Sustainable and high-performing materials for next-generation secondary batteries: improving the whole value chain

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Large-scale energy storage systems are becoming fundamental for the modern society, in order to take major advantage from renewable energy sources, such as wind and solar light. Nonetheless, the energy transition requires the implementation of technologies based on abundant and low-cost materials, to satisfy the exponentially increasing market demand and to mitigate the current scarcity of many key and critical materials, such as lithium and transition metals (Co and Ni, primarily).[1]
In this respect, secondary sodium-based batteries may represent the key technology since they possess high-energy density, low-cost, simple design and easiness in maintenance. In this work, different families of cathode and anode materials were tested separately in combination with ionic liquid-based electrolytes in lab-scale Na-metal cells. An overview of the different materials will be given, including high entropy oxides (HEO) and Prussian Blue analogues (PBAs) as cathodes, and carbonaceous materials as anodes. HEO are innovative materials, based on the concept of entropy stabilization, composed of multiple cations within a single-phase crystal structure, while PBAs have attracted wide attention due to low cost, facile synthesis, and appreciable electrochemical performance.[2] On the other side, carbonaceous materials can be obtained from the pyrolysis of waste materials, such as biomasses or disposed face masks, thus repurposing waste materials into high-value applications: all of these waste materials, indeed, are characterized by massive accumulation and heterogeneous composition.[3]
All of these electrode materials were tested in combination with standard electrolytes (based on organic solvents), but also with electrolytes based on room-temperature ionic liquids (RILs), resulting in great advantages in terms of safety, low toxicity and flammability, high electrochemical window and low cost.[4]
Lab-scale Na-metal and Na-ion full cells were fully characterized from an electrochemical point of view by means of electrochemical impedance spectroscopy, cyclic voltammetry and galvanostatic charge/discharge cycling. Materials exhibited stable cycling at relatively high specific capacities, with good coulombic efficiency, stable at above 98% even after prolonged cycling (up to 1000 cycles).
Furthermore, many efforts will be also dedicated in the frame of SUNRISE European project to the recycle of polyvinyl butyral (PVB), which is used as polymeric interlayer into laminated glass for construction and automotive. As a matter of fact, up to now most of the post-consume PVB from laminated glass is incinerated or landfilled, causing the loss of 125000 tons per year. Our goal is to exploit new strategies for the re-use in energy storage application of the fraction of recycled PVB that does not fulfill the optical and mechanical requirements for the reintegration into the original glass manufacturing process. Particularly, the recycled PVB will be used as a binder in the electrode preparation and/or as a separator. In order to be competitive with conventional binders and separators (such as CMC and PP/PE, respectively), the costs of the whole recycling process have been targeted at 10 $/kg for the binder and 60 $/kg for the separator.[5]
In conclusion, the independent optimization of each component of the energy storage systems will thus contribute to improve the whole value chain and foster the broadly coveted energy transition.

Acknowledgments
This work has received funding from the Italian Government (PRIN funding No 2017MCEEY4) and from the European Union's Horizon 2020 R&I program (SUNRISE project, grant agreement No 958243).

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