Journal Pre-proof

Hierarchical Carbon Nanotube-Decorated Polyacrylonitrile Smart Textiles for Wearable Biomonitoring

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Hierarchical Carbon Nanotube-

Respiratory monitoring carries vital information about the breathing functionality and" a 1 ʽ

biomonitoring.

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The Multi-walled carbon nanotube DMF dispersion (1.5 wt%) was purchased from Chengdu Organic Chemistry Co., Ltd. (China). The PAN (25014-41-9) was purchased from Wuhan Kermit Biomedical Technology Co., Ltd. (China). N, N- dimethylformamide (DMF), acetone, and nanosilver conductive ink (N196405) were purchased from Aladdin (Shanghai, China). Mechanical anemometer and hairdryer purchased from BOE. All the chemicals were used as received without further purification.

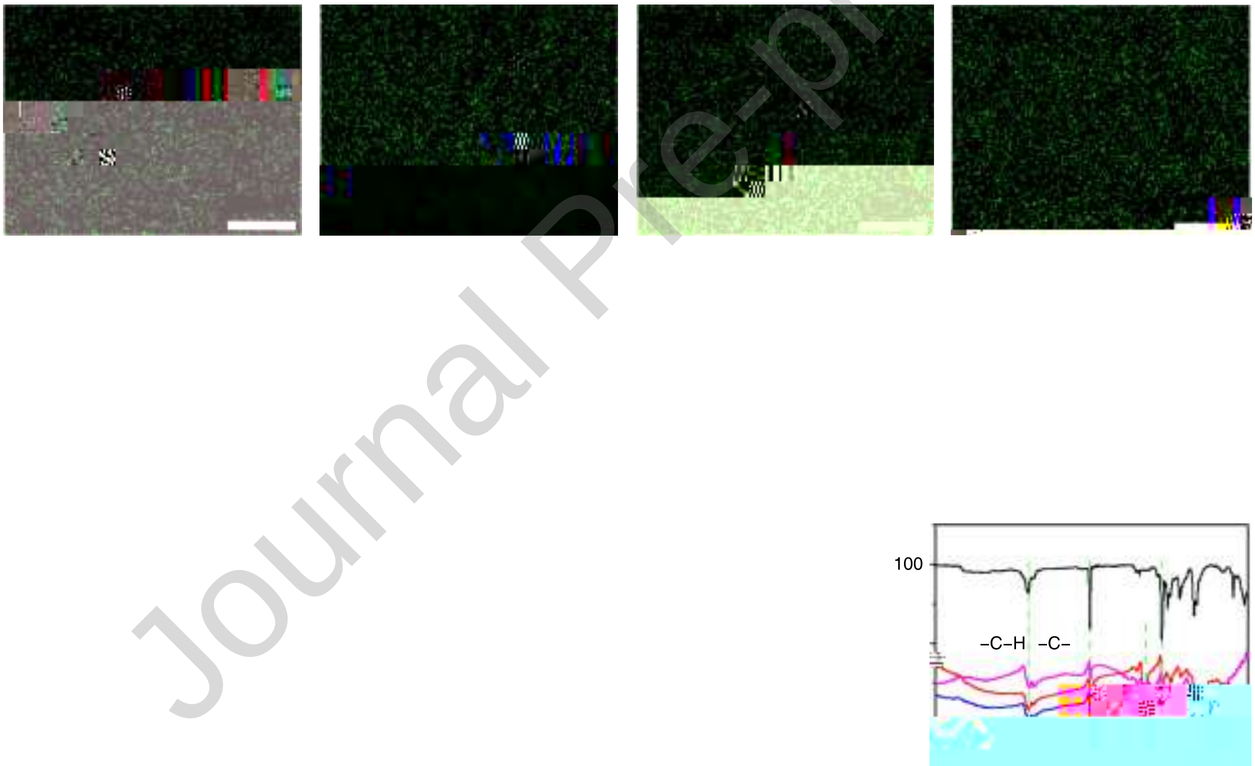

Figure 2. Characterisation of PCMs. (a) Scanning electron microscope (SEM) image of PAN spun membrane with an electrostatic spinning rate of 5 μL/min. (b-d) SEM image of PCMs synthesized with an electrostatic spinning rate of 5 μL/min and an electrostatic spraying rate of 2 μL/min (b), 4 μL/min (c), 6 μL/min (d). (e) Cross-section of PCM in (d). (f) Elemental carbon and nitrogen scans were performed on PCMs prepared at electrostatic spraying rates of 0, 2, 4 and 6 μl/min. (g) Mass ratios of carbon to nitrogen for PCMs produced at electrostatic spray rates of 0, 2, 4 and 6 μl/min. (h) EDS mapping of PCMs fabricated with an electrostatic spraying rate of 0, 2, 4 and 6 μL/min. (i) FTIR of PCMs fabricated with an electrostatic spraying rate of 0, 2, 4 and 6 μL/min.

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μL/min demonstrate superior sensitivity in comparison with other versions (Fig. 3h). This is because that the sparse CNTs cannot build up compact piezoresistive conducting network (Fig. 2b) while the excessive CNTs screen the relative resistance change under a constant applied force (Figs. 2d and e). To ensure the optimal sensing performance, the following measurement was conducted using the sensor based with an electrostatic spraying rate of 4 μL/min.

Figure 3i and Figure s2 shows the dependence of sensing response of PCM-based devices on the widthdevice to rapid expiration. (i) Real-time response of the device to deep exhalation.

Figure 4a elucidates the dynamic response of PCM enabled respiratory sensor under impact of exhaled gas flow, where a response time of 193 ms and recovery time of 104 ms was observed, respectively. The rapid response behaviors assure the device to discriminate the real-time breathing characteristics even under rapid respiratory pattern (Fig. 4a). A linear relationship between output current and airflow velocity corroborates the great capability in distinguishing the respiratory traits (Fig. 4b). Moreover, unnoticeable attenuation and distortion of output signals were detected after 600 cycles of loading and unloading of 5 m/s breathing flow, implying the durability and reliability (Fig. 4c). To verify the competence for respiratory monitoring, the PCM based sensor was mounted on a wearable mask to capture the real-time output signal profiles for deep, normal, shallow breathing patterns (Fig. 4d). Note that the respiratory rate and depth can be respectively associated with interval and peak-to-peak intensity of signal waveforms. Evidently, a deep breathing pattern contributes to a larger interval and huger peak-to-peak intensity. As a consequence, the as-prepared PCM based sensor can not only discern breathing rhythms such as normal breathing, deep breathing, kussmaul breathing, pause in breathing, etc., but also identify respiratory dynamics under physiological training (Figs. 4e and 4f) [66-68]. Figures 4g-i display the real-time waveforms towards slow expiration, rapid expiration and deep exhalation. Among these three different simulated respiratory patterns, the intensity and interval of the signal varies distinctly with other versions, confirming capability in discriminating respiratory characteristic.

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Figure 5. Application of the device based on machine learning. (a) Flowchart of machine learning. (b) Classification of respiratory characteristics and possible causes of these respiratory characteristics. (c) Cough monitoring (per minute). (d) Speaking monitoring (per minute). (e) Irregular breathing while running (per minute). (f) Regular breathing while running (per minute).

Failure in perceiving respiratory abnormalities gives rise to complications like diabetes mellitus, hyperglycaemia, cardiovascular disease and retinopathy. To boost the accuracy and fidelity in identifying respiratory r[illegible] lik [illegible]

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