Cellulose-based electrocatalysts for hydrogen and oxygen evolution reaction

With the environmental problem increase and the depletion risk of fossil fuels, there is an urgent need for an efficient, clean and sustainable source of energy, as well as new technology associated with energy conversion and storage. One of the most promising approach to overcome these issue may be the overall electrochemical water splitting to hydrogen and oxygen to produce energy. As a result of using such a power supply, no toxic gases are generated, only energy and water vapor. Hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) are basic reaction of this process. However, commercially used electrocatalyst are based on noble, low earth abundance and expensive metals (e.g. ruthenium, palladium iridium). Therefore there is a need to develop new electrocatalysts based on non-noble metals, which will be cheaper and possess improved electrocatalytic properties.

In recent years intensive works have been conducted to find more sustainable material which could replace commercial electrocatalysts. Much effort have been devoted to investigate transition metal compounds due to their earth-abundance, low cost and good electrical conductivity. Despite that they shows lower electrochemical performance they are subject to structural modifications and structural tailoring to enhance these properties.

In this project, tasks will be undertaken to overcome the above-mentioned problems. First, cellulose as low price and sustainable material will be used to synthetize cellulose nanocrystals (CNC) and cellulose nanofibers (CNF) to produce a platform with a high specific surface area and with increased electrical compatibility for the synthesis of nickel phosphide (NiP_x). NiP_x is a great candidate to be used as efficient electrocatalysts. However, despite its advantages, such as stability or a relatively low value of the overpotential, which is a key parameter determining the ability to electrocatalytically decompose water into oxygen and hydrogen, it is necessary to carry out a number of modifications to improve its properties. Therefore, a few approaches will be taken: (i) incorporation of addition transition metal (e.g. cobalt, iron) to enhance its catalytic activity; (ii) structural engineering, by preparation of one-dimensional nanorods or two-dimensional nanosheets to improve charge transfer ability; (iii) preparation porous NiP_x to improve mass/charge transfer; (iv) anion incorporation to reduce the charge transfer resistance; (v) appropriate matrix preparation to enhance the conductivity and dispersion of catalysts which embedded their performance. All of these modifications will allow to obtain highly active catalysts for electrochemical hydrogen evolution reaction and oxygen evolution reaction. Application of nanocellulose as a platform for synthesis of highly efficient electrocatalysts as well as development of advanced structures of active materials yet still need to be explored.