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Alumina Inorganic Molecularly Imprinted Polymer Modified Multi-Walled Carbon Nanotubes for Uric Acid Detection in Sweat

(Supplementary Information)

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Figure and table comments

Figure S1. We prepared a UA standard solution of 40 μM and tested its UV absorption spectrum. The same method was then used to test three actual sweat samples collected from volunteers, and the concentrations of the actual sweat samples were calculated by comparing their UV absorption spectra with that of the 40 μM standard solution.

Figure S2. The MWCNTs-Al_2O_3-MIP/GCE electrode was immersed in a prepared PBS buffer solution containing a specific concentration of UA with a pH of 7.4. The response current of the MWCNTs-Al_2O_3-MIP/GCE electrode was measured at various adsorption enrichment times. The trend graphs depict the relationship between adsorption times and current responses.

Figure S3. After the MWCNTs-Al_2O_3-MIP/GCE electrode was prepared, the electrochemical DPV response was directly tested in a PBS solution with pH=7.4 before and after eluting UA.

Table S1. The actual sample recovery test of MIP electrode was carried out by standard addition technique in PBS with pH=7.4.

Table S2. The actual sweat samples from 3 volunteers were tested by UV-vis absorption spectroscopy, of which the results were compared with those by electrochemical method.

Table S3. The performances of recently published works in the same field are compared favorably. The MWCNTs-Al_2O_3-MIP/GCE electrode exhibits an excellent detection range from 50 nM to 600 μM with limit detection of 50 nM. It can be seen that MWCNTs-Al_2O_3-MIP/GCE electrode has a low detection limit while maintaining a good linear detection range, and compared with other devices, MWCNTs-Al_2O_3-MIP/GCE electrode has a more convenient preparation method and lower cost.

Table S4. This presentation of the X-ray Photoelectron Spectroscopy (XPS) data focuses on the surface analysis of the MWCNTs-Al_2O_3-MIP/GCE. The XPS exhibits a prominent C 1s peak at 284.68 eV, an O 1s peak at 531.09 eV, and an Al 2p peak at 73.90 eV, with no discernible peaks for other elemental species apart from these. The corresponding elemental compositions of the MWCNTs-Al_2O_3-MIP/GCE are determined as follows: C (68.04%), O (21.70%), and Al (10.26%).

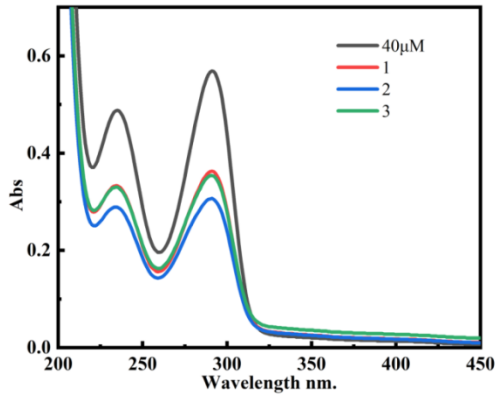

Fig. S1. UV absorption spectra of actual samples.

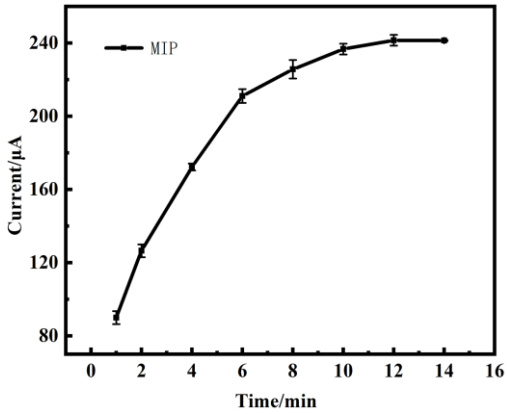

Fig. S2. Response of MWCNTs-Al_2O_3-MIP/GCE electrodes to uric acid (UA) at different sorption times.

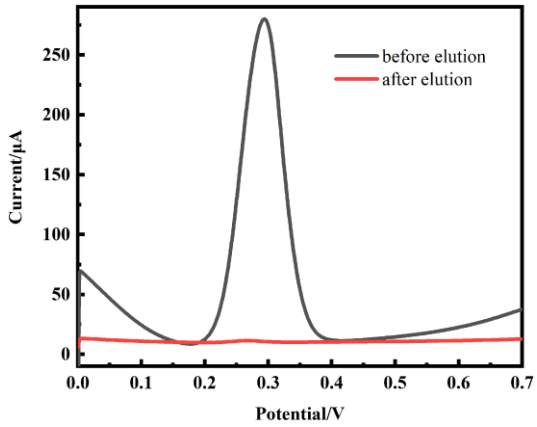

Fig. S3.Response of the MWCNTs-Al_2O_3-MIP/GCE electrode tested in PBS before and after elution.

