The research aim. The proposal aims to find sorbents for selectively capturing such transition metal ions as cobalt, nickel and manganese. For the first time, ionic covalent organic frameworks(ICOFs) are used to build selective electrodes for capacitive desalination (CDI) systems.

Why do we need to do it? The problem in the fractionation of Li, Co, Ni and Mn is related to their similar ionic radius sizes and similar precipitation condition, which prevents one-step separation of the selected metal ion. Conventional separation of TMI, like liquid-liquid extraction and ion-exchange resins, requires long-lasting operations and high-concentrated acids. Hence, searching for innovative materials for transition metal recovery is the hot point of designing a new separation method. It seems ICOFs are such perspective sorbents.

How to fix this problem? The new approach for separating transition metal ions combines the conventional capacitive deionization with dedicated ionic covalent-organic framework materials that selectively fractionate the Li, Co, Ni and Mn aqueous mixtures. The cell layouts of ICOF-CDI are presented in *Figure 1*.

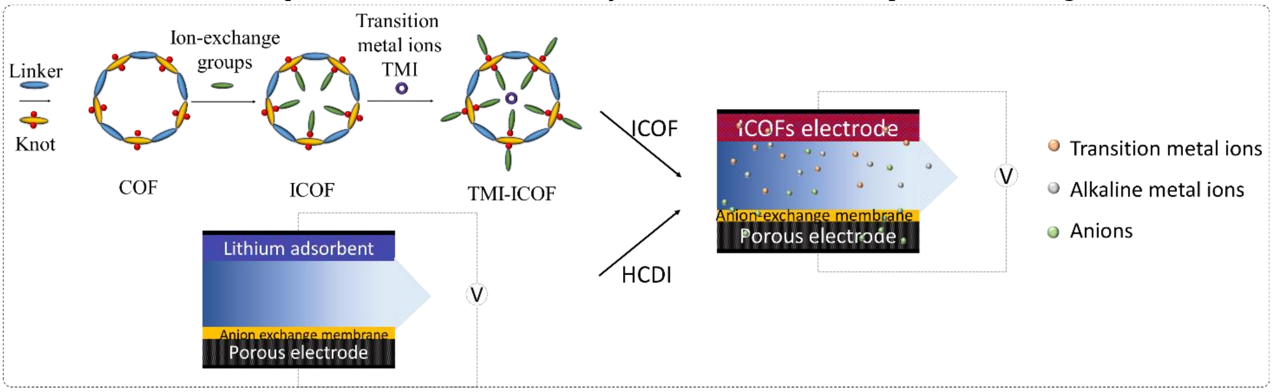

Figure 1. Innovative Ionic Covalent Organic Frameworks Capacitive Deionisation for TMIs capturing and releasing.

The shortage of knowledge. In the ICOFs, four features of crystallinity, stability, functionality, and selectivity play a significant role in developing the best ICOF sorbent dedicated to TMI recovery. Several strategies have been developed, from the selection of synthesis protocols, linkage and knots, and ion exchangers to post-modification paths. Hence**, understanding the above-listed effects on ion complexation, sorbent stability, and electrical potential allows for controlling metal ion fractionation**.

The core of the project. The project refers to finding the optimal configuration and synthesis protocol of ionic covalent-organic frameworks. It is important to note that an essential stage during the synthesis of ICOFs is their design concept which can be achievable by some evidence such as probable direction and particular orientation of covalent bonds between functional groups of the building blocks (knot and linker), linkage types, types of topologies as a result of the various symmetries of the building blocks, and the size of the pores that need to be engineered. **Hence, the central point to escaping this inescapable challenge is understanding the formation principles that govern the synthesis of complex, ordered, stable and selective material, as will be introduced in the electro-processes for transition metal ions fractionation.**

Which kind do we conduct the research? The work plan and research methodology are divided into three main sections: 1. Design and development of ICOFs; 2. Physicochemical and electrochemical analysis, 3. Testing ICOFs in CDI. The design and development of ICOFs are limited to synthesis protocols like hydrothermal, solvothermal and microwaved reaction strategies with selected knots and linkages like amines, imines, imidazoles, Schiff bases, quinolines and ion exchangers. Next, the physicochemical and electrochemical analysis is scheduled to be applied using SEM with EDS, TEM, XPS, XRD, FTIR, 1H NMR, 13C NMR, goniometer, EIS, and CV. The last step is creating ICOF-CDI and evaluating ICOF for separating TMI under an external electric field. Application HR CS AAS ion detection techniques allow us to understand the insertion and de-insertion processes within ICOF crystalline structure.

What do we discover? The project's assumption answers the following queries: of why ICOFs work under an external electrical field, and what makes them selective to the selected transition metal ions? The project results allow us to give answers to this question and correlate the properties of ICOF with selective capturing TMI.

Impact on the scientific field and society. The results give the background for developed environmentally-friendly, zero-waste, net zero carbon dioxide operation, energetically attractive methods of dealing with battery spent effluents. It benefits the inhibition of environmental contamination and provides a new way of rational waste management. Dealing with the problematic separation of Li, Co, Ni, and Mn using a novel type of materials brings benefits to the innovative method of TMI fractionation, enriches material science engineering, and will define the new trend in the separation under the external electrical field.