

This project aims to obtain new, advanced hydrogel materials. The research will focus on the functionalization of the polymer network of the gels to get their needed properties. Among those properties are autonomous self-healing, being conductive and biodegradable, and possessing good mechanical properties. It will be important that the obtained hydrogel materials exhibit the mentioned properties under conditions similar to those prevailing in the human body. The goals of this project will be realized through the functionalization of the polymeric materials with natural compounds: derivatives of natural amino acids and polysaccharides. As a result, these hydrogels will be prepared to benefit from autonomous self-healing properties in environmental conditions without any external stimuli. Also, it will be conductive, which could be used as a wearable sensor to monitor the human body movement or other movement objectives.

The polymeric hydrogels are cross-linked hydrophilic polymer networks filled with an aqueous solution. Fluid content in the hydrogels is usually very high. Nevertheless, these materials exhibit properties of liquids and solids. On the macroscopic scale, the gels behave as solid bodies. The tridimensional net is responsible for preserving their actual shape and storage of the mechanical energy, and participates in all deformation processes. In parallel, in the microscale, the gels exhibit properties of liquids: the diffusional transport of small molecules and ions takes place in them. Contrary, larger individuals, polymers, enzymes, and inorganic nanoparticles, can be easily trapped in the polymeric networks. Such hydrogel properties as: absorption of a large amount of water, the threedimensional network that gives specific mechanical properties, thermal and chemical resistance, flexibility, nontoxicity, often biocompatibility, biodegradability, and sorption of heavy metal ions and organic compounds stand behind wide use of the gels in many fields.

In addition to the properties mentioned above of polymer gels, the gels can exhibit other exciting features. By appropriate functionalization of the polymer network, hydrogels can undergo a self-healing, be degradable, conductive and possess good mechanical properties. Recently an increase in interest in the processes related to the self-healing of gel materials has appeared. These phenomena are related to the restoration of broken bonds in a mechanically damaged material or the formation of bonds between different hydrogel networks. Recently a fabrication of soft and flexible hydrogels with electrical conductivity also has got great interest due to their application in sensors, circuits, electronic skin, bioelectronics, and health-monitoring systems. However, despite significant interest in conductive hydrogels, they still have limitations to be used practically. First, they usually do not present rapid self-healing properties and suffer from damages. Second, they do not have good mechanical properties. Importantly, this project will pave the way for the fabrication of new fast self-healing and stretchable hydrogels.

This project aims to address weak mechanical properties by introducing a natural polymer into the hydrogel structure, enhancing the self-healing rate by employing reversible dynamic bonds, enabling conductivity by incorporating charged species, and biodegradability based on the nature of the chemicals. The preparation of new advanced gel materials with the desired properties fits well with the current trends in materials research. Biocompatible hydrogel materials with features such as autonomous self-healing, good conductivity, and mechanical properties gain great interest in medicine, bioengineering, and pharmacy as potential sensors, medical implants, and smart devices. Epidermal strain sensors based on hydrogels are essential devices that can be designed to monitor large physical movements (bend of knees, elbows, fingers, etc.) and minor motions of an esophagus during swallowing, detection of speech, or wrist pulse. Medical applications of the motion sensors are very broad; for example, they can monitor patients in a coma and immediately inform medical personnel about the patient's movement. The innovative nature of planned research is related to the use of natural compounds and their derivatives, such as amino acids and polysaccharides. I hope that the outcome of this project could enable the design and formulation of hydrogel-based materials and devices, inspiring future intelligent systems which will have great potential for various applications.