There are countless ingredients that make up the human body and mind, like all the components that make up me as an individual with my own personality. Sure I have a face and voice to distinguish myself from others, but my thoughts and memories are unique only to me, and I carry a sense of my own destiny. Each of those things are just a small part of it. I collect information to use in my own way. All of that blends to create a mixture that forms me and gives rise to my conscience. I feel confined, only free to expand myself within boundaries.

Ghost in the Shell (1995)

The project is devoted to the determination of the influence of redox pairs on the overpotential of hydrogen evolution reaction (HER) of transition metal chalcogenides (TMDs).

These materials have gained great popularity as electrode materials in electrochemical capacitors (ECs) working in an aqueous environment due to their high specific capacitance. Although, TMDs materials exhibit outstanding catalytic properties towards hydrogen evolution. This dual nature limits their efficient application in ECs and just like Ghost in the Shell main character suffers from [voltage] boundaries.

Therefore, the main aim of the project is to explore strategies for the inhibition of processes responsible for hydrogen evolution.

The primary task is to determine the influence of redox species on the overpotential of hydrogen evolution. Redox pairs will be added in form of ions to the electrolyte as well as in the form of functional groups immobilized on the surface of the material. Their presence will positively affect not only the delay of the water decomposition reaction but also on the increase of the stored charge through additional redox reactions. Another aspect is the possibility to tune the structural properties of the TMDs through hydrothermal synthesis. By controlling the conditions of the reaction i.e. time, temperature, and pressure, we are able to adjust the catalytic properties of the obtained TMDs.

An additional issue is the lack of knowledge in the literature about the mechanism of charge accumulation within TMDs. We can distinguish three basic processes that are assumed to occur: 1) physical adsorption of ions on the surface of materials, 2) surface Faradaic reactions, 3) insertion of ions between the layered structure of TMDs. Therefore, one of the project's additional aims is to conduct in-situ XRD studies that will enable the understanding of these phenomena.

The transversal review of obtained results will allow the formulation and proposal the effective strategies for inhibition hydrogen evolution reactions. Results of these fundamental studies could be further used in ECs operating with TMDs to increase the energy density of the device.