Supporting Information

Solution ion luminescence induced by triboelectric-discharge effect for rapid and intuitive detection of sweat ions

Haoyu Wang[1,2†], Jingjing Fu[1,3†], Xian Song[4†], Tingting Hou[1†], Xin Xia[5], Guoqiang Xu[2], Binbin Zhang[2], Keshuai Yang[4], Ru Guo[1], Chaojie Chen[1], Zuowei Sun[2], Guangyao Zhao[2], Zijian Zheng[3,6,7,8], Xinge Yu[2,], Yunlong Zi[1,5,9,*]*

1. Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong, China
2. Department of Biomedical Engineering, City University of Hong Kong, Kowloon Tong, Hong Kong, China
3. Department of Applied Biology and Chemical Technology, Faculty of Science, The Hong Kong Polytechnic University, Hong Kong, China.
4. Department of Sports Science, Zhejiang University, Hangzhou, Zhejiang 310058, China
5. Thrust of Sustainable Energy and Environment, The Hong Kong University of Science and Technology (Guangzhou), Nansha, Guangzhou, Guangdong 511400, China
6. Research Institute for Intelligent Wearable Systems, Research Institute for Smart Energy, The Hong Kong Polytechnic University, Hong Kong, China
7. PolyU-Wenzhou Technology and Innovation Research Institute, Wenzhou, Zhejiang, China
8. PolyU-Daya Bay Technology and Innovation Research Institute, Huizhou, Guangdong, China
9. Guangzhou HKUST Fok Ying Tung Research Institute, Nansha, Guangzhou, Guangdong 511400, China

[†] All authors contributed equally to this work

[*]*Corresponding authors, email: ylzi@hkust-gz.edu.cn, xingeyu@cityu.edu.hk.*

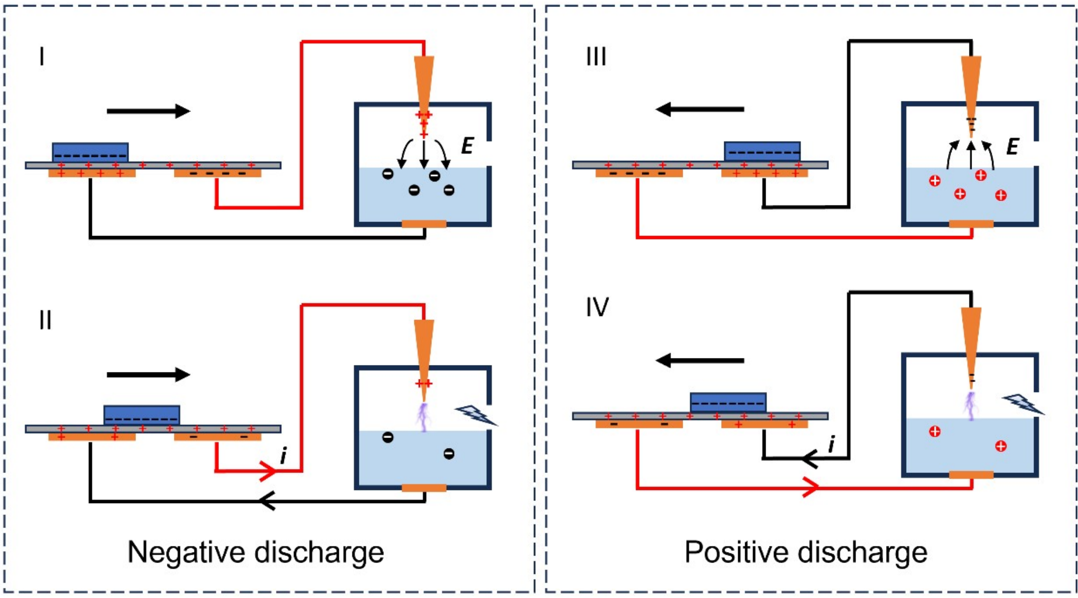

Figure S1. TDTS-SID in a complete working cycle of SFT-TENG.

