Liquid crystals (LC) are a fascinating state of matter with a wide application in display application and optoelectronics, especially important in the development of new functional materials, nanolithography, cell engineering, sensors and biosensors, but also providing fundamental models of biological self-organization of matter. The materials can be stimulated by external fields, but also having the ability to self-repair the resulting defects. Liquid crystalline materials reacting to external stimuli such as: electric/magnetic fields, light, stresses, pressure, interaction with the surface, chemical agents significantly changing their properties may act as a sensor and device that transmits the obtained effect, but also exhibit feedback features therefore they deserve to be called functional intelligent materials. In recent years, the researchers have focused on chiral superstructures and polar order in liquid crystalline (LC) phases of non-chiral V-shape molecules that have bow core or bow dimers with spacers that have odd no of carbons.

The project concerns a group of LC materials that can spontaneously undergo bent deformation of the director leads to emergence of a new nematic order, in which the director follows an oblique helicoid. This **novel phase**, twist-bent (N_{TB}) is a structural link between the well-known uniaxial nematic (N) and chiral nematic (N*) phases. In the NTB phase, the director forms a conical helix with a pitch ranging from several to tens of nanometers, in which director is tilted with respect to the helical axis. Despite intensive research, many properties of the NTB phase and how these relate to the molecular structure have still to be established and understood. Of particular interest is the role of molecular bend in driving the formation of the NTB phase and a key molecular feature that determines this is the nature of the linking group between the mesogenic units and spacer. We recently show that molecular bent has also clear impact on the molecular biaxiality. We proved the biaxiality can directly be related to the periodicity of the helical structure. Thus, by determining the molecular biaxiality using IR spectroscopy, we can predict the helical pitch of the NTB structure. The later parameter is of great importance for the application of the NTB materials. Nanoscale pitch of the helix as compare to micrometer range of the typical cholesteric materials can reduce the switching time by 3-orders of magnitude. The switching time of the flexoelectric effect is found of the order of few microseconds, we recently reported the switching frequency of the soft mode in the in MHz region

The project presents an innovative approach to comprehensive description of macroscopic properties of the material based on their molecular properties. The main goal of the project will be to determine the relationship between the molecular structure and the resulting macroscopic properties of the material. To achieve this, it is necessary to determine the orientation and polar order for a group of liquid crystals (LC) of different molecular structure: different structures of the central part of the mesogen core and the changing structure of chains in tails, and ultimately determine the relationship between the structure of molecules and their ordering and macroscopic properties of liquid crystal phase.

The direct result of the research envisaged in the project will be the determination of a number of macroscopic parameters describing the thermodynamic properties and characterizing the anisotropic physical properties of a group of newly synthesized LC materials with various molecular structure**.** One of the important tasks of the project is to obtain the possibility of modeling the electro-optic effect (EO): ie the effect of electroclinic and switching time and modeling of structural changes as a function of temperature and electric field.

The combination of fast electro-optical (EO) reaction time with analogue properties means that EC liquid crystal materials are extremely attractive for a wide range of applications. This group of materials is particularly interesting to us because of their interplay between polarization and biaxiality. These materials show fast EO switching, high contrast between ON-OFF states, giving the possibility of their use in fast switching electro-optical devices. Using polarization microscopy, infrared and Raman spectroscopy, anisotropy measurements of the refractive index, the ranges of relevant mesophases and appropriate values of anisotropies measured by these methods will be determined. Planned research includes studying the structure of the molecule system, i.e. local ordering of molecules, macroscopic ordering of phases as well as the dynamics of molecular and collective processes. The extent of local order correlation determined from the widening of the peaks in the X scattering image will be compared with the range of correlation polar order determined from dielectric measurements and polarization. An approximate ODF distribution function and corresponding order parameters will be determined using birefringence measurements.