

Organic Potassium Batteries to Face K-ion Challenges

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Our world is grappling with an energy transition vital for planet survival. For this reason, Li-ion batteries (LIBs) have reached unprecedented attention from the research community and the global market. Nonetheless, lithium scarcity prevents LIBs from covering the entire demand of storage at global scale. As a result, potassium-ion batteries (PIBs) are strongly emerging as a viable technology for stationary storage and large-scale production for its features: abundancy, low costs, the closest redox potential to Li, the smallest Stokes radius, and compatibility with aluminium current collector at every voltage. Nonetheless, desolvated K-ions show the biggest radius, arising some challenges: once intercalated in rigid inorganic electrode material structures, K-ion may cause their distortion, resulting in drastic capacity decay, like in commercial graphite and Prussian blue. And yet, the latter two are still the best option as anode and cathode materials to face the bigger K-ion challenge.

From this starting point, our group has focused on possible solutions to address these issues in both anode and cathode, keeping always into account the imperative of lower impact PIBs production since they are meant for the large-scale. Indeed, here we report a highly porous carbon material, prepared from lignin and potassium carbonate, with X-Ray diffraction evidences of no stacking of graphene layers, and thus no limited interlayer volume. Its disordered structure allows the K-ions to insert in the carbonaceous anode without causing any damage to the structure, but instead, upon cycling, they may cause its rearrangement to a structure perfectly suitable for K-ion hosting. This behaviour is electrochemically translated in an increase of capacity for the first cycles and null decay of capacity, the values of which are comparable to commercial carbon blacks.

On the cathode site, in potassium battery field very few satisfying options have been published to now. Organic electrodes are not-critical raw materials-based, cheap, environmentally friendly, tunable, and - above all - their intrinsic mechanical flexibility can lead to the reversible and damage-free accommodation of large sized K-ions, resulting in stable PIB performance. Their biggest drawback is the high solubility in organic solvents. In consideration of this, stable aminoxyl radicals like TEMPO have been investigated to exploit its tunability as functionalized monomer unit to reduce its solubility.

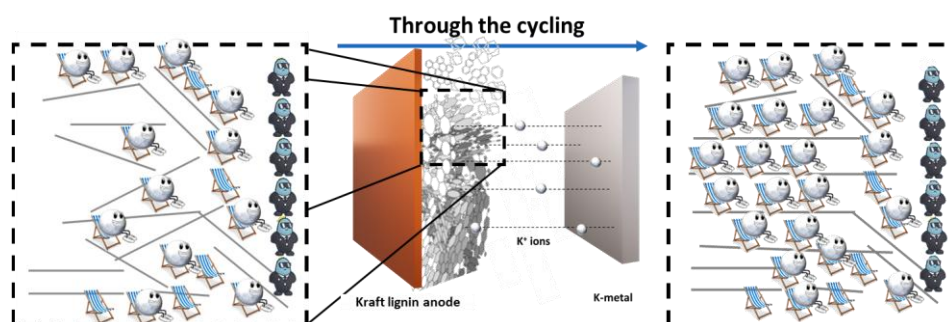


Figure 1: Representation of the rearrangement of the organic anode through the cycling.

References

[1] Trano et al. *Energy Mater.* **2024**, 4, 400008.