Plasma is considered the fourth state of matter, consisting of electrons, ions with various charges, atoms, free radicals, molecules (both in resting and excited states), and UV photons. In recent years, it has gained particular attention from scientists. The temperature of cold plasma is below 60°C, making it suitable for numerous applications. It is now recognized as a potential tool for sterilizing food, water, medical instruments, and packaging materials.

However, studies by several researchers have revealed that the direct application of plasma gas on food surfaces can result in color loss and the degradation of bioactive compounds. To prevent quality deterioration, plasma-treated water (PTW) or plasma-activated water (PAW) is employed. Interaction between cold plasma and water causes water clusters to break into smaller sizes. As a result, the treated water exhibits specific physicochemical properties, which have become a subject of scientific research. Observable changes include modifications in pH, electrical conductivity, freezing and boiling points. Scientists have also noted several unique properties of plasma-treated water, such as a lower refractive index, reduced viscosity, increased diffusivity, and decreased density and dielectric constant. Additionally, plasma treated water demonstrates enhanced membrane and cell wall penetration abilities, as well as antibacterial activity.

PTW and PAW are typically produced using plasma treatment in the contact mode. During this process, free radicals are generated through direct interactions between liquid molecules and electrons or ions from the plasma. The remarkable properties of plasma-treated water suggest broad application potential. However, the presence of free radicals can lead to undesirable changes, such as the oxidation of active substances like vitamins, polyphenols, or amino acids, reducing their biological activity. To address this, this project proposes a novel plasma treatment method to produce indirect plasma treated water (IPTW), which is free of free radicals.

The project aims to explore innovative solutions for producing biomaterials for immobilizing bioactive substances. The primary goal is to investigate the feasibility of using biopolymers created with IPTW as carriers for selected hydrophilic and hydrophobic bioactive substances. The hypothesis suggests that this modification will impart unique physicochemical properties to materials commonly used for encapsulation. It is also expected that IPTW will influence the release kinetics of active substances, enabling the creation of microcapsules with diverse properties and expanding their application potential.

This research represents a novel approach to producing biomaterials for active substance immobilization, as there are no existing scientific reports on using plasma-treated water for this purpose. Current knowledge highlights existing encapsulation methods that enable the immobilization of active substances in protective coatings, forming microparticles of various sizes and forms. However, there are limitations in stabilizing both hydrophilic and hydrophobic substances. This study focuses on exploring innovative modifications to encapsulation techniques, including changes in coating materials, to broaden their applicability.

Research within this project, centered on encapsulating bioactive substances in biopolymer-based coatings produced with IPTW, may be groundbreaking for the biomaterials field. The most significant expected outcome is obtaining results confirming the revolutionary potential of this innovative modification in preventing the degradation of bioactive substances, improving their stability, influencing release kinetics, and enhancing retention. These findings could open pathways for applications in functional foods, benefiting both the food industry and consumers.

The research plan comprises three stages, starting with the formulation of hydrosols, followed by the characterization of microcapsule coatings, and concluding with the analysis of bioactive substance release kinetics. The studies will assess thermal stability, rheological properties, antioxidant activity, and the release kinetics of active substances. This comprehensive research plan, divided into three phases, will provide crucial insights into the potential applications of IPTW in encapsulation using natural biopolymers.

If the research hypothesis is confirmed, the project outcomes could open new possibilities for producing biomaterials for bioactive substance encapsulation, leveraging the unique properties of IPTW. The potential applications of these innovations may contribute to the advancement of biopolymer materials and expand their range of uses.