Many technology fields face new challenges that require searching for materials with unique properties that can meet special requirements. Thus, in the last years, the rapid development of materials science has been observed. Aerogels are one of the most interesting modern materials, and therefore they attract the attention of scientists, researchers and practitioners alike.

The term “aerogel” comes from the combination of words “aero” (that is – related to air) and “gel”. Gel is defined as soft, solid or solid-like material consisting of two or more components, one of which is a liquid, present in substantial quantity and the second - a three-dimensional cross-linked solid network within this liquid. If we remove the liquid embedded in a 3D solid structure, without damaging this porous skeleton, we can obtain something with outstanding properties – an aerogel. Aerogels are sometimes called “solid mist”, “frozen smoke” or “ghost material”. The reason is its lightness - it is only a few times heavier than the same volume of air. In a vacuum, the solid structure of some aerogels is less dense than the air itself.

Aerogels exhibit exceptional physicochemical properties. Because aerogel is up to 99.8% “empty”, it stands out with low density, large specific surface area, high sorption capacity – moreover, most of its properties are controllable and can be easily adjusted depending on a purpose. These basic features of aerogels result in more complex ones, such as low heat or electric conductivity. Suffice it to say that until 2011, the silica aerogel was in fifteen entries in the Guinness Book of Records for material properties, including the best insulator and the lowest density of solids. This is why a vast number of current and potential applications of these materials arises from in such areas as construction (insulation of buildings and aeroplanes, including windows – thanks to see-through aerogels), environmental protection (sorbents, filters, membranes), bioengineering (tissue scaffolds, biosensors), spacecraft (space-dust collectors) and many others.

Despite having the above-mentioned extraordinary properties, aerogels are not entirely perfect materials. When considering their potential mass production, one find two main disadvantages that limit their practical application. Firstly, since they are composed primarily of air, and their skeletons consist of randomly interconnected particles, aerogels are usually brittle. Secondly, a crucial step for preparing aerogels is the drying process, which replaces the liquid solvent within the pores of the gels with air. In order to preserve their fragile/deformable porous structure, aerogels are usually prepared via supercritical drying, which means conducting the process at very high pressure and temperature, thus making the technology energy-consuming and expensive.

This project aims to overcome both listed above issues by developing double-crosslinked organosilica aerogels. The “double-crosslinking” means that the molecules of precursor – specific “bricks” building the aerogel structure - are linked in two ways. The first kind of link is the silane bond, which is typical for all known silica aerogels. The second kind is the hydrocarbon chain resulting from polymerisation reaction between precursors organic groups containing a double bond. The presence of the second bonds will increase the mechanical resistance of the aerogels and their flexibility. In addition to improving the mechanical properties of the material itself, the latter feature will enable the drying process to be carried out under atmospheric pressure, as the elasticity of the gel form will prevent the structural deterioration that is usually encountered when drying "typical" gels. In turn, this could open the way to aerogels production on a larger scale and, consequently, expand the application of these unusual materials.