Foamed plastics are widely used. Everyone has come into contact with rigid styrofoam packaging or soft mattresses made of polyurethane foams. There are many more applications of foams due to their unique properties: lightness, stiffness or vice versa flexibility, impermeability or absorption, and others. The process of foaming polymeric materials is complex and multi-stage. Generally, it involves the nucleation of gas bubbles in the polymeric material, which then grow due to the expansion of the gas until a cellular structure is formed. Such a structure is stabilized by solidification of the polymer in the walls between the bubbles. The properties of the foam, which determine its application, are influenced by the polymeric material used, but also by the thickness and continuity of the walls between the bubbles. Although many foaming methods and technologies have been developed, the knowledge of foaming is to large extent empirical. The methods and principles for foaming of one polymer may not be applicable to another. This applies in particular to polymer nanocomposites, i.e. plastics in which nanoparticles of another material are dispersed. Despite the many advantages of nanocomposite materials, foaming of them is not popular. One can find the statements that nanofillers are "anti-foaming" agents, causing breaking of foam cell walls and deteriorating properties.

The project focuses on developing a process for efficient foaming of polymer nanocomposites. The conditions that should be met by the foamed nanocomposites have been formulated. It should exhibit the so-called strain hardening, which prevents the walls from excessive expansion. It is also necessary to achieve a very good dispersion of nanofiller and adequate adhesion between the components, at the level of Van der Waals forces.

Foaming of three types of nanocomposites: with nano-platelets, montmorillonite and graphene, and two types of all-polymer nanocomposites with polymer nanofibers: 1.) the nanofibers in the polymer matrix will be formed from the added second polymer in-situ while mixing. This process will occur due to deformation of the polymer powder, with disentangled macromolecules, or 2.) due to deformation of the added component in the molten state and its crystallization induced by the polymer flow during mixing. Such nanocomposites were previously developed and studied by us in earlier works. We are certain that they meet the conditions for effective foaming of the material.

Various foaming methods will be used in the research, with the use of infusion the polymer with carbon dioxide under increased pressure and chemical blowing agents. Depressurization or thermal decomposition of the foaming agent will cause the formation of gas bubbles and foaming of the polymer. The studies will concern nanocomposites, in which the matrices will be various polymers, both polyolefins and biodegradable polyesters, as well as polyamides produced from natural resources. The structure and properties of materials will be investigated using various techniques, including electron microscopy, differential scanning calorimetry, X-ray scattering, methods for measuring rheological and mechanical properties, and crystallization, including flow-induced crystallization.

During expansion of gas bubble walls, nanoinclusions: nanofibers and nanoplates, will cause strain hardening and will orient, which will strengthen the walls and strengthen the foams. The nucleation of the bubbles on the nano-inclusions should contribute to better control of the cell structure.

It is expected that the foaming of such nanocomposite materials will lead to better foams with better controlled structure and properties, which will also reduce the polymer contribution in the foams while significantly improving their properties.