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Materials Innovation for Next-Generation Batteries

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Lithium-ion batteries enabled the success of portable electronics and find increasingly application in electric vehicles and in centralized and decentralized stationary storage for the temporal and spatial balancing of energy supply and demand.
We are investigating cathode materials for next-generation lithium-ion batteries. Our research focuses on nickel-rich layered oxides with reduced content of critical cobalt. Increasing the nickel content in layered oxides offers significantly improved lithium storage capacity, but at the price of reduced cycling stability. Employing sacrificial electrolyte additives, we were able to demonstrate a NMC811/graphite full cell with a capacity retention of >90% after 200 cycles.
To improve operational safety and reduced cell production costs, we are also developing concepts to replace the liquid electrolytes based on highly flammable organic solvents in lithium- and sodium-ion batteries by non-flammable aqueous electrolytes. The major disadvantage of water as electrolyte solvent is its intrinsically narrow electrochemical stability window (thermodynamically only 1.23 V) limiting maximum cell voltage and consequently the batteries energy density. We recently discovered an aqueous sodium-ion electrolyte system with a much wider electrochemical stability window of 2.6 V enabling us to demonstrate a $NaTi_2(PO_4)_3$/$Na3(VOPO_4)_2F$ full cell with 85% capacity retention after 500 cycles [1].
We are also developing solid-state electrolytes for all-solid-state batteries based on closoborate salts and recently reported a mixed-anion $Na_4B_{12}H_{12}B_{10}H_{10}$ closoborate phase offering high sodium ion conductivity of 1 mS/cm at room temperature. This achievement further enabled us to assemble an all-solid-state battery with a sodium metal anode and a $NaCrO_2$ cathode delivering a capacity retention of 85% after 250 cycles bringing this class of materials to a technology readiness level comparable to other current all-solid-state battery concepts [2].

References:
[1] Kühnel R.-S., Reber D., Battaglia C., ACS Energy Lett., 2017, 2, 2005.
[2] Duchêne L., Kühnel R.-S., Stilp E., Cuervo Reyes E., Remhof A., Hagemann H., Battaglia C., Energy Environ. Science, 2017, 10, 2609.

CV: Dr. Corsin Battaglia
Corsin Battaglia received his PhD in surface science from the University of Neuchâtel in 2008 and joined EPFL as a postdoc in 2009. From 2012 to 2014, he held a joint postdoc position at the University of California Berkeley and Lawrence Berkeley National Laboratory. Since 2014, he is directing the laboratory Materials for Energy Conversion at Empa, the Swiss Federal Laboratories for Materials Science and Technology. His current research focuses on energy storage technologies, synthesis and processing of electrochemical materials and their integration and performance assessment in batteries and electrolysers.