double layer capacitance in 1 mol·L¹ NaOH. The
as-prepared sensor was washed with copio ectrochemical

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⁻¹ NaOH. The

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is depicted in 28(1), 2104211 (3 of 11)

min to electrodeposit CoS, whose electrochemical

active area was calculated to be 6.69 cm² using the

double layer capacitance in 1 mol·L⁻¹ NaOH. The

as-prepared sensor was washed with copi 28(1), 2104211 (3 of 11)

min to electrodeposit CoS, whose electrochemical

active area was calculated to be 6.69 cm² using the

double layer capacitance in 1 mol·L⁻¹ NaOH. The

as-prepared sensor was washed with copi 28(1), 2104211 (3 of 11)

min to electrodeposit CoS, whose electrochemical

active area was calculated to be 6.69 cm² using the

double layer capacitance in 1 mol \cdot L¹ NaOH. The

as-prepared sensor was washed with 28(1), 2104211 (3 of 11)

min to electrodeposit CoS, whose electrochemical

active area was calculated to be 6.69 cm² using the

double layer capacitance in 1 mol·L¹ NaOH. The

as-prepared sensor was washed with copio $28(1)$, 2104211 (3 of 11)

min to electrodeposit CoS, whose electrochemical

active area was calculated to be 6.69 cm² using the

double layer capacitance in 1 mol \cdot L⁻¹ NaOH. The

as-prepared sensor was washed $28(1)$, 2104211 (3 of 11)

min to electrodeposit CoS, whose electrochemical

active area was calculated to be 6.69 cm² using the

double layer capacitance in 1 mol \cdot L⁻¹ NaOH. The

as-prepared sensor was washe $\frac{S(1)}{S(1)}$, $\frac{2104211}{3}$ of 11)

in to electrodeposit CoS, whose electrochemical

tive area was calculated to be 6.69 cm² using the

uble layer capacitance in 1 mol·L⁻¹ NaOH. The

prepared sensor was washed wit 28(1), 2104211 (3 of 11)

min to electrodeposit CoS, whose electrochemical

active area was calculated to be 6.69 cm² using the

double layer capacitance in 1 mol·L¹ NaOH. The

ize-prepared sensor was washed with copi $28(1)$, 2104211 (3 of 11)
min to electrodeposit CoS, whose electrochemical
active area was calculated to be 6.69 cm² using the
double layer capacitance in 1 mol·L¹ NaOH. The
as-prepared sensor was washed with copio 电化学(*J. Electrochem.*) 2022, 28(1), 2104211 (3 of 11)

ve paper (grit 2000 and min to electrodeposit CoS, whose electrochemical

ve ultrasonic washing active area was calculated to be 6.69 cm² using the

ure water for

by acctone, ethanol, and ultrapure water for 15 min, double layer capacitance in 1 mol·L⁻¹ NaOH. The
the as-pretreated graphite foils were put into a drying as-prepared sensor was washed with copious deio-
oven at 60 °C the as-pretreated graphite foils were put into a drying

over a for one are some as was washed with copious deion-

over at 60 °C for 12 h. Thriedy, an above-pretreated zized water and dried at room temperature. The

grap oven at 60 °C for 12 h. Thirdly, an above-pretreated ized water and dried at room temperature. The
graphite foll was pot onto a cleaning glass slab, and preparation procedure of CoS/GTE is depicted in
then the scotch trans graphite foil was put onto a cleaning glass slab, and

then the scoto transparent the was manually ap-

by dedicated in

the dieta and stuck to the piece of top surface of graphite

by a glass slide, the tape was

3.1 Mor then the sociels transparent tape was manually ap-

Scheme 1.

