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Electrophoretic deposition of TiO_2-CNTs nanocomposite for cathode applications in Li-S batteries

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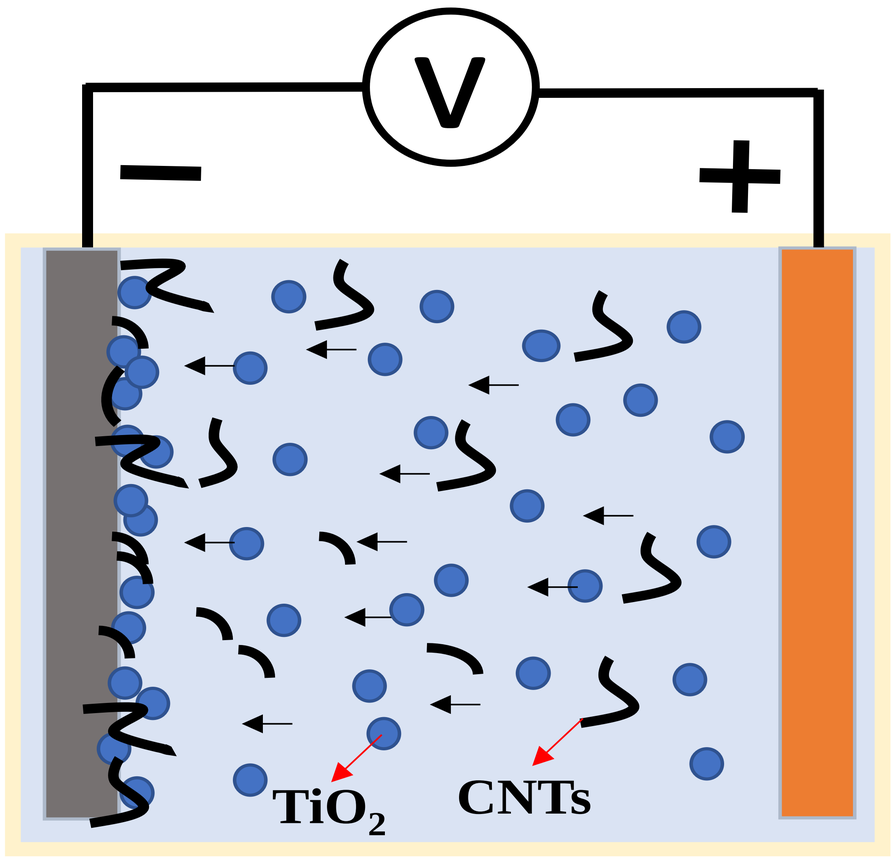
Overview

Over the last few decades, scientific research in the field of lithium-sulfur batteries (LSBs) has been surmounted because of their high theoretical capacity (1675 $mAhg^{-1}$) and energy density (2500 $Whkg^{-1}$). However, its practical application is behind the critical challenge associated with the irreversible dissolution of lithium polysulfide (LPSs) into the electrolyte which causes the shuttle effect. In the present study, titanium dioxide with carbon nanotubes (CNTs-TiO_2) nanocomposite was co-deposited on a carbon fiber paper to trap the long-chain polysulfide effectively. To fabricate the 3D cathode, a layer of CNTs-TiO_2 was deposited using a binder-free electrophoretic deposition (EPD) method. Elemental sulfur impregnation was carried out at 200 ^oC using the vapor-infusion technique. The prepared nano-composite presented outstanding electrochemical performance because of the synergistic effect of conductive CNTs and polar TiO_2. The CNTs-TiO2/S nanocomposite cathode displayed the high initial discharge capacity of 1300 $mAhg^{-1}$ at 0.1C. The sample with 50% CNT showed higher capacity retention over prolonged cycling. The result indicated that the prepared cathode has a high potential for LSB cathode

