Wearable Supercapacitive Ions Monitoring Sensors

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Abstract: The rapid progress of wearable technologies has opened up opportunities for ground-breaking self-powered sensing systems that have the potential to transform various sectors, especially healthcare, and energy. In this work, we developed a new textile-based supercapacitive sodium ion monitoring sensor for wearables. For this, a textile supercapacitor (SC) were fabricated using poly(3,4ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) as the active electrode. The fabricated SC was used as a wearable supercapacitive sensor and in which the influence of Na^+ ions variation was investigated by changing the concentration of NaCl from 0-16 mM. The fabricated sensor exhibited a sensitivity of 2.05 mF/log [Na^+] in the range of 2-16 mM NaCl. The sensor's influences towards KCl variation were also monitored, demonstrating its potential for multiple ion monitoring. Finally, as an application, the sensor's performance was monitored in an artificial sweat solution for wearables.

Introduction and State of the Art: Human sweat is rich in chemicals including electrolytes, metabolites, and foreign chemicals (shown in Fig.1) [1]. Among these parameters, monitoring of Na ions is highly important for physiological and mental well-being. Various sensors reported for Na ion monitoring. This includes (i) potentiometric $Na_{0.44}MnO_2$ sensor (58 $mVdec^{-1}$) [2] , (ii) carbon fibres based potentiometric sensor (55.9±0.8 mV/log[Na^+]) [3] (iii) resonance sensor (3.7319 dB/%ppm) [4], and (iv) amperometric sensor (4.0 nA/µM) [5]. In comparison to these reported works, in this work, we developed a new supercapacitive Na ion monitoring sensor on the textile substrate that could be implemented as a self-powered wearable sensor. We utilized simple and low-cost methods for the fabrication of sensors.

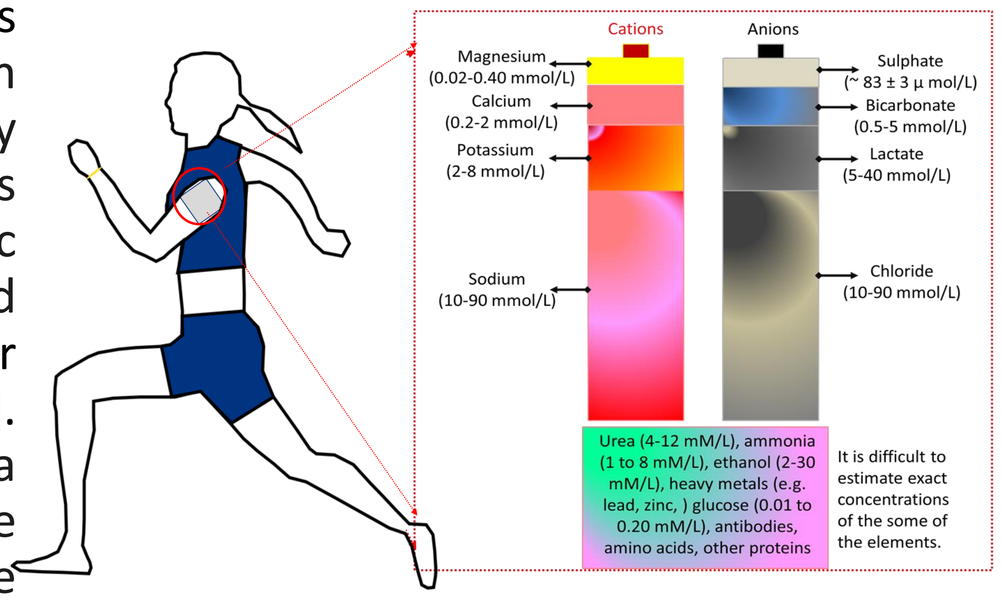

Fig. 1: Chemical contents of human sweat [1]

Experimental Section: The major steps in the design of sensors and their characterization are as follows (experimental setup shown in Fig.2)

Step 1: Development PEDOT: PSS-coated conductive textile with a dimension of 2 cm^2.

Step 2: Development of SC by using ethyl cellulose cloth as a separator and packaging it with the same cellulose cloth (similar to previous work [6]).

Step 3: Evaluation of the electrochemical performance of the fabricated SC as a sensor in different concentrations of NaCl (1-16 mM), and its interference in KCl and artificial sweat as the electrolyte.