biel and state to the piece of the same sites of graphite **3 Results and Discussion**

foil. After pressed by a glass silde, the tape was

3.1 Morphological plied and stuck to the piece of top surface of graphite

(bil. After pressed by a glass slide, the tape was

(a) a glass slide, the tape was **3.1 Morphological Analysis**

quickly stripped off: Finally, the parts of the ta foil. After pressed by a glass slide, the tape was
 3.1 Morphological Analysis

quickly stripped off. Finally, the parts of the tape

without graphite were sheared of it o obtain the 3D

or TE were investigated by menas quickly stripped off. Finally, the parts of the tape

without graphic were sheared off to obtain the 3D

province increasing the obtain the 3D

province sheared off to the tail of 2D can be considered by means of SEM. As were sheared off to obtain the 3D

ing flexible GTE. The area of GTEs

played in Figure 1(A), the surface of GTE exhibit

electrolyte solution was controlled by

the typical folded and crumpled layered structure

graphs a obtain the 3D GTE were investigated by means of SEM. As dis-

area of GTEs played in Figure 1(A), the surface of GTE exhibited

controlled by the typical folded and crumpled layered structure of
 $\frac{1}{2}$ CTE change mean porous self-standing flexible GTE. The area of GTEs played in Figure 1(A), the surface of GTE exhibited
exposed to the electrodye solution was controlled by the typical folicled and crunched dy
exposed of the electrode Te exposed to the electrolyte solution was controlled by

Techn tope scaling and iminidat at 0.25 cm².
 2.4 Electrodeposition of CoS on CTE

planes on its surface, which denotes that the GTE

The cobalt sulfule (CoS) was 28(1), 2104211 (3 of 11)

min to electrodeposit CoS, whose electrochemical

active area was calculated to be 6.69 cm² using the

double layer capacitance in 1 mol·L¹ NaOH. The

as-prepared sensor was washed with copio 28(1), 2104211 (3 of 11)

min to electrodeposit CoS, whose electrochemical

active area was calculated to be 6.69 cm³ using the

double layer capacitance in 1 mol·L¹ NaOH. The

as-prepared sensor was washed with copio $28(1), 2104211$ (3 of 11)
min to electrodeposit CoS, whose electrochemical
active area was calculated to be 6.69 cm² using the
double layer capacitance in 1 mol·L¹ NaOH. The
as-prepared sensor was washed with copious min to electrodeposit CoS, whose electrochemical
active area was calculated to be 6.69 cm² using the
double layer capacitance in 1 mol $\cdot L^{-1}$ NaOH. The
as-prepared sensor was washed with copious deion-
ized water and min to electrodeposit CoS, whose electrochemical
active area was calculated to be 6.69 cm² using the
double layer capacitance in 1 mol·L¹ NaOH. The
as-prepared sensor was washed with copious deion-
ized water and drie active area was calculated to be 6.69 cm² using the
double layer capacitance in 1 mol·L⁻¹ NaOH. The
as-prepared sensor was washed with copious deion-
ized water and dried at room temperature. The
preparation procedure double layer capacitance in 1 mol·L⁻¹ NaOH. The
as-prepared sensor was washed with copious deion-
ized water and dried at room temperature. The
preparation procedure of CoS/GTE is depicted in
Scheme 1.
3. Results and D as-prepared sensor was washed with copious deion-
ized water and dried at room temperature. The
preparation procedure of CoS/GTE is depicted in
Scheme 1.
3. Results and Discussion
3.1 Morphological Analysis
The structu ized water and dried at room temperature. The
preparation procedure of CoS/GTE is depicted in
Scheme 1.
3 Results and Discussion
3.1 Morphological Analysis
The structure and morphology of the as-prepared
GTE were inves preparation procedure of CoS/GTE is depicted in
Scheme 1.
Scheme 1.
3 **Results and Discussion**
3.1 **Morphological Analysis**
The structure and morphology of the as-prepared
GTE were investigated by means of SEM. As dis-
pl Scheme 1.
 3 Results and Discussion
 3.1 Morphological Analysis

