Synthesis and Study of Composite Aerogels Based on Graphene Oxide and MXene for Lithium-Sulfur Batteries

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Lithium-sulfur (Li-S) batteries have attracted considerable attention due to their high theoretical energy density, low cost, and environmental friendliness. However, their practical application is limited by sulfur's low conductivity and polysulfides' shuttle effect. To overcome these limitations, composite materials have been widely studied.

Graphene oxide (GO) has shown potential in serving as an electrode material due to its exceptional chemical stability and mechanical flexibility. It has the ability to be transformed into a 3D porous aerogel through a hydrothermal process followed by freeze-drying [1].

Recently, a new type of 2D material called MXenes has gained attention for its potential use in energy storage systems. Among the different types of MXenes, those based on titanium have been extensively researched and are being considered hosts for sulfur in Li-S batteries due to their highly polar 2D structure and excellent conductivity. Due to the similarities in their two-dimensional structure, it is highly advantageous to combine $Ti_3C_2T_x$ MXene and rGO in order to create a three-dimensional, porous aerogel with a highly efficient two-dimensional polar adsorption interface.

The fabrication of three-dimensional nitrogen-doped graphene oxide was achieved by combining one-pot hydrothermal assembly and followed a freeze-drying technique [1]. This method applies ethylenediamine (EDA) as a nitrogen source and 3D graphene structural modifier. Mxene was produced via the Wet Chemical Route which uses HF to remove "A" layers from the MAX phases[2].

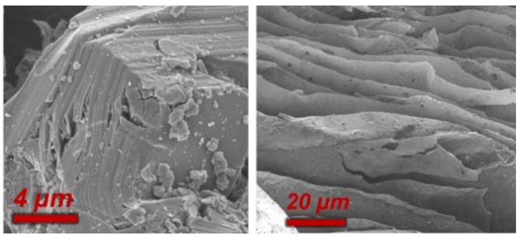

Figure 1. SEM images of Max-phase on the left and Mxene on the right

Mxene@S, rGO@S, and Mxene/rGO@S composites are synthesized and characterized them by SEM, TEM, and XPS. We have successfully removed "A" layers from the MAX phases which are shown in SEM images.

The CR2032 coin-type cells are used for conducting electrochemical measurements. The homogeneous slurry was coated on carbon-coated aluminum foil to prepare a cathode, which consists of synthesized composites mentioned above (80 wt%), conductive acetylene black (10 wt%), and polyvinylidene fluoride binder (10 wt%) all of which are dispersed in N-methyl-2-pyrrolidone. The as-prepared cathode, Mxene/rGO@S exhibited an initial discharge capacity of 918.11 mAh/g and maintained a capacity above 800 mAh/g after the 15th cycle, demonstrating its potential as a promising material for Li-S batteries.

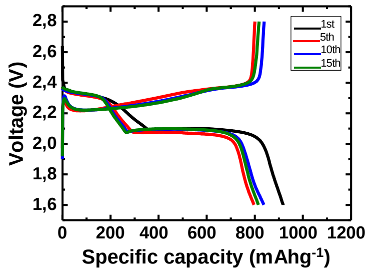

Figure 2. Galvanostatic charge-discharge profiles of Mxene/rGO@S composite (under cycling)

Acknowledgments

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References

[1]Jianjun Song, et. al., Mater. Chem. A, 2019,7, 6507-6513.
[2]Ming, F., Liang, H., Huang, G., Bayhan, Z., & Alshareef, H. N. (2020). Advanced Materials 2020, 2004039.

Mukhammed Kenzhebek, young researcher. He completed his master's degree at L. N. Gumilev Eurasian National University (ENU) in nuclear physics. He works as a research assistant on a project "Synthesis and Study of Composite Aerogels Based on Graphene Oxide and MXene for Lithium-Sulfur Batteries" at the private institution National Laboratory Astana.

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