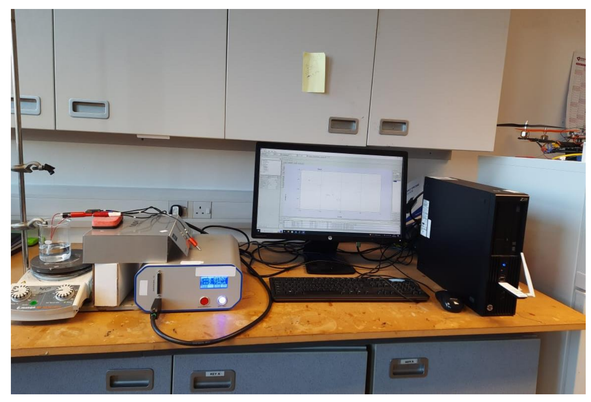

Fig. 2: Electrochemical sensing system for supercapacitive sensor

Results and Discussion

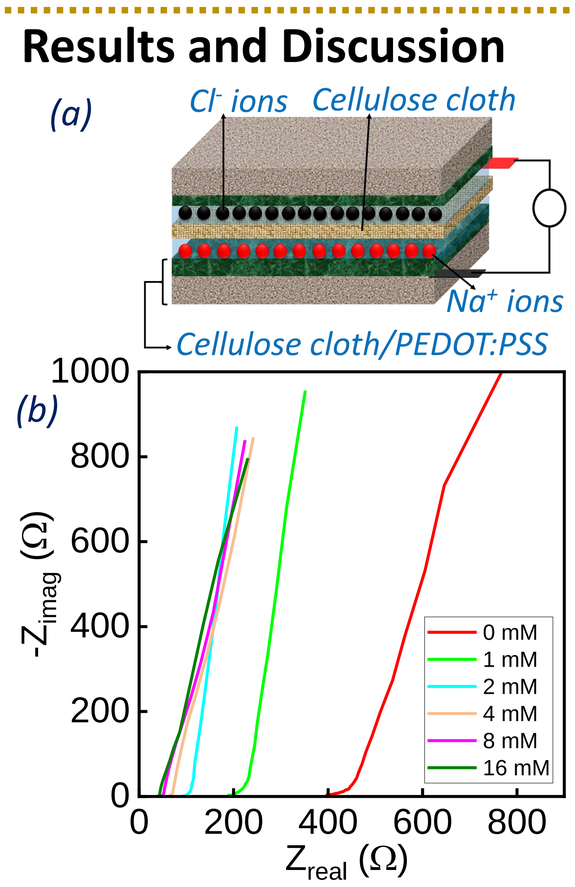

Fig. 3 (a) Schematic Capacitive sensor and (b) Nyquist Plot for NaCl variation

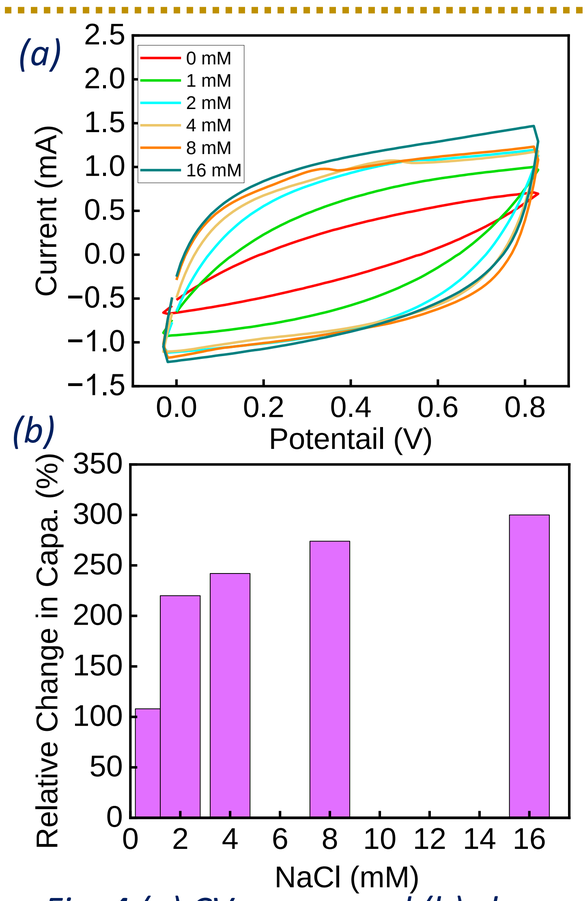

Fig. 4 (a) CV curves and (b) change in capacitance for NaCl variation

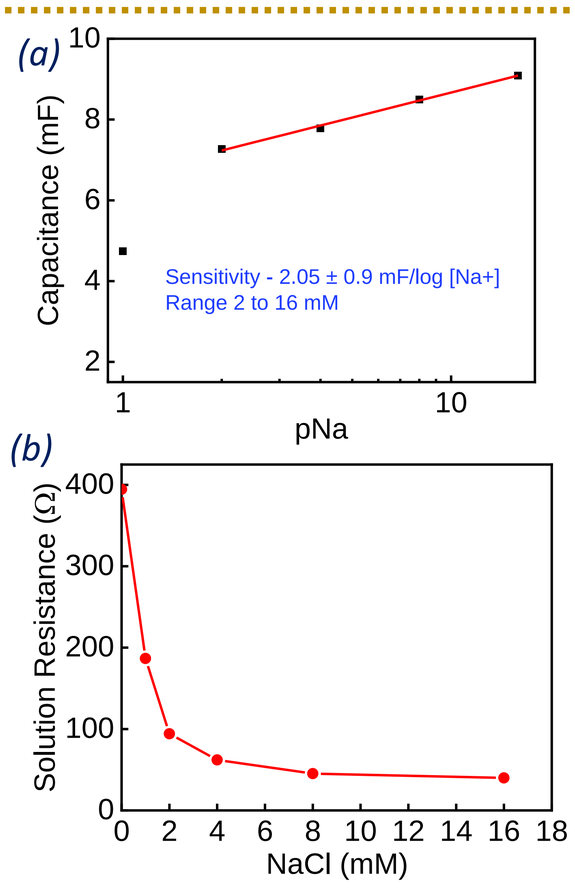

Fig. 5 (a) Sensitivity of the sensor and (b)solution resistance variation with NaCl