The structure and morphology of the as-prepared

GTE were investigated by means of SEM. As dis-

played in Figure 1(A), the surface of GTE exhibited

th **3 Results and Discussion**
 3.1 Morphological Analysis

The structure and morphology of the as-prepared

GTE were investigated by means of SEM. As dis-

played in Figure 1(A), the surface of GTE exhibited

the typical f **3.1 Morphological Analysis**
The structure and morphology of the as-prepared
GTE were investigated by means of SEM. As dis-
played in Figure 1(A), the surface of GTE exhibited
the typical folded and crumpled layered struc The structure and morphology of the as-prepared
GTE were investigated by means of SEM. As dis-
played in Figure 1(A), the surface of GTE exhibited
the typical folded and crumpled layered structure of
graphene sheets with s GTE were investigated by means of SEM. As dis-
played in Figure 1(A), the surface of GTE exhibited
the typical folded and crumpled layered structure of
graphene sheets with some exposed graphene edge
planes on its surface played in Figure 1(A), the surface of GTE exhibited
the typical folded and crumpled layered structure of
graphene sheets with some exposed graphene edge
planes on its surface, which denotes that the GTE
could improve the e e typical folded and crumpled layered structure of
aphene sheets with some exposed graphene edge
anes on its surface, which denotes that the GTE
suld improve the electron transmission rate and
ultidimentional electron tran

generally a non-stoichiometric compound[36]. Another For a sum of the allotted to the strategy and the strength of the strength of the Binding energy/eV index (color on line)

S 2 $p_{3/2}$, separately, which relies on the existing sulfur

into on the surface and the Co-S bon xisting sulfur
Specifically,
t ca. 164.5 ~
ial amount of
sited CoS is
 $d^{[36]}$. Another
 2^2 , potentially
 $SO_4^{[33, 37]}$. The ²⁵
 Example 18

160 162 164 166 168 170

Binding energy/eV

164 166 168 170

Binding energy/eV

ited CoS. (color on line)

S 2p₃₂, separately, which relies on the existing sulfur

ion on the surface and the Co-S bon ting sulfur
ecifically,
a. 164.5 ~
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the 22 , $28(1)$, 2104211 (5 of 11)

The results were in good agreement with the previ-

itively, while the cathodic peak a negative shift with

ous reported^{try}.
 3.3 Electrochemical Behavior of Prepared

to the in the \mathcal{R}_c is not electrochemical costs and the previse of the previse in good agreement with the prevision in the achodic peak a negative shift with the suse protect²⁶.
 CoS/GTE by unasit-rocessime scenarios in e the $\mathcal{P}(L)$ R is the much contrast, the method of the previous contrast, the previous exported $\mathcal{P}(L)$. It is the method of **Prepared** by quasi-reversible cleared transfer reaction for the method ous reported¹⁹⁸ 40.62% The method of the method of the studies a percent and method in the studies appeared and the reduc-
 Alternative studies are the interesting scan rate, denoting an electrochemical
 3.3 Electrochemical Behavior tion and the the provident in the previous operator of the microssing scan are, denoted the increase of electrodeposited CoSCTE and the increasing scan are, denoted by equal-text-of-terminal-

3.3 Electrochemical Behavio **EVALUAT SECT (SECT CONTIFY)**
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itively, while the cathodic peak a negative shift with
ous reported²⁸.
3.3 Electrochemical Behavior of Prepared by quasi-reversible clearton framsfer reaction for the XPS results were in good agreement with the previ-

ous reported¹⁸⁹.

the increasing scan rate, denoting
 CoS/GTE
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are increased Figure 3(morted¹⁹⁾.

the increasing scan rate, denoting an electrochemical-
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 COP 3.3 Electrochemical Behavior of Prepared by quasi-reversible electron transfer reaction for the reading this consections in equation (1) and (2)³⁸^m. In addition, as Initially, the electrochemical performance of the

 RPS results were in good agreement with the previ-
XPS results were in good agreement with the previ-
itively, while the cathodic peak a negative shift with
the increasing scan rate, denoting an electrochemical-
3.3 Elec $#E\#(J. Electronen.)$ 2022, 28(1), 2104211 (5 of 11)

