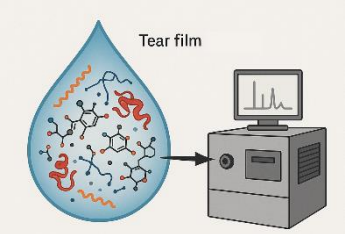
What do tears reveal about cystic fibrosis? A look at cystic fibrosis through the lens of the tear film

(*popular science summary of the research project*)

Cystic fibrosis (CF) is a congenital genetic disease inherited in an autosomal recessive manner. While it primarily affects the respiratory and digestive systems, recent research shows that its consequences may extend to many other organs and systems—including the visual system. One of the hallmark features of CF is abnormal secretion by exocrine glands, producing mucus that is overly thick, sticky, and difficult to clear from the ducts, ultimately impairing the function of affected organs.

The tear film is a complex, three-layered structure composed of water, proteins, lipids, and mucins. It plays an essential role in protecting the eye, providing hydration and nourishment, and ensuring clear vision due to its optical properties. In CF, the tear film composition can be altered—both chemically and physically—which may lead to irritation, dry eye syndrome, or even visual disturbances.

The aim of our project is to conduct an in-depth analysis of tear fluid properties in adult CF patients. We seek to determine whether—and how—the tears of these individuals differ from those of healthy controls and whether such differences might serve as indicators of disease progression. The study will involve 30 adult CF patients and 30 age- and sex-matched healthy volunteers.



Advanced technologies will be employed for this analysis. One of them is spectroscopy, which enables researchers to “look inside” the sample and identify its molecular components, including proteins, lipids, and metabolites. Another approach is electrochemical measurement—using specially modified graphene electrodes, we will be able to detect very small amounts of substances, including inflammatory markers, which may indicate the presence or intensity of disease processes. We will also determine the zeta potential, which reflects the electric charge of microscopic tear droplets. A change in this parameter can suggest tear film instability—manifesting as dry eye symptoms such as excessive tearing. Additionally, we will assess particle polydispersity, or the variation in tear particle sizes, which could also serve as a potential biomarker of pathological changes. Our project will also apply modern electron microscopy techniques—scanning electron microscopy (SEM) and transmission electron microscopy (TEM)—to visualize elements invisible to the naked eye. SEM will allow high-magnification observation of dried tear samples, revealing surface structures such as crystals or deposits. TEM, in turn, will provide insight into the internal composition of tears, including vesicles, lipids, and mucins. These techniques will help determine whether and how the tear structure in CF patients differs from that of healthy individuals, with potential diagnostic and clinical implications. Importantly, all measurements will be performed non-invasively—the material will be collected using soft filter paper strips placed at the temporal side of the lower conjunctival fornix.

The collected data will be statistically analyzed, and we will investigate whether correlations exist between tear fluid properties and selected ophthalmic parameters—such as non-invasive tear film break-up time (N-TBUT) and the Schirmer test—as well as clinical indicators like pulmonary function measured by forced expiratory volume in one second (FEV1). Our goal is to identify tear-based biomarkers that could serve as non-invasive indicators of disease progression and its ocular impact.

This project integrates expertise from analytical chemistry, ophthalmology, pulmonology, and biomedical sciences. We anticipate that our research will improve understanding of how cystic fibrosis affects the tear film and ocular surface and will contribute to the development of new diagnostic and therapeutic tools.