3D printing functional CNT-modulated nanoporous membranes for Energy Applications

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A self-standing 3D-printed PLA/sulfur/CNT cathode with high sulfur loading based on a biodegradable low-cost commercial polylectic acid (PLA) as the binding was fabricated via a facile robocasting 3D printing process (Figure 1a). The PLA/sulfur/CNT cathodes with different CNT loadings (3, 5, 7, and 10 wt%), interconnected porosities (10%, 30%, 50%, and 70%) and thicknesses (100, 200 and 300 µm) were 3D printed by utilizing in-house nanoengineered filaments Figure 1b). A nanoporous network of CNTs is developed (Figure 1c). Coin cells were fabricated (inset of Figure 1d) and their electrochemical performance is analyzed. The 3D-printed sulfur/CNT cathode shows excellent electrochemical performance in terms of capacity, cycling stability, and rate retention by facilitating Li+/e- transport at the macro-, micro-, and nano-scale in Li-S batteries. Meanwhile, the areal loading of the sulfur/carbon cathode can be easily controlled by the number of stacking layers during 3D printing process. The Li-S batteries assembled with the 3D-printed sulfur/CNT cathodes with a sulfur-loading of 6 mg cm^{-2} deliver an initial capacity of 1096 mA h g^{-1} (100 µm thick) and high capacity retentions of % within 100 cycles at 0.5 C (Figure 1d). Moreover, cathodes with sulfur-loadings of 11 mg cm−2 (200 µm thick) and 17 mg cm^{-2} (300 µm thick) show lower initial specific discharge capacities of 810 mA h g^{-1} and 542 mA h g^{-1} due to increased thickness. However, the areal capacity of 17 mg cm^{-2} (300 µm thick), 11 mg cm^{-2} (200 µm thick), and 11 mg cm^{-2} (200 µm thick) show areal capacity (at areal current density) of 9.2 (2.84 $mAcm^{-2}$), 8.91(1.84 $mAcm^{-2}$), and 6.5 mAh cm^{-2} (1.0 $mAcm^{-2}$), respectively.

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References

[1] V. Gupta et al, Journal of Power Sources, 494 (2021) 229625.

Figures

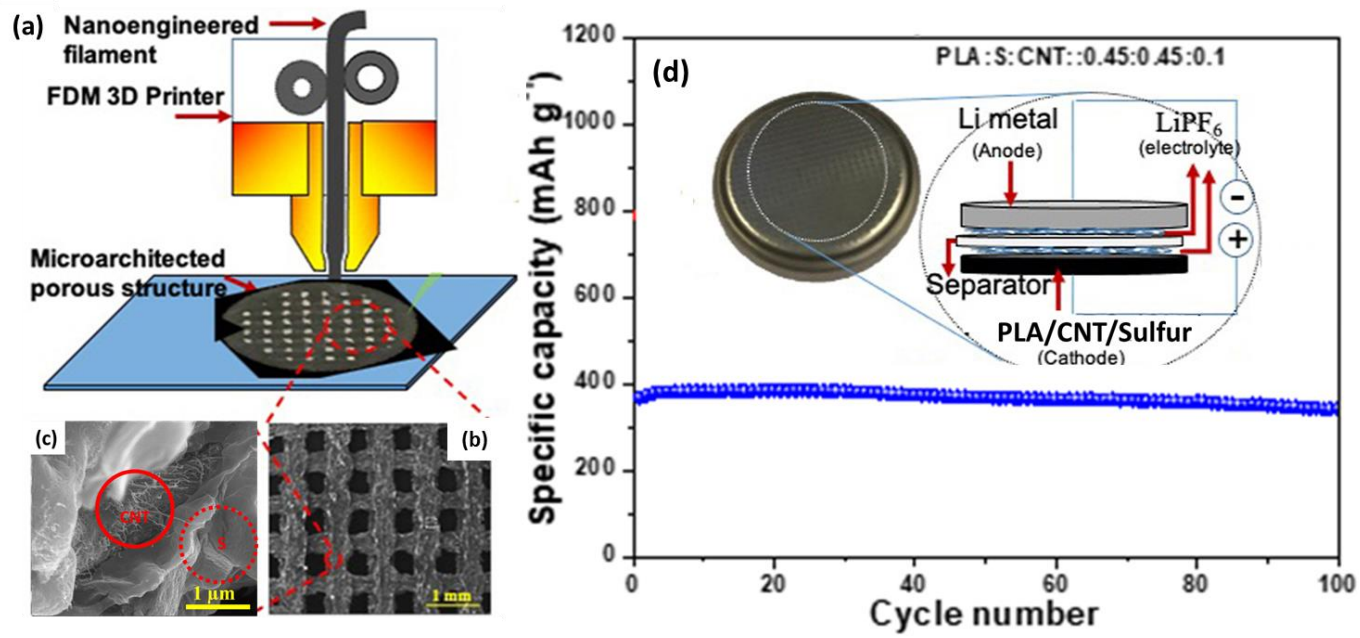

Figure 1: (a) Fabrication of PLA/S/CNT nanocomposite involving solvent casting, filament extrusion, and 3D printing. (b) A 3D printed PLA/S/CNT cellular nanocomposite with 10wt.% CNT loading (100 µm). (c) SEM images of a 3D printed PLA/S/CNT cellular nanocomposites with different 10% CNT loading. (d) Cyclic stability of a 3D printed PLA/S/CNT nanocomposite electrode at 0.5C rate (inset shows the schematics of the coin cell).