Table S1. Standard addition technique for the determination of Uric Acid.

Sample	Added (μM)	Detection (μM)	Recovery(%)	RSD(%)
1	1.00	1.14	114.0	0.07
2	50.00	53.11	106.2	0.09
3	100.00	96.81	96.8	0.09

Table S2. Analysis of actual samples taken from the sweat of the volunteers.

Sample	Number	UV detection (μM)	MIP detection (μM)	Recovery(%)	RSD(%)
Sweat	1	25.52	25.85	101.3	1.55
	2	21.58	22.25	102.2	2.47
	3	24.89	24.07	97.9	1.40

Table S3. Sensing performance comparison of different sensors for uric detection

Electrode Materials	Detection technique	Detection limit (μM)	Linear range (μM)
this work	DPV	0.05	0.5-600
$ZnCl_2$-CF/GCE[1]	DPV	0.11	1-2000
A–Co–NG[2]	IT	0.0333	0.4-41950
3D SACNT[3]	CV	1	100-1000
CoPc/GQDs[4]	DPV	0.145	1.99–5415
Ti-C-Tx modified GCE[5]	DPV	0.075	100-1500
OPEDOT-AuNPs-ERGO[6]	GECT	5	4-100

(MIP)-molecularly imprinted polymer；（MWCNTs）- multi-walled carbon nanotubes;(NG) -N-doped grapheme; (SACNT)- Super-Aligned Carbon NanoTube; (Ti-C-Tx)-mixed phase titanium carbide; (OPEDOT)- overoxidized poly(3,4-ethylenedioxythiophene); (AuNPs)-gold nanoparticles; (ERGO)- electrochemically reduced graphene oxide；（CoPc）- cobalt phthalocyanine；（GQDs）- graphene quantum dots.

Table S4. Element content of MWCNTs-Al_2O_3-MIP/GCE characterized by XPS.

name	BE	FWHM (eV)	CPS.eV (P)	Atomic (%)
C1s	284.68	3.24	369841.62	68.04
O1s	531.09	3.39	298070.82	21.70
Al2p	73.9	3.15	34187.62	10.26

References

[1] W. Zhang, L. Liu, Y. Li, D. Wang, H. Ma, H. Ren, Y. Shi, Y. Han, B.C. Ye, Electrochemical sensing platform based on the biomass-derived microporous carbons for simultaneous determination of ascorbic acid, dopamine, and uric acid, Biosens Bioelectron, 121 (2018) 96-103.

[2] F.X. Hu, T. Hu, S. Chen, D. Wang, Q. Rao, Y. Liu, F. Dai, C. Guo, H.B. Yang, C.M. Li, Single-Atom Cobalt-Based Electrochemical Biomimetic Uric Acid Sensor with Wide Linear Range and Ultralow Detection Limit, Nanomicro Lett, 13 (2021) 1-13.

[3] M. Yang, H. Wang, P. Liu, J. Cheng, A 3D electrochemical biosensor based on Super-Aligned Carbon NanoTube array for point-of-care uric acid monitoring, Biosens Bioelectron, 179 (2021) 113082.

[4] B. Wu, M. Li, R. Ramachandran, G. Niu, M. Zhang, C. Zhao, Z. Xu, F. Wang, GQDs Incorporated CoPc Nanorods for Electrochemical Detection of Dopamine and Uric Acid, Advanced Materials Interfaces, 10 (2022)2200738.

[5] N. Murugan, R. Jerome, M. Preethika, A. Sundaramurthy, A.K. Sundramoorthy, 2D-titanium carbide (MXene) based selective electrochemical sensor for simultaneous detection of ascorbic acid, dopamine and uric acid, Journal of Materials Science & Technology, 72 (2021) 122-131.

[6] N. Dalbeth, H.K. Choi, L.A.B. Joosten, P.P. Khanna, H. Matsuo, F. Perez-Ruiz, L.K. Stamp, Gout, Nature Reviews Disease Primers, 69 (2019)280.