With the advancement of technology, the role of materials engineering is increasingly appreciated and has attracted the attention of many researchers around the world. Recently, advanced materials have become a fundamental factor shaping the economic and technical development of societies. The properties of a given material must be tailored to the needs in specific applications. Undoubtedly, materials that deserve considerable attention are aerogels. They belong to highly porous materials (porosity at the level of about 90%), which makes their thermal conductivity coefficient exhibit very low values, thanks to which aerogels are characterized by excellent thermal insulation properties and can compete even with polystyrene. Aerogels can be manufactured from a wide range of materials and their properties can be formulated in any way depending on the target application. Aerogel structures obtained from oxides (e.g.: SiO_2, Al_2O_3, ZrO_2) are characterized by good thermal stability. Semiconductor aerogels such as cadmium sulfide (CdS), zinc sulfide (ZnS), cadmium selenide (CdSe), and cadmium telluride (CdTe) exhibit semiconducting and luminescent properties, and their highly porous structure promotes improved photocatalytic, photovoltaic, and sensing properties. With such properties, these materials are widely used in energy storage, catalyst support, sensing, chemical adsorption, thermal insulation, biomedicine, and shock absorption, supporting the development of industries such as environmental protection, transportation, artificial intelligence, medicine, and construction. In addition to the properties, as well as the potential applications of a given material, it is undoubtedly also important how it is produced, which affects the profitability of using this material in industry. Traditional methods of obtaining aerogels include the "sol-gel" method, which is time-consuming, because apart from standard preparation of the gel solution, post-processing related to giving the desired shape to the aerogel structure is also necessary. At this point, incremental technologies help, i.e. irreplaceable 3D printing. Application of this method for obtaining highly porous aerogel structures allows to eliminate the stage associated with shaping of the final object, as it is given during the printing process. There is no doubt that when choosing a method for synthesizing aerogels, it is worth considering 3D printing techniques, since the elimination of one stage during the obtaining of the material allows to accelerate the process, making the production cheaper. Recent literature highlights the expanding body of research on 3D printing of aerogels, particularly those composed of graphene, graphene oxide (GO), titanium dioxide (TiO_2), and silicon dioxide (SiO_2). These studies underscore the potential of extrusion based 3D printing. Nonetheless, the search for higher precision and resolution in printing has led researchers to explore Digital Light Processing (DLP) as a superior technique for crafting aerogels with intricate microstructures and high surface areas, crucial for applications demanding precise material properties. By leveraging the unique properties of nanoparticles and optimizing their dispersion and interaction within the resin, it is possible to engineer aerogels with tailored porosities that meet or exceed the 90% threshold, which is essential for applications requiring ultralight materials with high surface areas.

The main aim of this project is improving the manufacturing process of aerogel structures employing advanced 3D printing technologies. This project will be based on three main aspects, namely: 1) synthesis of high-performance photoinitiators for initiating cationic or hybrid Photopolymerization, 2) optimization of 3D printing parameters in DLP technology from photocurable resins containing newly synthesized high-performance photoinitiating systems, 3) selection of the most suitable drying method for the obtained aerogel structures. In the first stage of the research, a detailed study of the obtained photoinitiators is planned to understand their spectroscopic, photochemical, photophysical and electrochemical properties. Further stages of the research will focus on 3D printing experiments, as well as on optimization of printing parameters. Subsequent stages will be directly related to aerogel structures (selection of drying method, obtaining porous structure, porosity testing). It is expected that the result of this project will be the development of new compounds for the role of cationic photoinitiators, whose absorption characteristics will be compatible with the emission characteristics of light sources used in DLP printers. In a further stage of research, the newly developed photoinitiators are expected to produce highly porous aerogel structures. The interdisciplinary character of the undertaken research problem will allow to significantly broaden the knowledge of organic chemistry, especially material engineering and photochemistry.

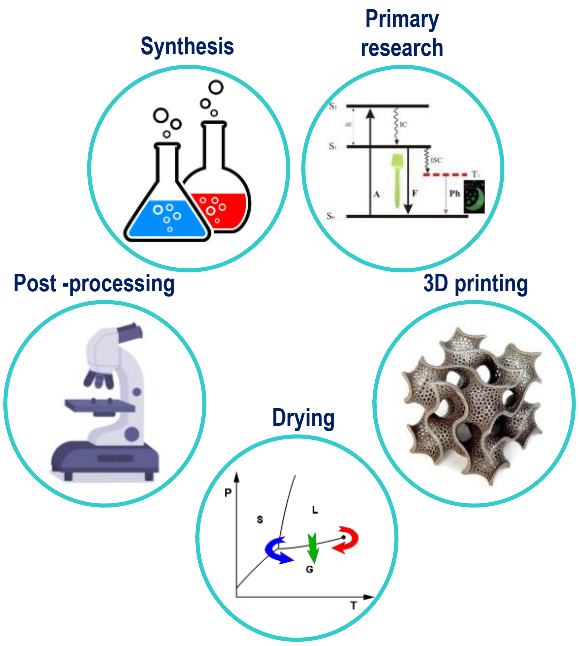

Figure 1. Research plan.