The increasing presence of hazardous substances in the environment, industry, and everyday life, together with the growing need to separate and recover valuable chiral compounds, calls for new types of materials that go beyond conventional sensors or filters. The proposed project will aim to create cholesteric polymer sensors and absorbers (ChPS&As) — a unique class of smart polymeric materials capable of combining, within a single system, selective detection, immobilization, and recovery of chemical analytes (Fig. 1).

The key to their detection function will lie in the helical structure present in the polymer. When specific analytes are absorbed, the polymer will undergo a well-defined change in its helical pitch, directly translating into a visible shift of reflected color. This "optical fingerprint" will provide an immediate, easy-to-read signal detectable by the naked eye, without the need for external instrumentation, batteries, or complex electronics. Such a direct, battery-free optical readout will not only be fast and reliable but will also enable use in field conditions, decentralized monitoring stations, or wearable protective equipment, where portability and simplicity are crucial.

Beyond sensing, ChPS&As will actively capture and sequester hazardous or valuable chemicals. Carefully designed molecular receptors and functional linkers embedded in the polymer network will provide selective recognition sites, ensuring high binding efficiency even in complex mixtures. This dual function (detection and immobilization) will ensure that harmful compounds are not only identified but also effectively contained. Importantly, after controlled desorption (for example, induced by mild acid/base treatment or suitable solvents), the analyte will be released, enabling recovery of valuable molecules or safe disposal of toxic ones, while the polymer itself regains its functionality and can be reused. This regenerative property will increase sustainability, lower operational costs, and enhance long-term usability.

From a scientific perspective, the project will be situated in a curiosity-driven basic research area that addresses fundamental questions about the interplay between molecular architecture, supramolecular interactions, and macroscopic material response. It will explore how specific molecular design choices — such as the type of mesogenic monomer, the structure of chiral linkers, or the arrangement of functional groups — influence the pitch of the cholesteric helix, the stability of the polymer network, and the efficiency of analyte binding. By bridging theoretical design, organic synthesis, and advanced optical and physicochemical characterization, the research will generate new knowledge about self-organization, molecular recognition, and responsive soft matter. This knowledge will be of high fundamental value while at the same time forming the scientific foundation for practical applications.

The advantages of the proposed ChPS&As will be numerous: (i) high sensitivity, thanks to their colorimetric response visible to the naked eye; (ii) strong selectivity, derived from tailored receptor groups; (iii) multifunctionality, as they unite sensing and absorbing in one platform; (iv) reusability and sustainability, enabled by triggered desorption and absorber regeneration; and (v) practical usability, since they will work without electricity, bulky equipment, or specialized training. These features will make them ideally suited for real-world scenarios where rapid, cost-effective, and reliable monitoring is required.

Applications will span both civilian and defense areas. In environmental protection, ChPS&As will monitor water and soil pollution or capture industrial contaminants, such as heavy metal cations (e.g., As^{3+} and Hg^{2+}). In pharmaceuticals, they will help separate valuable chiral compounds. In defense, integration into soldiers' uniforms or gas masks will provide real-time warning and partial protection from hazardous chemicals, including chemical warfare agents (e.g., Sarin or Soman), combining safety with practicality.

By addressing both basic scientific challenges and urgent societal needs, this project will exemplify how fundamental research with high curiosity-driven value can be directed toward impactful outcomes. It will not only advance our understanding of complex functional polymers but will also pave the way for scalable, sustainable, and field-ready solutions for chemical detection, protection, and recovery.

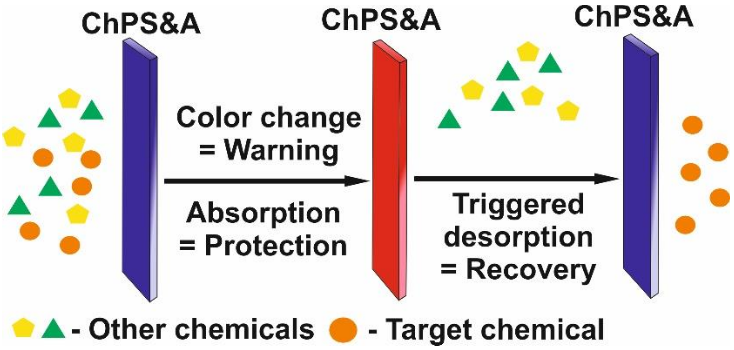

Figure 1. General concept of ChPS&As enabling detection, immobilization, purification, and – after triggered desorption – recovery of various chemicals.