Efficient and sustainable energy storage technologies are highly desirable to meet ever-increasing energy demands in today's world. To this end, electrochemical energy storage technologies, and in particular rechargeable batteries hold great potential for technological breakthroughs in the field of energy. Lithium-ion batteries are currently the dominant technology, primarily due to their high energy and power densities. However, due to the high potentials required for charging lithium-ion batteries, break-down of volatile and flammable electrolytes and solvents can cause gas release and ignition. Specifically, the growth of lithium dendrites can lead to shorting. Moreover the lithium resources on earth can only sustain consumption for another 55 years at an average annual growth rate of 5%. Thus, the development of new rechargeable more safety and lower cost battery systems are therefore needed and could fuel various energy applications, from consumer electronics to grid storage.

The overall aim of the research proposal is to develop new two dimensional redox active covalent organic frameworks and explore in depth and in broad context electrochemical performance as aluminum and zinc ions rechargeable batteries as shown on Fig.1. The novel storage energy devices will be made with organic 2D COFs consisting of abundant light elements (C,O,N,S) as cathode, safer and lower cost anodes, and non-volatile and non-flammable electrolytes, which is sustainable and support the framework of green chemistry for obtaining "clean energy". Presented project is therefore targeted at developing a solid knowledge on the use of the principles of nanoscience in tuning the properties of 2D COFs through their controlled synthesis and modification (to obtain conjugated covalent organic frameworks) with well designed moelcular systems, which allow to impart to 2D COFs a multifunctional nature, to fabricate prototypes and devices for energy storage applications.

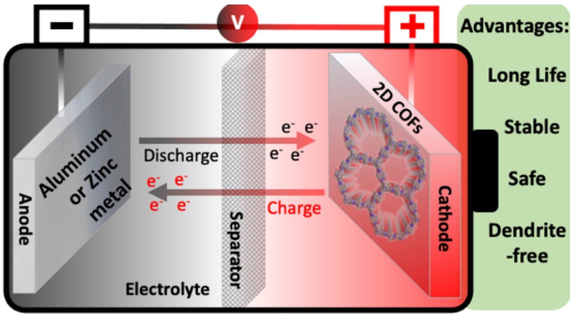

Fig.1 Schematic representation of the project.

While construction of novel redox-active COFs is still necessary to expand the family of porous 2D materials, exploring their applications is important to push the research field forward for practical uses. Noteworthy, the metal-free 2D COFs based electrodes show environmental and economic benefits of low toxicity, sustainability and easy processability.

Within the project, the following objectives will be realized:

- establishing efficient and realiable methods for synthesis 2D COFs in green, facile and cost-effective approaches
- determination of the structure-performance relationship for the construction and characterization of sustainable Al and Zn ions batteries across different metrics i.e. energy density and cycling stability.
- investigation of the mechanism of 2D COFs cathode degradation during electrochemical operation.

The project hypothesis includes the proper selection, design and modification of redox active units embedded within covalent organic frameworks will allow to obtain new, highly performing conjugated 2D materials with pre-designed energy storage properties. The use of such complex materials as cathodes in Al and Zn ion rechargeable batteries will yield in cell-level energy densities >100 Wh/kg and >90% capacity retention after 1000 cycles.