Since the nineties, biomass gasification is gaining relentless attention due to increasing awareness of society in the context of renewable energy and sustainable development. This phenomenon comes from the fact, that biomass is a renewable source that is widely and relatively evenly distributed, it is considered as neutral in terms of CO_2 emission, and most importantly, gasification can be considered as one of the most flexible fuel conversion processes. In fact, gasification can be applied in electricity and heat production, but the most common use of the gasification product – the syngas – is a chemical synthesis of many products, e.g. methanol, ammonia or the wide range of hydrocarbons in the Fischer-Tropsch synthesis. In case of biomass gasification, the important obstacle is the presence of easily condensable tars in the syngas. Moreover, when the synthesis purpose is to consider, additional problems come from the presence of sulfur and nitrogen compounds. The reason for that is that practically all of the synthesis processes require the application of metallic catalysts that are deactivated in the presence of sulfur or nitrogen compounds.

The tar issue is the main reason responsible for suppressing the development of biomass gasification technology. Consequently, the last decades were focused on searching and investigating methods that would allow overcoming this problem. Many researchers put their hopes in plasma methods. These techniques provide a high temperature (such plasma is called a warm one) and the presence of reactive species, e.g. electrons, radicals, ions, and excited molecules. Matching these two properties results in high efficiency of tar compounds conversion that are additionally transformed into valuable syngas compounds – CO and H_2. While the plasma methods are undoubtedly efficient in terms of conversion rate, there are also relatively expensive and requires qualified personnel. Therefore, it is only logical that plasma techniques should be coupled with correspondingly advanced and profitable application of syngas, such as chemical synthesis processes.

The context of matching plasma techniques with chemical synthesis emphasize the issue of the catalyst poisoning by sulfur and nitrogen compounds. Undoubtedly, the same properties of plasma that provide high conversion of tar compounds will affect the transformation of hydrogen sulfide (H_2S) and ammonia (NH_3) – the most abundant sulfur and nitrogen compounds that can be found in the biomass-derived syngas.

In the microwave plasma, two zones can be distinguished – the proper and the after plasma zone. The former one, located at a close distance to the plasma ignition point, can be characterized by a significantly higher temperature and concentration of reactive species than the latter one. Based on that, a hypothesis can be formed that in the proper plasma zone NH_3 and H_2S will mainly decompose into H, N, and S radicals, that on the other hand, will recombine in the after plasma zone. However, due to the presence of other syngas compounds, i.e. CO, CO_2, H_2, CH_4, H_2O, N_2, and hydrocarbons, the recombination may result in the production of COS, CS_2, SO_2, HCN, NO_x and heteroatomic organic compounds. The nature of these products may impact the catalyst poisoning mechanism, its regeneration, and optimization of methods for removal of these impurities.

Therefore, the aim of this project's researches will be to understand the fate of NH_3 and H_2S under microwave plasma treatment in the presence of syngas compounds. To achieve this, the researches will be conducted in the microwave plasma reactor with the use of simulated gaseous mixtures. The main part of the research will be the qualitative and quantitative analyses be the means of gas chromatography techniques. Additionally, optical emission spectroscopy (OES) will be applied to identify particles and molecules present in the proper plasma zone. On the base of collected data, the reaction pathways of sulfur and nitrogen transformation will be proposed. Moreover, the influence of the process conditions on the final products will be determined. The obtained results will be verified by means of chemical kinetics calculations.

The project results could be further used in planning and optimizing all the process that involve plasma treatment of gases that contain H_2S and/or NH_3. While the project is focused on biomass gasification, obtained results could be also beneficial in other areas e.g. valorization of sour natural gas, biogas reforming or decomposition of H_2S and NH_3 for the purpose of hydrogen production – in all of these applications plasma treatment is considered. Moreover, extensive research with MW plasma can generally result in enhancing knowledge about this specific plasma discharge.