Comparing Metal-Organic Batteries With Lithium, Aluminum and Zinc, Using Bioderived Organic Molecules for More Sustainable Batteries

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Today, the world is transitioning from fossil fuels to renewables, necessitating energy storage due to the intermittent nature of these new sources. To address this issue, we turned to nature, utilising two bioderived materials: the natural dye alizarin and one of the forms of vitamin K, menadione, to fabricate organic cathodes. Their high theoretical capacities could offer a viable alternative to lithium-ion batteries containing rare lithium and environmentally hazardous cobalt. Firstly, we prepared cathodes from 4 and 8 mg of active materials, conductive carbon, and polytetrafluoroethylene. Organic materials can host various ions, so in addition to lithium, we explored combinations with more abundant metals, such as aluminum and zinc, the latter also enabling the use of aqueous electrolytes, which improves safety and simplifies battery handling. Electrochemical properties such as capacity and voltage were evaluated using galvanostatic charge-discharge methods. The voltages of the electrochemical cells followed the order of metals in the redox series, with lithium having the highest voltage and zinc cells the lowest. Cathodes with alizarin and those with a higher mass of active material offered higher capacity. The best-performing cathodes achieved initial capacities of up to 0.6 mAh per square centimetre. Organic cathodes show great promise, and further research could lead to their commercialisation. Future studies aim to maximise material utilisation through electrode design and stabilise the capacity retention of active materials. This could be achieved through utilisation of new electrolytes with lower solubility of active materials or preparation of insoluble compounds based on these active groups.