Influence of the physicochemical properties of composite of nanocrystalline cellulose doped by imidazole and its derivatives on the proton conductivity

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Introduction

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 will 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.

Research project objectives and methodologies

The main goals of the thesis are to develop the 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.

The realization of the project will start with the synthesis of nanocrystalline/heterocyclic composites followed by their characterization with the aid of a variety of experimental techniques: el*ementary analysis*, *Scanning Electron Microscope*, *thermogravimetric analysis*, *differential scanning calorimetry*, and the following spectroscopy methods: *infrared*, *impedance and solid-state* NMR. The impact of the properties of nanocomposites on their proton conductivity should be reliably determined as a result of combining analysis of the experimental data.