The Stabilizing Effect of Carbon Nanotubes in Red Phosphorus Li-Ion Battery Anodes

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Due to increased awareness of the harmful effects of CO_2 emissions, there has been a steady shift towards a more carbon-neutral society. Central to this change is the need to eliminate humanity's reliance on fossil fuels. Hence, an accelerated search for better energy storage systems is taking place with battery research, in particular, focused on alternative anode materials.

Among the countless electrode materials proposed for Li-ion batteries [1], little attention has been given to phosphorus (P). Theoretically, P boasts extremely high gravimetric and volumetric charge capacities (2596 mAh/g and 2266 mAh/cm^3, respectively). This is several times more than those exhibited by graphite (372 mAh/g and 756 mAh/cm^3, respectively), the standard anode material used in commercial batteries [2]. However, its potential for battery applications suffers from poor cycling performance and rate capability, consequence of considerable volume changes during lithiation and delithiation [3].

In this work, we propose to stabilize P-based anodes by mixing amorphous red phosphorus with carbon nanotubes (CNT). The CNT/P composites were synthesized via a sublimation-deposition method that preserves the structure of the nanotubes which act as a filler [4]. Remarkably, upon cycling, the inter-linked phosphorus particles/agglomerates do not undergo the drastic loss of contact with the current collector commonly seen for this anode material (Figure 1). The same synthesis procedure was employed with other nanocarbons and their electrochemical results compared to those of the CNT composite. Overall, a synergetic effect is confirmed, but its magnitude is dependent on the morphology of the nanocarbon filler.

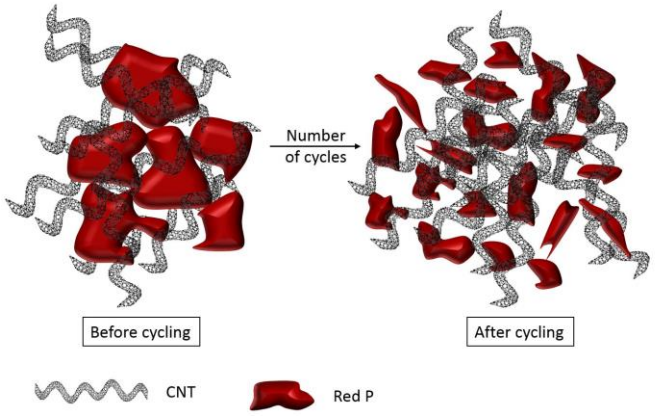

Figure 1: Stabilization of the P anode using carbon nanotubes (CNT)

References

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