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MXene Coating for High Capacity Anode Free Lithium Battery

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Li metal as anode material in Lithium-ion batteries is attractive as it has several advantages such as higher theoretical capacity, volumetric and gravimetric energy density compared to the conventional graphite anodes. This has lead to very intensive global research activity in the development of lithium metal batteries. The work reported in the paper published in *Advanced Functional Materials*[1] is an important development in the attempt to realise Anode-Free Lithium-Metal Batteries (AFLMB), which offer the advantages of lower mass, higher energy density, and a simplified electrode design. However, unlike the lithium-metal batteries, AFLMBs initially contain no lithium-metal anode, but only bare copper being present as a current collector. In the beginning, the lithium ions are extracted from the cathode, transported through the electrolyte, and deposited onto the copper current collector. This deposited lithium subsequently functions as the anode.

Conventional lithium-ion batteries contain excess lithium in the negative electrode, which can partially compensate for lithium consumed by side reactions. In anode-free cells, however, the lithium is limited to the amount initially present in the cathode. Consequently, even a small amount of inactive or irreversibly consumed lithium can cause substantial capacity loss. In addition, the Surface defects, roughness, and local variations in current density can promote mossy, porous, dendritic, or electrically isolated lithium growth. The challenge therefore lies in getting a uniform coating of Li on copper surface.

A freshly deposited lithium reacts strongly with the electrolyte and forms a solid electrolyte interphase, commonly called the SEI. A thin and stable SEI is beneficial because it protects the lithium surface while allowing lithium ions to pass through. In contrast, an irregular or mechanically unstable SEI can crack during cycling, expose fresh lithium to the electrolyte, increase interfacial resistance, and promote the formation of so-called 'dead lithium'. These effects are particularly damaging in anode-free cells because there is no excess lithium to compensate for the losses.

The work discussed here addresses these problems by combining a three-dimensional nanotubular copper current collector with an ultrathin coating of titanium carbide MXene. MXenes are two-dimensional transition-metal carbides, nitrides, or carbonitrides with surface terminations such as –O, –OH, and –F. The nanotubular copper architecture provides a high-surface-area framework for lithium deposition, while the MXene coating modifies the chemical and electrochemical properties of the interface. Together, these features can reduce local current-density concentrations, promote more uniform lithium deposition, and improve the mechanical and electrical stability of the deposited layer.

According to the experimental and computational results, the functionalized MXene surface interacts with hexafluorophosphate anions in the electrolyte. The authors attribute this interfacial interaction to influence the decomposition chemistry of fluorine-containing

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electrolyte species, Lithium Hexafluoro Phosphate ($LiPF_6^-$) and favour the formation of a LiF-rich SEI. LiF is electronically insulating and mechanically robust and when incorporated into a thin and well-distributed composite SEI, it can limit electron transfer to the electrolyte, suppress further electrolyte decomposition, and help to regulate lithium-ion transport across the interface.

The proposed mechanism was investigated using characterization techniques including SEM, TEM, XPS, and ToF-SIMS, together with computational calculations. These results provide evidence that the nanotubular copper/MXene structure modifies both the morphology of lithium deposition and the chemistry of the interphase.

The electrochemical results also demonstrate the advantages of the design. In anode-free full cells using an NCM811 cathode and a concentrated electrolyte, the MXene-coated nanotubular copper electrode delivered approximately 78 mAh g^{-1} after 125 cycles, with a Coulombic efficiency close to 99%. This is a significant capacity enhancement compared to the bare copper current collector which showed a value of about 45 mAh g^{-1}. In lithium-plating and stripping tests, the coated electrode operated for approximately 746 cycles, whereas the bare copper electrode experienced a short circuit near the 133rd cycle. The authors also demonstrated the feasibility of the approach in a larger pouch-cell configuration.

The main significance of the work is that it regulates the electrode–electrolyte interface without requiring a change to the bulk electrolyte formulation. Nevertheless, challenges remain before commercial application, including the reproducibility of the nanotubular structure and coating, manufacturing scale-up, mechanical stability during extended cycling, electrolyte compatibility, and validation under practically relevant conditions.

Overall, the work presents a promising strategy for improving the stability of anode-free lithium-metal batteries by modifying the current collector surface.

Reference

1. Kim E, Jung H, Kim J, Chang S-J, Kim G, Park,YC, Seo YK, Park KJ, Choi S, Seo K, Han H, Cho S-H, Ahn CW, Nguyen VT, Shin H, Lim M, Jung H-T, Lee Y, Lee J. anion-interactive anode interfaces for stable anode-free lithium metal batteries. Adv Funct Mater. 2026; 36(80):e77931. https://doi.org/10.1002/adfm.77931