XPS results were in good agreement with the previ-

ous reported^[38].
 3.3 Electrochemical Behavior of Prepared by quasi-reversible elec
 CoS/GTE reactions in equation (1 **EMPLEMENTA Electrochemical**
 EMPLEMENTA Electrochemical S2022, 28(1), 2104211 (5 of 11)
 EXPS results were in good agreement with the previ-

tively, while the cathodic peak a negative shift with

ous reported^[38] CoS/GTE reactions in equation (1) and (2)^[39, 40]. In addition, as **EVALUATION**
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 EVALUATION
 EXECUTE:
 Example 10.1
 Example 10.1 (*Let the the m*) 2022, 28(1), 2104211 (5 of 11)

XPS results were in good agreement with the previ-

itively, while the cathodic peak a negative shift with

ous reported^{ps|}.
 3.3 Electrochemical Behavior of Prepared EVALUAT THE 19
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revi-

itively, while the cathodic peak a negative shift with

the increasing scan rate, denoting an electrochemical-

reactions in equation (1) and (2)^[39,40]. In addition, as

f t the $202, 28(1), 2104211 (5 of 11)$

Shows reported^{ry,}

shown in good agreement with the previ-

itively, while the cathodic peak a negative shift with

the increasing scan rate, denoting an electrochemical-
 3.3 Electroch 28(1), 2104211 (5 of 11)
itively, while the cathodic peak a negative shift with
the increasing scan rate, denoting an electrochemical-
ly quasi-reversible electron transfer reaction for the
reactions in equation (1) and (28(1), 2104211 (5 of 11)
itively, while the cathodic peak a negative shift with
the increasing scan rate, denoting an electrochemical-
ly quasi-reversible electron transfer reaction for the
reactions in equation (1) and (28(1), 2104211 (5 of 11)
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ly quasi-reversible electron transfer reaction for the
reactions in equation (1) and (28(1), 2104211 (5 of 11)
itively, while the cathodic peak a negative shift with
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ly quasi-reversible electron transfer reaction for the
reactions in equation (1) and (28(1), 2104211 (5 of 11)
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reactions in equation (1) and (28(1), 2104211 (5 of 11)
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reactions in equation (1) and (, 2104211 (5 of 11)

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asi-reversible electron transfer reaction for the

ions in equation (1) and (2)^[39, 40]. In addit $(0, 2104211 (5 \text{ of } 11))$

Sy, while the cathodic peak a negative shift with

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CoO + OH^- \Longleftrightarrow CoOOH + H_2O + e^-(1)
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$$
CoOOH + OH \iff CoO2 + H2O + e
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 (2)

mmol \cdot L⁻¹) in 0.1 mol \cdot L⁻¹ NaOH solution at a scan 1y quasi-reversible electron transfer reaction for the
reactions in equation (1) and (2)^{[39, 40}]. In addition, as
shown in Figure 3(C), both the oxidative and reduc-
tive peak currents varied linearly in proportion to t

Figure 3 (A) CVs of bare GTE and CoS/GTE in 0.1 mol·L⁻¹ NaOH (scan rate: 50 mV·s⁻¹). (B) CVs of CoS/GTE in 0.1 mol·L⁻¹ NaOH

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necessition is $\frac{4}{3}E\frac{\pi}{7}(L\text{ *Eterocohem.*) 2022, 28(1), 2104211 (6 of 11)}\text{acceleration, which is widely accepted that the oxid-1. Figure 4(A) displays the amperometric current re-
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current resp 电化学(*J. Electrochem.*) 2022, 28(1), 2104211 (6 of 11)
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figure 4(A) displays the amperometric current re-
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^[20]. It can be seen that the corresponding cal-

correlation coefficient R² = 0.9953), with

a linear response $\frac{dE}{dt}$ (*L Electrochem.*) 2022, 28(1), 2104211 (7 of 11)
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idiffusing^[20]. It can be seen that the corresponding cal-

