The scientific goal of the project is synthesis of the new type of hydrogel nanocomposite materials with given properties: electroactive, sensitive to selected environmental parameters and mechanically stable. The aim is that the functional groups introduced into the hydrogel network are capable of reversible redox reactions. The oxidation state of redox groups should significantly affect the properties of hydrogels (change their swelling ratio).

Hydrogels composite are materials that are becoming more and more popular. Nowadays, we can come across with this type of materials both in the laboratory and as articles of everyday use. This is due to their unique properties. Polymer gels are three-dimensional polymer networks containing large amounts of solvent. The most common solvent that fills the network is water, therefore these systems are called hydrogels. The large water content in polymer hydrogels make them similar to soft tissues. A unique property of many polymeric gels is to undergo the volume phase transition under the influence of an external stimulus. During the volume phase transition, gels pass from the swollen- to the shrunken state (or vice versa) and this is related to the absorption or expelling water from the network. The described change in the swelling ratio (change in the solvent content in the network) takes place as a result of changes in environmental parameters, such as temperature, pH, ionic strength and presence of an electric field. The introduction of nanostructures to hydrogels network can give them new properties such as: biodegradability, electroactivity or antibacterial properties.

This project will be focused on obtaining two kinds of the gels: macrogels and thin layers deposited on the electrodes surfaces. Macrogels will be obtained by free radical polymerization method. This method allows to obtain polymer gels of various composition and allows the introduction of additional components during synthesis. In this way, inorganic nanostructures will be introduced into the hydrogel matrix. The obtained hydrogel nanocomposites / hybrid materials will be characterized by improved electrical conductivity and improved mechanical properties. In next step, the redox compounds will be introduced into the gel network. In the case of thin hydrogel layers, electrochemically-induced free radical polymerization will be used to modify the electrode surfaces. This method allows to simultaneously form and attach thin gel layers on regular- and micro-electrode surfaces.

Functionalization of the hydrogel network with suitable groups that undergo oxidation and reduction reactions leads to formation of electroactive polymer gels. The properties of these hydrogels will depend on the oxidation state of the redox groups. For the obtained electroactive hydrogel nanocomposites, it will be investigated how the oxidation state of redox groups affect the swelling ratio, the phase transition temperature and conductivity of gel. The electrochemical and physico-chemical characteristics of the obtained hydrogels will be performed. Obtaining hydrogels with reversible, stable redox systems that change the swelling ratio of the gels will allow to obtain switchable systems controlled both chemically and by changing the applied potential. It is important to obtain materials in which the redox centers can be quickly and efficiently oxidized/reduced, because under such conditions the shrinkage/swelling process will be sufficiently fast. Pivotal for application is that process should be also reversible. The obtained hydrogel materials will also be tested in terms of their self-healing properties. It will be examined how the self-healing properties depend on the swelling ratio of the macrogel and whether it is possible to combine two substrates covered with thin layers of these gels.

Combining of properties such as: electroactivity, elasticity, mechanical strange, biocompatibility and permeability for small molecules in one materials will allow to us them for construction of artificial muscles/tissues, switchable biosensor, ON-OFF electrodes and drug delivery systems. The multifunctionalities that can be found in electroactive nanocomposite hydrogels justifies the research that are the subject of this proposal.