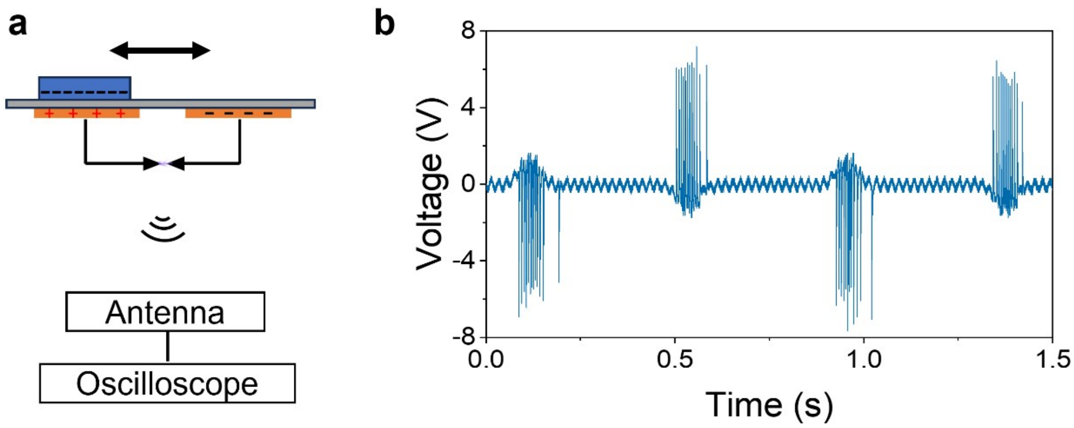

Figure S2. Wireless EM wave signal induced by triboelectric-discharge effect. (a) System scheme of generation of the triboelectric-discharge effect-induced EM wave. The SFT-TENG is driven by a linear motor. (b) Received EM wave signal in a complete working cycle of SFT-TENG.

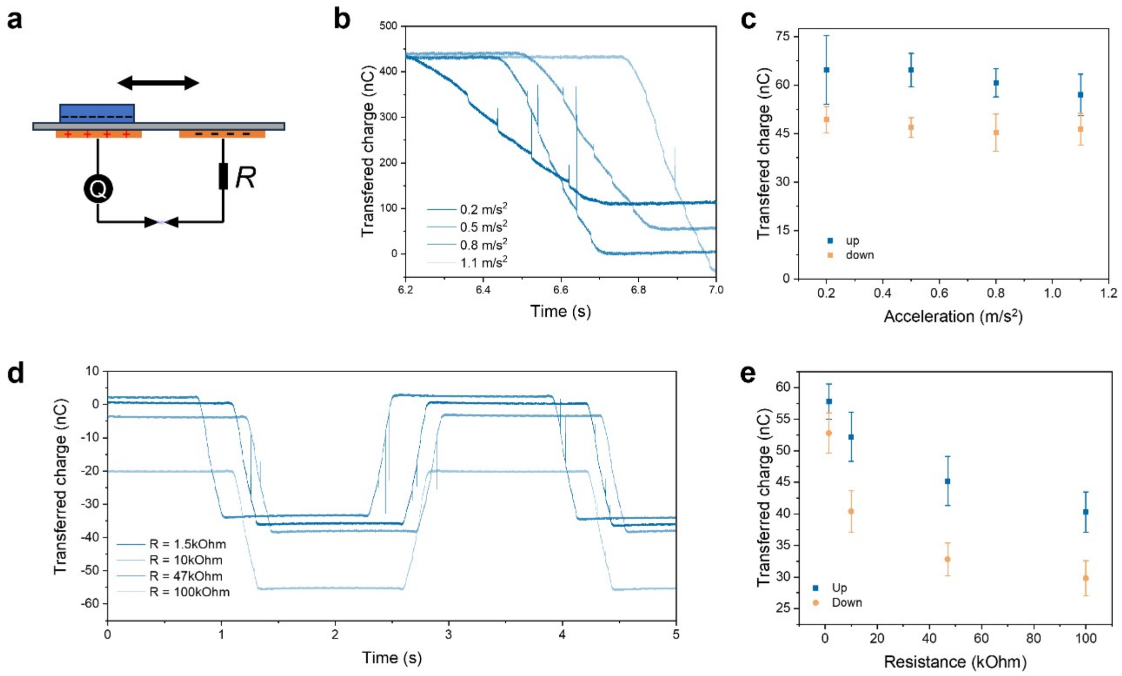

Figure S3. The study of multiple discharge phenomenon during the working cycle of SFT-TENG. (a) A wired measurement circuit during triboelectric discharge process. (b) The measured transferred charge variation with different acceleration of input mechanical trigger. (c) The relationship between the released charge with different acceleration. (d) The measured transferred charge variation with different series connected resistor. (e) The relationship between the released charge with different series resistance.

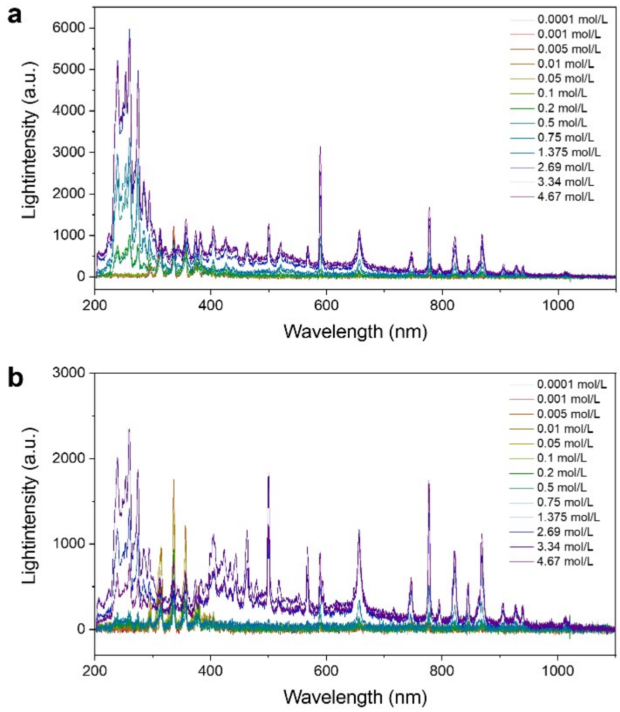

Figure S4. Zoomed-in figures in Fig. 3. (a-b) The spectrums of TDTS-SID in sodium chloride solutions with different concentrations in (a) positive and (b) negative discharge cases.