Experimental

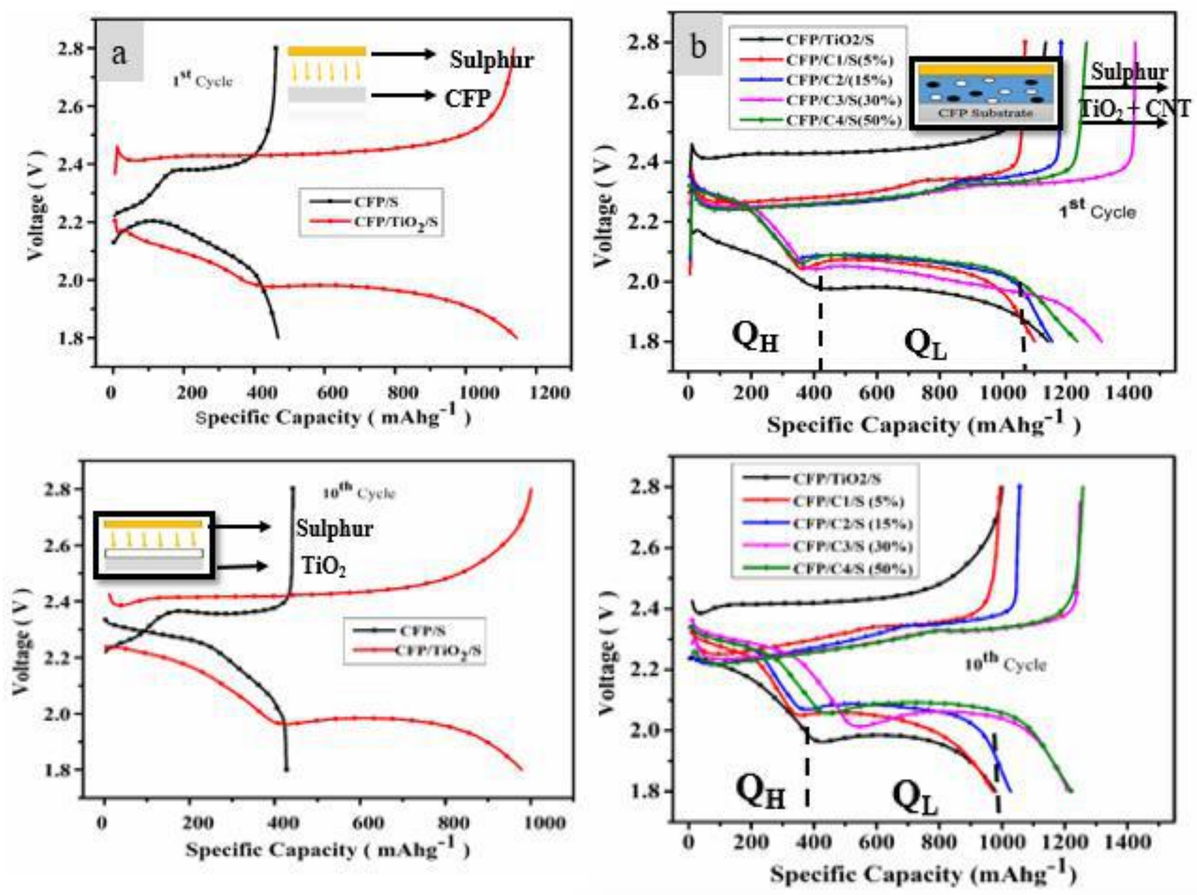
Table.1 Co-deposition of TiO_2-CNTs nanocomposite (TC) on carbon fiber paper substrate using EPD. TiO_2 is fixed (0.1g) .

Sr. No	CNT (Wt.) %	Comp. Areal loading ($mgcm^2$)	Sulfur (mg)	(C+S) wt. (mg)	E (µL)	C/S ratio	C/E ratio	S/A ratio ($mgcm^{-2}$)
C_0	0	0	2.5	2.5	40	0	0	1.42
C_1	0	10.62	2.5	8.5	40	2.4	0.15	1.42
C_2	5	10.62	2.5	8.5	40	2.4	0.15	1.42
C_3	15	10.62	2.5	8.5	40	2.4	0.15	1.42
C_4	30	10.62	2.5	8.5	40	2.4	0.15	1.42
C_5	50	10.62	2.5	8.5	40	2.4	0.15	1.42