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a mmol \cdot L⁺ (correlation coefficient $R^2 = 0.9953$), with sity increased again. Considering that the blood glu-
add a LOD of 8.5 kmol \cdot L² (S/N cm₂). Compared with propositivity of 2.8 and a LOD of 8.5 kmol $\$

 $\frac{\text{d}E}{\text{d}E}$
diffusing^[20]. It can be seen that the corresponding cal-
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that the corresponding cal-

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diffusing^[30]. It can be seen that the corresponding cal-

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schoof a linear response in the ranges of Cl₂ while no apparent responses of UA and Fru to the glu-
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diffluing²⁹⁹. It can be seen that the corresponding cal-

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ferents, such as UA (0.33 mmol·L⁺) and AA (0.125
mmo $\frac{\text{H} \& \frac{\text{L}}{\text{L}} \& (J. \text{Electrochem.}) 2022, 28(1), 2104211 (7 of 11) }{\text{hetero} \& \text{intero} \& \text$

er reported Co-based electro-

ferents, such as UA (0.33 mmol·L⁺) and AA (0.125

ic glucose sensors (Table 1), mmol·L⁺)<sup>¹⁴⁰₁ it can be concluded that the CoS/GTE

of our proposed sensor are sat-

suitablitied supe</sup> -1 exhibited superior selectivity toward glucose detec-
tion, which can potentially applied in clinical analy-
sis of in vitro glucose.
The repeatability of the CoS/GTE was tested. The
consecutive tests were carried out at t

It is one of the indispensable concerns in the elec- trochemical glucose sensor to own good selectivity performance towards other physiological species in- cluding ascorbic acid (AA), dopamine (DA), uric acid (UA) and fructose (Fru). Therefore, the $I-t$ curve was measured in order to investigate the influence of com- mon interferents on glucose oxidation at a fixed poten- tial. As shown in Figure 4(D), it can be evidently seen			sis of in vitro glucose.											
				The repeatability of the CoS/GTE was tested. The										
			consecutive tests were carried out at the same CoS/ GTE in 0.1 mol $\cdot L^{-1}$ NaOH including 0.5 mmol $\cdot L^{-1}$											
								glucose for five parallel times. The calculated RSD of the glucose oxidation-current response for each mea- surement was 3.38%, demonstrating a good repeata- bility of the fabricated CoS/GTE.						
			that the CoS/GTE had a notable response for glucose, the interference signals of AA and DA current respons-			For reproducibility assessment, five as-obtained CoS/GTEs sensors were examined under the same								
					Table 1 Comparison of analytical performances for different Co-based sensors.									
			Electrode material	Method	Sensitivity $(\mu A \cdot cm^{-2} \cdot (mmol \cdot L^{-1})^{-1})$	Linear range/ $(mmol \cdot L^{-1})$	Test Potential/V	Detection Limit/ $(\mu mol \cdot L^{-1})$	Flexible substrate	Ref.				
CoS	Hydrothermal method	139.35; 28.44	$0.005 \sim 1.10$; $1.20 \sim 10.20$	0.20	1.5	No	$[20]$							
$CoS/3D$ porous carbon skeleton	Hydrothermal method	679	$0.01 \sim 0.9$	0.45	\overline{c}	$\rm No$	$[21]$							
Co_xS_y rGO-PEDOT	CV	113.46	$0.0002\sim$ 1.380	0.65	0.079	No	$[22]$							
Nickel-cobalt phosphate	Hydrothermal method	302.99	$0.002 \sim 4.47$	0.55	$0.4\,$	$\rm No$	$[42]$							
NiCo ₂ S ₄ /Ni/CFP	CV	283	$0.0005 \sim 6$	0.45	0.05	Yes	$[43]$							
3D graphene frameworks/ $Co3O4$ composites	Sol-gel	122.16	$0.025 \sim 0.080$	0.58	0.157	No	$[44]$							
CoTsPc		122.5	$0.01 \sim 6.34$		0.14	No	$[45]$							
CoOOH nanosheets	Redox reaction	341	$0.03 \sim 0.7$	$0.4\,$	30.9	$\rm No$	$[46]$							
CoP	Precipitation method	116.8	$0.5 \sim 5.5$		9	$\rm No$	$[47]$							
$\mathrm{CoS/GTE}$	${\rm CA}$	323.3	$0.025\sim1.0$	$0.5\,$	8.5	Yes	This work							