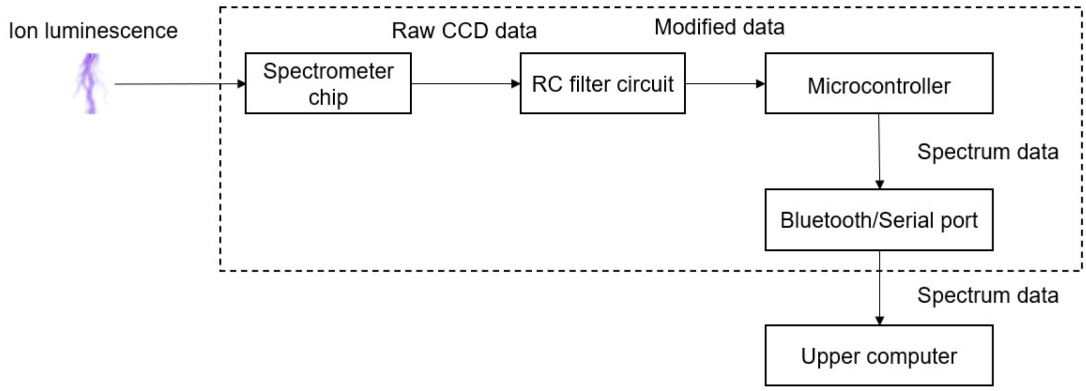

Figure S5. The overall circuit block diagram of handheld spectrometer.

Table S1 The comparison between TDTS-SID-based sweat ion detection method with similar works.

Detected types of metal ions	Working principle	Additional material needed	Sensitivity	Limit of detection	Detection time	Ref.
K^+, Na^+	electrochemical	ion sensitive electrodes	48 (K^+) and 87.9 (Na^+) mV/ decade	1 mM (K^+) 10 mM (Na^+)	real-time	[1]
K^+, Na^+	electrochemical	ion sensitive electrodes	~ 50 (K^+) and 70 (Na^+) mV/ decade	1 mM (K^+) 10 mM (Na^+)	real-time	[2]
K^+, Na^+	electrochemical	ion-selective electrodes	41.5 (K^+) and 58.2 (Na^+) mV/decade	1 mM (K^+) 1 mM (Na^+)	real-time	[3]
K^+	electrochemical	ion-selective electrodes	57.9 mV/decade	$10^{-2.65}$ mM	~ 20 s	[4]
Ca^{2+}	electrochemical	ion-selective electrodes	32.7 mV/decade	0.125 mM	real-time	[5]
NH_4^+	electrochemical	ion-selective electrodes	59.2 mV/decade	0.1 mM	~ 5 s	[6]
Cu^{2+}	electrochemical	ion sensitive material	0.414 μA (μg $L^{-1})^{-1}$ cm^{-2}	0.0368 μg/L	NA	[7]
K^+, Na^+, Ca^{2+}, Li^+	spectrum	/	~ 10/decade (0.1 mM-100 mM); ~2000/decade (100 mM-4670 mM)	0.1 mM (Na^+)	real-time	This work

Reference

1 Niu, J. *et al.* A Fully Elastic Wearable Electrochemical Sweat Detection System of Tree-Bionic Microfluidic Structure for Real-Time Monitoring. *Small* **20**, 2306769, (2024).

2 Xu, G. *et al.* Triboelectric Nanogenerator Enabled Sweat Extraction and Power Activation for Sweat Monitoring. *Advanced Functional Materials* **34**, 2310777, (2024).

3 Zhai, Q. *et al.* Vertically Aligned Gold Nanowires as Stretchable and Wearable Epidermal Ion-Selective Electrode for Noninvasive Multiplexed Sweat Analysis. *Analytical Chemistry* **92**, 4647-4655, (2020).

4 Miller, P. R. *et al.* Microneedle-Based Transdermal Sensor for On-Chip Potentiometric Determination of K+. *Advanced Healthcare Materials* **3**, 876-881, (2014).

5 Nyein, H. Y. Y. *et al.* A Wearable Electrochemical Platform for Noninvasive Simultaneous Monitoring of Ca^{2+} and pH. *ACS Nano* **10**, 7216-7224, (2016).

6 Guinovart, T., Bandodkar, A. J., Windmiller, J. R., Andrade, F. J. & Wang, J. A potentiometric tattoo sensor for monitoring ammonium in sweat. *Analyst* **138**, 7031- (2013).

7 Zhang, Q. *et al.* Smartphone-based wearable microfluidic electrochemical sensor for on-site monitoring of copper ions in sweat without external driving. *Talanta* **266**, 125015, (2024).