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MXene//MnO_2 Asymmetric Supercapacitors with High Voltages and High Energy Densities

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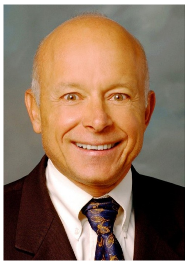


Michel W. Barsoum

Invited for this month's cover picture is the work of Prof. Rosen's and Prof. Barsoum's groups at Linköping and Drexel Universities. The cover picture shows two typical cross-sectional images of TMA^+-MnO_2 and $Mo_{1.33}CT_z$ free-standing films, with highly stacked flakes, exhibiting excellent flexibility and high volumetric capacitances. Micrographs taken by Dr. W. Zeng and colorized and aesthetically enhanced by Patricia Lyons of Moorestown, NJ. Read the full text of the Research Article at 10.1002/batt.202200151.

What is the most significant result of this study?

The most significant result of this study is that MnO_2 flakes fabricated using a facile, inexpensive, highly scalable process possess excellent electrochemical characteristics. Specifically, we converted Mn_3O_4 powders into 2D TMA^+ intercalated MnO_2 birnessite flakes by simply heating Mn_3O_4 powders in 25 wt.% TMAH aqueous solution at 80 °C for 2 days. The resulting flakes demonstrated electrocatalytic activities for reversible O_2 reactions that are comparable with Pt/C electrodes. As shown here, they also perform well as supercapacitor electrodes.

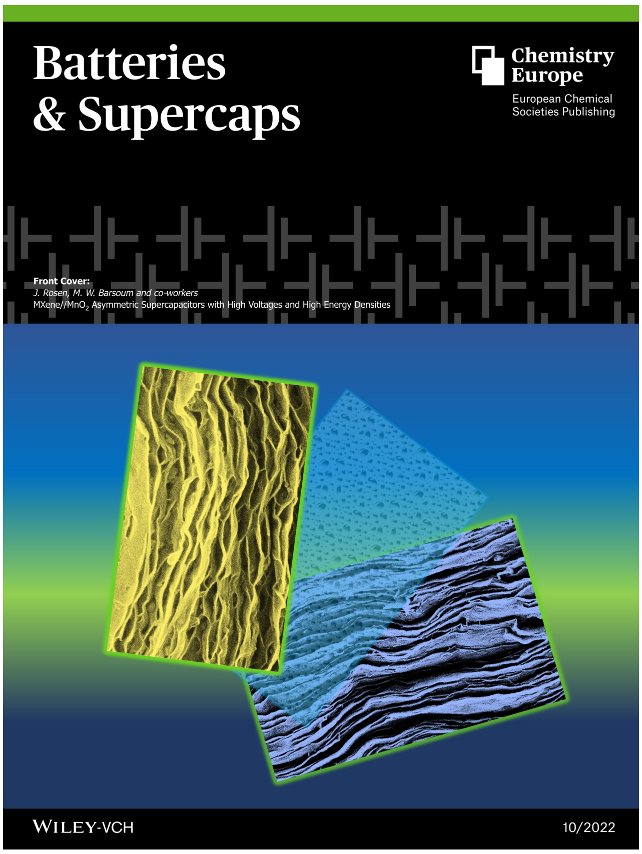
When coupled with $Mo_{1.33}CT_z$ MXene free-standing films, our $Mo_{1.33}CT_z$(-)//TMA^+-MnO_2(+) aqueous asymmetric supercapacitors (AASCs) with the resulting voltage, 2.5 V, in a highly concentrated (21 mol kg^{-1}) LiTFSI electrolyte as far as we are aware, is the *highest voltage ever reported for MXene-based aqueous SCs to date*. This AASC, in turn, results in high energy and power densities (86.5 Wh L^{-1} at 2 mV s^{-1} and 10.3 kW L at 1000 mV s^{-1}). It is noteworthy that our energy density is approaching 100 Wh L^{-1}, with excellent cyclability, which is significant to address the "space anxiety" for SCs.

What was the inspiration for this cover design?

This cover contains two cross-sectional images of TMA^+-MnO_2 and $Mo_{1.33}CT_z$ film electrodes. Both exhibit highly stacked nanoflakes. Even without binders or additives, high volumetric capacitances and high energy densities were obtained.

How did the collaboration on this project start?

This is a collaboration among Linköping University (Sweden), Drexel University (US) and Southeast University (China). The first report about the MnO_2 two-dimensional (2D) birnessite is



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by Hussein O. Badr in Prof. Barsoum's group at Drexel University. It was found that these 2D flakes have good electrochemical performance. So, we collaborated and constructed $Mo_{1.33}CT_z(-)//TMA^+-MnO_2(+)$ aqueous asymmetric supercapacitors (AASCs) that achieved high energy densities.

Is your current research mainly curiosity driven (fundamental) or rather applied?

It is an interesting story. Processes to fabricate one-dimensional (1D) and 2D materials that are readily scalable, cost-effective, and eco-friendly are important from both scientific and industrial viewpoints. Recently the Barsoum group discovered such a process wherein cheap compounds are converted to 1D and 2D materials under quite mild conditions. The first paper on Ti-based materials was published in *Materials Today*. A second paper on the fabrication of 2D MnO_2 birnessite flakes by simply heating Mn-based powders in an organic salt at 80 °C for 2–4 days was also just published in *Matter*. In this paper, we show one application for these 2D materials. The combination of good electrochemical properties with ease and low-cost manufacturing may very well lead to commercial applications.