Basic Research

Metal Organic Framework Nanosheets Employed as Ion Carriers for Self-Optimized Zinc Anode

Aqueous rechargeable zinc ion batteries are promising in electric grid storage due to their low cost and intrinsic safety. However, the practical implementation is hindered by the poor reversibility of the zinc anode, primarily caused by the chaotic Zn deposition present as dendrite and side reactions.

Recently, a research group led by Prof. YANG Weishen and Dr. ZHU Kaiyue from the Dalian Institute of Chemical Physics (DICP) of the Chinese Academy of Sciences (CAS) has proposed a strategy of "ino carriers" by importing macromolecular Zn^{2+} carriers with a large mass-to-charge ratio to decouple the ion flux from the inhomogeneous electric field and substrate. This strategy provided an efficient pathway to overcome the dendrite and side reaction problems.

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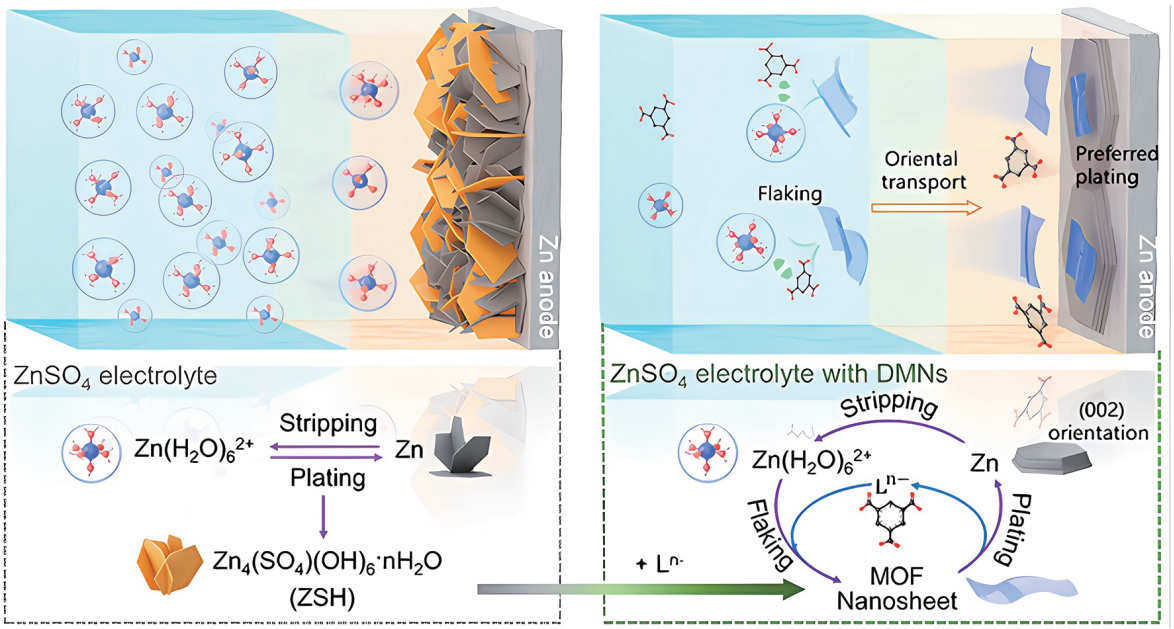
The researchers found that metal organic framework (MOF) nanosheets featuring migration capability under an electric field due to their one-dimensional (1D) channel structure and preferential Zn^{2+} adsorption, as well as unique reductive chemistry due to the weak coordination between ligands and zinc ions, enabling them to serve as dynamic Zn^{2+} ion carriers.



By harnessing dynamic MOF nanosheets, zinc anodes underwent a remarkable self-optimization process, resulting in the creation of a highly desirable surface with an unprecedented (002) orientation that is entirely free from any undesirable byproducts (Image by ZHU Kaiyue)

The dynamic MOF nanosheets could continually optimize the zinc anode during cycling. Specifically, the zinc electrode was gradually reconstructed towards a horizontally aligned lamellae-like morphology and enhanced (002) texture, showing a relative texture coefficient of 96.9 (maximum value of 100). This optimization of the morphology and texture could be attributed to the horizontal alignment of Zn^{2+} ions by the constraints of the MOF nanosheets.

Additionally, the presence of MOF ligands contributed to the elimination of undesirable $Zn_4SO_4(OH)_6{\cdot}4H_2O$ byproducts. These byproducts were spontaneously converted into useful MOF nanosheets through the unique properties of ligands. Consequently, Zn||Zn symmetric cells and Zn||$(NH_4)_2V_{10}O_{25}{\cdot}8H_2O$ full cells employing MOF nanosheets in electrolytes exhibited outstanding cycling performance at both low and high rates.

"The versatility of the 'ion carrier' holds promise for potential expansion into achieving highly reversible cycling in other rechargeable metal cells, owing to its broad applicability to various ligands, substrates and electrolytes," said Prof. YANG.

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Reference

Yang, Hanmiao, Zhu, Kaiyue, Xie, Weili, Zhang, Liming, Jiang, Weikang, Li, Weijian, . . . Yang, Weishen. (2023). MOF nanosheets as ion carriers for self-optimized zinc anodes. *Energy & Environmental Science*. doi:10.1039/D3EE01747H