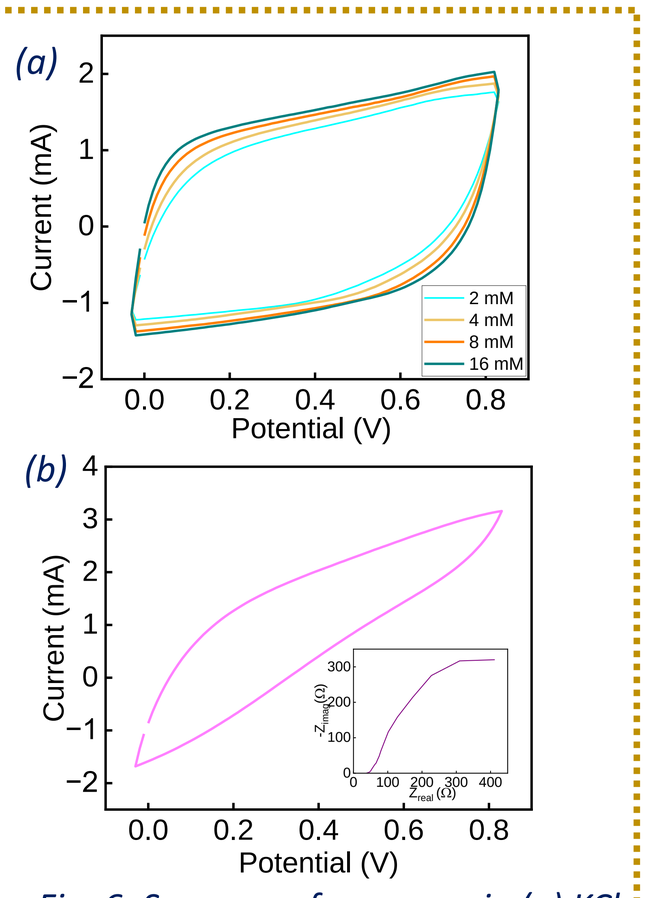

Fig. 6: Sensor performances in (a) KCl and (b) artificial sweat solutions

Conclusion and future

- The sensor shows stable performances in NaCl, KCl and artificial sweat solutions.
- Sensitivity of the fabricated textile supercapacitive Na ion sensor is 2.05 mF/ log [Na^+] for the range of 2- 16 mM NaCl
- Need to integrate with electronics circuit for online self-powered sensing applications for wearables

References

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