Hybrid and Elastomeric Polymer Networks: Synthesis, Structure and Properties

Elastomeric polymers derived from non-toxic monomers are important group of materials used in various applications, including medicine. They can serve as biodegradable scaffolds for cells, thus stimulating their proliferation towards new tissue formation/repair/regeneration. Many polymers exhibit such properties, however they usually need to be prefabricated (*via* injection or compression moulding, or 3D printing), and then inserted into living tissue and fixed with sutures or tacks. An alternative process of material preparation (polymerization) *in situ in vivo* is particularly needed, such as by photopolymerization - a photochemically induced process, lasting seconds to minutes. During this process, a monomer, usually liquid, is polymerized into a solid, which becomes an implant or scaffold for tissue regeneration. The possibility to eliminate the implant fixation stage is also greatly needed, as this could shorten procedure times and reduce the risk of complications.

The need for such materials has led to the proposed work on the preparation of novel biomimetic and hybrid elastomeric networks formed upon UV photopolymerization. First, we will synthesize new precursors for networks preparation using non-toxic synthetic/natural origin molecules (fatty acid derivatives, PEGylated fibrinogen and catechol derivative) and non-toxic catalysts (including enzymes). We will characterize their physico-chemical properties, including viscosity which is important for injectability. Importantly, combination of various precursors differing in their intrinsic properties, i.e. hydrophobicity and elasticity of fatty acid long-chains, cellular outgrowth of protein hydrogel, and biomimetic adhesion of catechol functionalities will result in preparation of new materials where all these unique features will be preserved upon UV-LED photopolymerization. Biofunctionality of new materials (adhesion to wet surfaces and cell adhesion) will be investigated with mechanical tests and fluorescence microscopy. Photocrosslinking of new compounds will be assessed with differential photocalorimetry, while degradation of UV-cured hybrid networks will be investigated in hydrolytic and enzymatic conditions (using hydrolases and proteases). Promising biological performance of previously developed hydrophobic and elastomeric UV-cured networks developed in our lab was motivation to design such new elastomeric and amphiphilic, hybrid networks, which to our knowledge, never been synthesized. This pioneering research will produce a new group of polymeric biomaterials featuring elasticity of hydrophobic elastomeric component and cellular outgrowth of protein hydrogel, and it will generate new knowledge on photocrosslinking kinetics, degradation profile, and adhesion mechanism of new materials to wet surfaces (emulating behavior of living organisms, here mussels).

This basic research will yield new knowledge in the field of elastomeric networks featuring amphiphilic character, determining future potential applications. However, one of important potential application field involves polymeric implants delivered through minimally invasive procedures capable of adhering to tissues, e.g. heart tissue after infarct or other discontinuities of soft issues.