Highly Pressure-Sensitive, Hydrophobic, and Flexible 3D Carbon Nanofiber Networks by Electrospinning for Human Physiological Signals Monitoring

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Abstract

Previously, 3D porous materials have achieved great progress in pressure-sensing or other various applications. For instance, Qin and co-workers fabricated a flexible graphene/polyimide nanocomposite foam with a high pressure sensitivity (0.18kPa^{-1}) for stain sensor application.[1] Another research reported a hierarchical assembly strategy for fabricating nanocomposite foams with lightweight, hydrophobicity, and superinsulating properties.[2]. However, it still remains a challenge to prepare ultrahigh pressure-sensing materials simultaneously owning other versatile characteristics. Herein, an easy-fabricated and cost-efficient preparation has been proposed to fabricate versatile carbon nanofiber aerogels (CNFNs) with superior pressure sensitivity based on modified electrospinning and thermal treatment. 3D floc is directly fabricated by electrospinning, which is different from conventional electrospinning into thin film, and then CNFNs was prepared with the floc through thermal carbonization. To the best of our knowledge, the CNFNs exhibited the highest pressure sensitivity of 1.41 kPa^{-1} compared with similar 3D porous materials. Different from traditional carbonaceous materials with brittle feature [3], the CNFNs preformed robust mechanical properties, excellent flexibility, stable resilience and super compressibility of ＞95%.

Contributing to the stable mechanical and piezoresistive properties of the CNFNs, a pressure sensor is designed with the CNFNs, which is capable in monitoring human physiological signals, such as phonation, pulse, respiration activities of human joints. The three peaks in a pulse waveform correspond to percussion wave (P-wave), tidal wave (T-wave) and diastolic wave (D-wave), respectively, which is assistant information for medical diagnosis. Meanwhile, an arch-array platform for direction identification of tangential forces and an artificial electronic skin bioinspired by human's hairy skin have been ingeniously designed. Besides the high pressure sensitivity, the CNFNs demonstrate other versatile properties as well, concluding ultralight density of 3.6 mg/cm^3, hydrophobicity, a relatively low thermal conductivity (23 mW • m^{-1} • K^{-1}) and infrared emissivity (0.62). Therefore the CNFNs show promising potential in a wide range of applications, such as thermal insulation, infrared stealth and electrodes for supercapacitors, etc.

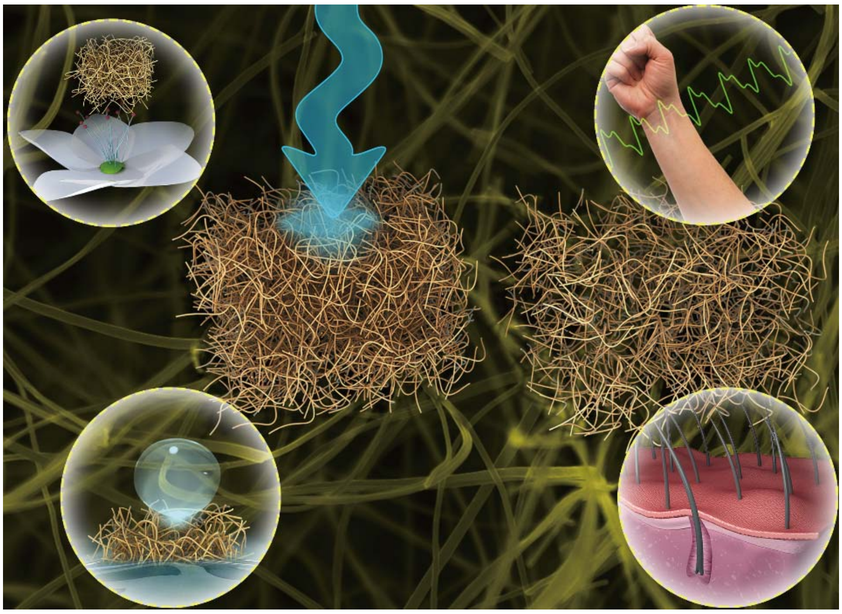

Figure 1: Schematic illustration of the CNFNs with versatile properties.

References

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