The Effect of Spatial Confinement on the Properties of Liquid-crystalline Mixtures of Azo and Chiral Compounds

Liquid crystals, found in many devices such as phones, TV displays, and thermometers, combine the properties of liquids and solids thanks to the partial arrangement of molecules. The numerous existing and potential applications of multicomponent liquid crystal materials emphasize the importance of continuing and deepening their research. Many research centers analyze the relationship between the properties of mixtures and their composition. This allows the prediction and creation of systems with desired parameters, such as phase transition temperatures or optical properties. This research is crucial for applying liquid crystals in electronics, optics, and medicine.

One of the fascinating applications of liquid crystals is liquid crystal thermography. This method allows for the visualization of heat emitted from the surface of observed objects. The phenomenon is based on the change in the colour of liquid crystals depending on the temperature when illuminated with white light. The cholesteric (chiral nematic) phase and its helical structure play a crucial role in this process (**Fig. 1a**). With the temperature change, the length of the spiral (helix) changes, which affects the change in the wavelength of light reflected in the visible range (**Fig. 1b**). Materials based on cholesterol derivatives have found wide application in this field.

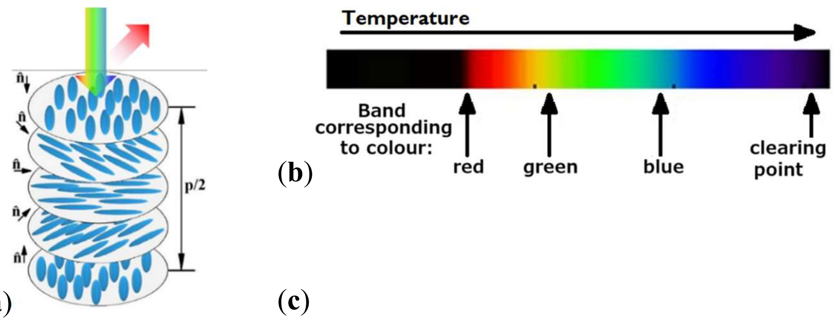

Fig. 1. (**a**) Schematic diagram of the cholesteric phase, where $\hat{n}$–preferred molecular alignment direction, *p/2*–half of the helix length; (**b**) thermochromic effect example; (**c**) structural formula of the azo liquid crystal compound from the (E)-4-(4-(alkyloxyphenyl)diazenyl)phenyl alkanoate group.

The planned studies will focus on liquid crystal materials containing azo compounds. These compounds are of particular interest for several reasons. First, they can affect the properties of liquid crystal mixtures, especially the temperature range at which the cholesteric phase is stable. Second, azo compounds are colourful (colours from yellow to brown), which can affect the colour response of the system. Third, the azo group (highlighted in blue in **Fig. 1c**) is sensitive to UV radiation, which causes trans-cis photoisomerization, leading to a change in the molecule shape while losing the ability to form liquid crystal phases. Due to the reversibility of this process, they can act as photosensitive switches. It will also be valuable to investigate how these compounds' additions affect the mixtures of cholesterol derivatives and other liquid crystal substances. Initial studies have shown that compounds from the (E)-4-(4-(alkyloxyphenyl)diazenyl)phenyl alkanoate group (**Fig. 1c**) can modulate the temperature range of the cholesteric phase in blends with cholesteryl pelargonate, as well as affect the colour response. In some cases, the blends formed glassy states of liquid crystalline or crystalline phases, which is particularly interesting from the understanding of the formation processes and properties of glassy states.

The most important step of the planned works will be to inspect how these materials behave in confined spaces, such as polymer fibers produced by electrospinning and porous membranes with nanometer pore diameters (10^{-9} m). A better understanding of the behaviour of liquid crystal materials in confined spaces is important for projecting and producing advanced temperature sensors, UV light sensors, or drug delivery systems.

The main goal of the project is to compare the physicochemical properties of the prepared blends with their pure components, such as the phase situation, structures of the observed phases, and inter- and intramolecular interactions for various types of space confinements. Additionally, changes in the colour response as a function of concentration will be investigated. In the project, samples in bulk form, i.e., without spatial limitations (for property comparison), and in spatial limitations contained in polymer fibers will be analyzed. The expected result of the project is to obtain functional mixtures that will have practical applications, e.g., in liquid crystal thermography, optical switches, or matrices for transporting medicinal substances.

The research will be carried out using many complementary methods, such as optical microscopy for observing textures, differential calorimetry for measuring phase transition temperatures and thermal effects, and several other methods allowing for the study of the structure and dynamics of mixtures, and fibers morphology. Experimental methods will be supported by computational methods.