This project deals with the deployment of a new proton conducting material on the potential uses in a variety of electrochemical devices including hydrogen fuel cells which are of special interest because they permit clean and efficient technology for direct conversion from the chemical to electrical energy. A proton exchange membrane, one of a most important part of these devices, allows the transportation of the protons from the anode to the cathode and plays a role of separator between the two electrodes. There is a big challenge to find an appropriate material which can fulfill both functions at the same time. Nafion, today is a most common use polymer as a membrane, but it operates only in hydrated conditions, is relatively expensive, and its production is a challenge.

We search for material which should be inexpensive, easy in production, flexible, solid-state, environmentally friendly, and exhibits high proton conductivity in unhydrated conditions. In this respect, nanocomposites consist of nanocrystalline cellulose functionalized by nitrogen-containing heterocyclic molecules e.g., imidazole is highly interesting. The nanocrystalline cellulose is sustainable nanomaterial, green disposal, recycle at end of life, biodegradable and biocompatible, is characterized by a reduction in weight, high aspect ratio and high surface area, high strength and modulus, high thermal stability, light weight, and opportunities for chemical modification. The heterocyclic molecules are attractive due to their proton donor and acceptor function, the high thermal stability, formation of the hydrogen bonding network similar to that found in the water, and the high degree of self-dissociation, which is beneficial for the proton transfer. They are “dry” conducting species.

The main goals of the project are to develop a new proton conducting nanocomposite of the designed properties, determine and understand an influence of the physicochemical properties of nanocomposites on proton transport, and of its correlation with the conductivity, and to assess their potential use as the solid proton conducting biopolymer electrolytes. To achieve these goals the following studies will be carried out:

- Synthesis, chemical and morphology characterization of the conducting membranes based on nanocrystalline cellulose impregnated by the heterocyclic molecules (such as imidazole and its derivatives)
- Determination of the structural, thermal and dynamic properties of the nanocomposites and their relation to the macroscopic electric conductivity
- Assess the mechanism of proton transfer on the surface of the nanocrystalline cellulose and identify its connection with proton conductivity

The alarming signs of energy shortage are beginning to be noticeable around the world as a result of a continuous increase of the energy consumption in today’s society. In this situation, the development of new proton conducting materials with specific properties for fuel cells application is highly recommended. Fuel cells are an alternative to standard sources of energy. In this respect, an object of study is on current topics of research highlighted for special focus all over the word. The knowledge improving the understanding of the proton transport and its correlation to the mechanism of the proton conductivity is still unique and undoubtedly insufficient in such technologically important materials as nanocomposites. The project results will enhance our understanding of materials relevant to modern science. Moreover, because our composites are based on natural biopolymer such as nanocellulose, thus, if they will be successfully applied as membranes, will contribute towards the protection of the environment and people's health.