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conditions using 0.5 mmol·L⁴ glucose in 0.1 mol·L⁴ 2020L0498), Cultivate Scientific a

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NaOH. The conditions using 0.5 mmol - L⁺ glucose in 0.1 mol - L⁺ 202010498), Cultivate Scientific Research Excel-

NAOH. The RSIS were calculated to be 0.03%, lense Programs of Higher Education Institutions in

Neineng a good r NaOH. The RSDs were calculated to be 6.03%,

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evincing a good reproductibility. After being stored in Shanxi (No. 2018/0143), Key Scientific and Tech-

sit are particular evincing a good reproducibility. After being stored in

Shamxi (No. 2020KJ023), Key Scientific and Technical Texposes controllar than controllar controllar controllar sensor for half a month, the CoS/GTE glucose sensor cov air exposure for half a month, the CoS/GTE showed

nological Projects of Datong City (No. 2018014) as

85.7% of its initial response current, indicating that

the Special Key Laboratory of Guizhou

the expecies CoS/GTE gl enzymeless CoSNTE glucose sensor owns agree-

Province (No. [2018]004), the Science Foundation of

the Science and Technology Operatment of Guizhou

Practical Applications

o validate the applicability of the CoSNTE, the
 able stability¹⁶¹. the Science and Technology Department of Guizbou

To validate the applicability of the CoS/GTE, the Province (No. [2015]1736), and Matural Science Research

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cose concentration of 5.20 mmol -1.¹ by the standard

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III Rahman M.M. Ahammad

4 Conclusions

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ranging from 96.5 to 102,5% in human serum sam-

ples with RSD from 3,92% ~ 4,84%(Table 1). Hence,

the ranging from 96.5 to 102.5% in human serum sam-

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the cGSGTE can be used as a potential sensor for electrodes for

(28(1), 2104211 (8 of 11)
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This work was financially supported by Applied
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This work was financially supported by A

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(amol -L⁺⁾ RSD⁹⁶ Mean

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 $^{1/1}$ RSD/% Mean
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一种基于电沉积 3D 花状 CoS 在自支撑石墨烯 胶带电极上的非酶葡萄糖传感器的研究与应用 _{电化学(*J. Electrochem.*) 2022, 28(1), 2104211 (11 of 11)
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沉积 3D 花状 CoS 在自支撑石墨烯}

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摘要: 本文将 3D 纳米结构花状 CoS 电沉积在石墨烯胶带电极(GTE)上,制备了一种对葡萄糖响应良好的电化 学传感器。结构分析显示电沉积的 CoS 均匀地分散在了电极上。实验结果表明,制备的花状 CoS/GTE 葡萄糖传 **十种基于电沉积3D花状 CoS在自支撑石墨 7.4 mmole 1.025.28(1), 2104211 (11 of 11)

7.5 节电极上的非酶葡萄糖传感器的研究与应用

7.6 节电极上的非酶葡萄糖传感器的研究与应

4.0 mmpthe 1.4 mmole 1.0 mmole 1.4 mmole 1.0 mmole 2.1 mmole 1.4 mmole 2.1 mmole 2.1 mmole 2.1 mmole 2.1** -' 显示出良好的线性关系,灵敏度为 323.3 μA•(mmol•L⁻l)·'•cm⁻,检出限为 8.5 μmol•L^{-ι} -1 (S/^N = 3)袁而且制备的传感器能够应用于血清葡萄糖的检测^遥 这表明本文制备的传感器具有一定的应用潜力^遥 关键词:柔性电极;花状 CoS;电沉积;葡萄糖传感器