

## Short description

The aim of this doctoral dissertation was the synthesis and detailed investigation of the physicochemical properties of new hybrid organic–inorganic compounds (HOICs), characterized by electric-field-induced switchable phase transitions. Eight compounds based on the quinuclidine cation (Q) and transition metal salts were synthesized, with the general formulas  $(Q)_2MBr_4$  and  $(Q)_2MCl_4$  ( $M = Cu, Co, Mn, Cd, Pb$ ). These materials were obtained via a slow solvent evaporation method, producing high-quality single crystals suitable for advanced characterization.

The scope of the study involved a comprehensive analysis of the materials' structural, thermal, dielectric, and spectroscopic properties using a variety of experimental techniques: single-crystal X-ray diffraction (XRD), broadband dielectric spectroscopy (BDS), impedance spectroscopy (IS), differential scanning calorimetry (DSC), and electron paramagnetic resonance (EPR). A particular focus was placed on identifying and analyzing phase transitions and their correlation with the crystal structure and the molecular dynamics of the Q cations, known for their rotational flexibility that strongly influences ferroic behavior.

The most significant finding of this research is the discovery of ferroelectricity in  $(\text{quinuclidine})_2\text{CuBr}_4$ . Structural and dielectric studies revealed an order–disorder type phase transition, dielectric hysteresis, and stable, reversible changes in dielectric permittivity with temperature. These observations provide clear evidence of spontaneous and switchable electric polarization, a hallmark of ferroelectric materials.

This result represents a major contribution to the field of functional hybrid materials and demonstrates the potential of environmentally friendly HOICs for use in modern electronics, including non-volatile FeRAM memories, logic state switches, sensors, and microelectromechanical systems (MEMS). Hybrid compounds based on organic cations present a promising alternative to conventional ferroelectrics, which often contain toxic elements like lead and are difficult to integrate into flexible electronics.

The dissertation also emphasizes the crucial role of hydrogen bonding in the structural integrity and dielectric properties of the materials. The ability of the organic cations to reorient dynamically within the crystal structure plays a fundamental role in enabling dielectric switching behavior. Understanding this molecular motion and its connection to ferroelectric ordering is vital for designing next-generation switchable materials.

These results pave the way for further exploration of hybrid compounds with varied organic cations and halide compositions, tailored to specific technological applications.