Synergistic effect of Ni/TiO_2 heterostructures on performance enhancement of lithium-sulfur batteries

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Lithium-ion batteries (LIBs) opened new opportunities for rapid development of modern portable devices. LIBs use mainly the intercalation cathodes represented by transition metal oxides and phosphates as cathodes, which are incapable of fulfilling the requirements of electric vehicles and high energy storage systems due to their limited energy density (less than 400 W h kg^{-1}). Moreover, intercalation type cathodes have several drawbacks associated with high cost of materials and safety issues which also limit their use in electric vehicles and large-scale power systems. Therefore, implementation of alternative systems with higher specific capacity, energy density and inexpensive sources is required to meet high demands. In this regard, lithium sulfur (Li-S) batteries are considered as one of the most promising energy systems due to high theoretical specific capacity, which results in a theoretical energy density of 2600 Wh kg^{-1}[1]. Moreover, sulfur has low cost, considerably less environmentally impact and abundant resources [2]. However, the implementation of Li-S batteries is hindered due to several drawbacks such as low conductivity of sulfur, complicated redox reactions, shuttle of soluble intermediates (polysulfides, LiPS), dendrite growth on lithium anode and volumetric expansion of cathode upon reduction to Li_2S_2/Li_2S which leads to structural degradation and lower the cycle life of batteries [3].

The shuttle effect can be suppressed via encapsulation of sulfur into carbon matrices, synthesis of conductive sulfur composites with polymers, etc. In our recent works we reported on carbon materials with metal -oxides, -sulfides and -nitrides as sulfur immobilizers exhibiting strong affinity to LiPSs. Despite such strong immobilization effect of metal compounds, the conversion of sulfur to the end products needs to be enhanced by introduction of electrocatalysts. In this work, the synergistic effect of heterostructures with double functions, titanium dioxide as LiPSs immobilizer with Ni nanoparticles as electrocatalysts were prepared and analyzed as an effective sulfur host material.

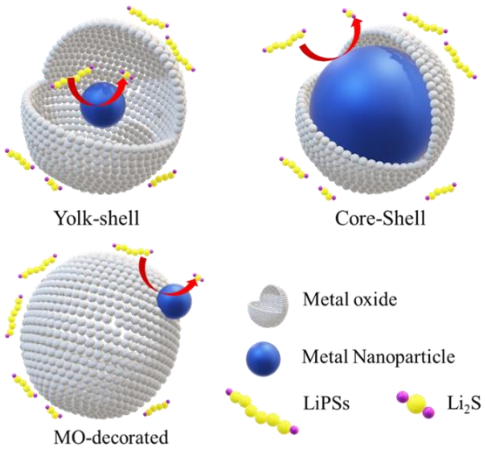

Figure 1. The histogram illustrates the possible structure of Ni-TiO_2 composite compounds.

The present study focuses on the implementation of composite compounds with dual effects on the performance enhancement of Li-S batteries.

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