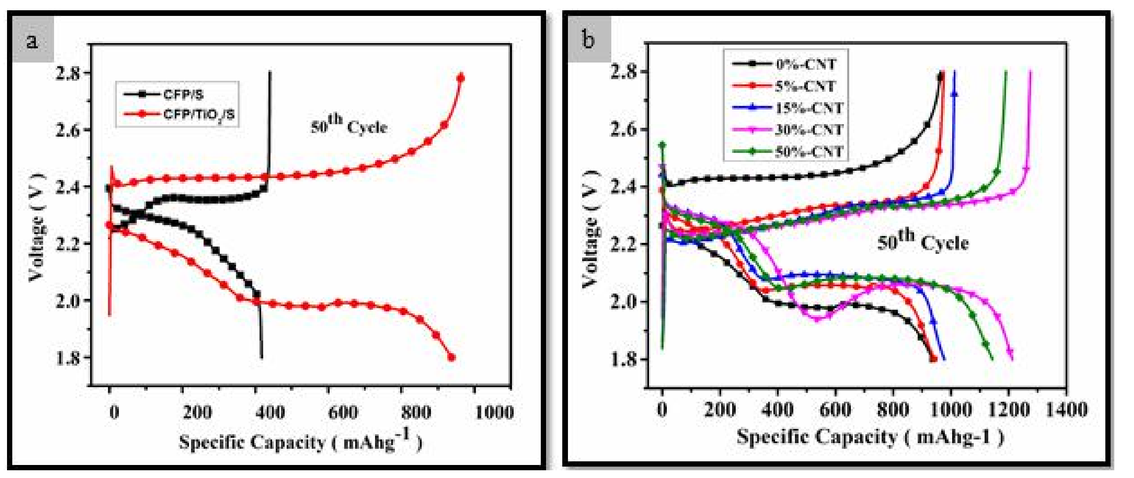


Graphical representation of LSBs mechanism upon discharge/charge with EPD deposition of (TiO_2-CNTs/S) composite on CFPs substrate

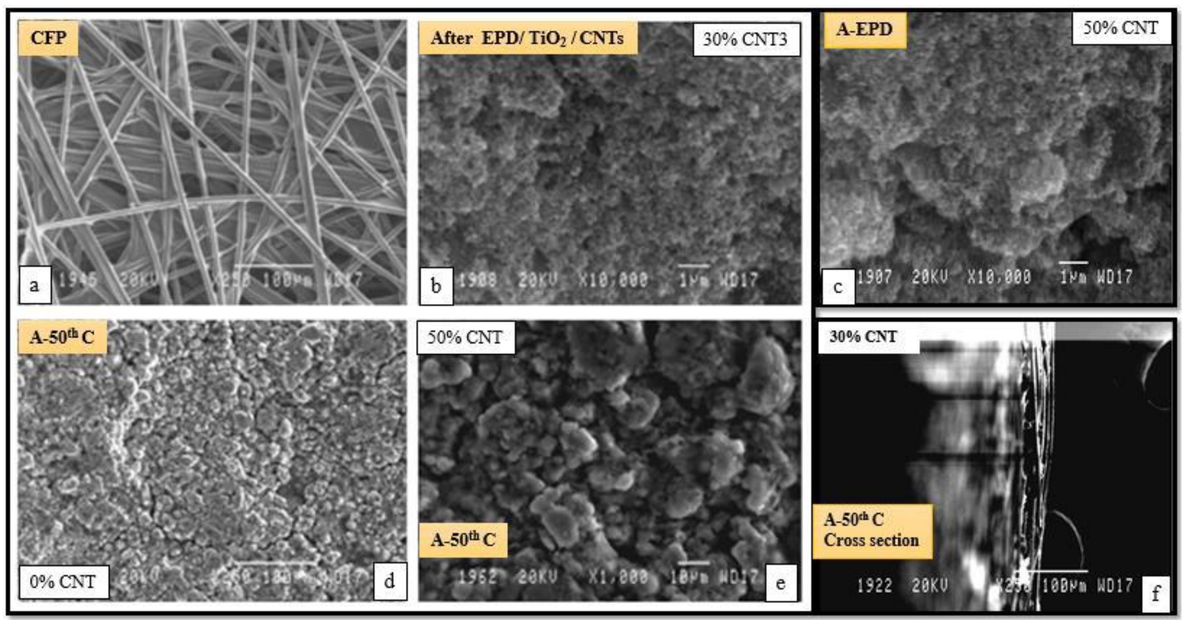
Results



a) cycling output of CFP/S and EPD-CFP/TiO_2/S, b) and EPD-CFP/TiO_2/CNTs/S with CNTs weight ratio (0-50) % for 1st and 10th Cycles.



The charge/discharge profile a) cycling output of CFP/S and EPD-CFP/TiO_2/S, b) and EPD-CFP/TiO_2/CNTs/S with CNTs weight ratio of (0-50) % for 50th Cycles.



SEM images (a-f) before and after EPD until the 50th cycling with cross sectional area of 30% CNTs

Conclusion

Electrophoretic deposition (EPD) technique was successfully employed to deposit various TiO_2-CNTs nanocomposite combinations (0-50%) CNTs on the 3D carbon based composite. The nanocomposite with 30% CNTs addition showed higher initial capacity 1340 $mAhg^{-1}$ and capacity retention 1250 $mAhg^{-1}$ after 50 cycles with no crack formation in the cathode. The result suggested that the prepared nanocomposite trapped the lithium polysulphides successfully because of the polar nature of TiO_2 while CNTs provided conductive pathways for smooth electron flow.

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