Beyond Lithium batteries: New materials and Devices

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In last decade, at the global level the energy system has been undergoing a radical metamorphosis towards the development of sustainable methods for energy conversion with a lower environmental impact in comparison with fossil fuels. This prompts the development of suitable energy conversion and storage devices, such as innovative secondary batteries. In this concern, the research on novel nanostructured functional materials is a hot topic in the field of secondary batteries running on alkaline- and alkaline-earth elements able to provide power for a wide range of applications ranging from portable electronic devices to automotive applications.

For more than thirty years, the research laboratory "*Chemistry of the Materials for the Metamorphosis and the Storage of Electrochemical Energy - CheMaMSE*" has been at the forefront of materials design and study for electrochemical energy storage applications. In particular, solid-state polymer-, ceramic-, or heterophasic-based electrolytes for the post-lithium era are currently under vigorous development to enable high-energy density metal anode batteries. In addition, high-temperature, stable ionic liquid-based electrolytes have been recently demonstrated to be a successful choice for application in batteries based on multivalent metals such as magnesium and aluminum. Finally, great efforts are also focused to obtain high-voltage and high-energy cathodes for application in lithium and magnesium batteries.

This report overviews the synthesis and the characterization of innovative families of functional materials meant for *"beyond lithium battery"* applications and opens the way for future research trends in this field. Particular attention will be dedicated to the study of the correlations between composition, nanostructure, coordination and operating mechanism characterizing these materials. The performance of the materials in prototype devices under operating conditions will also be discussed.

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