Harnessing molecular rotations in plastic crystals: a holistic view for crystal engineering of adaptive soft materials

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Abstract: Plastic crystals (PCs), formed by certain types of molecules or ions with reorientational freedom, offer both exceptional mechanical plasticity and long range order, [1,2] hence they are attractive for many mechano-adaptable technologies. While most classic PCs belong to simple globular molecular systems, a vast number of examples in the literature with diverse geometrical (cylindrical, bent, disk, etc.) and chemical (neutral, ionic, etc.) natures have proven their wide scope and opportunities. [2,3] All the recent reviews on PCs aim to provide insights into a particular application, for instance, organic plastic crystal electrolytes or ferroelectrics. [4-6] This tutorial review presents a holistic view of PCs by unifying the recent excellent progress in fundamental concepts from diverse areas as well as comparing them with liquid crystals, amphidynamic crystals, ordered crystals, etc.[7] We cover the molecular and structural origins of the unique characteristics of PCs, such as exceptional plasticity, facile reversible switching of order-to-disorder states and associated colossal heat changes, and diffusion of ions/molecules, and their attractive applications in solid electrolytes, opto-electronics, ferroeletrics, piezoelectrics, pyroelectrics, barocalorics, magnetics, nonlinear optics, and so on. [6,7,9] The recent progress not only demonstrates the diversity of scientific areas in which PCs are gaining attention but also the opportunities one can exploit using a crystal engineering approach, for example, the design of novel dynamic functional soft materials for future use in flexible devices or soft-robotic machines. [3,7,9,10]

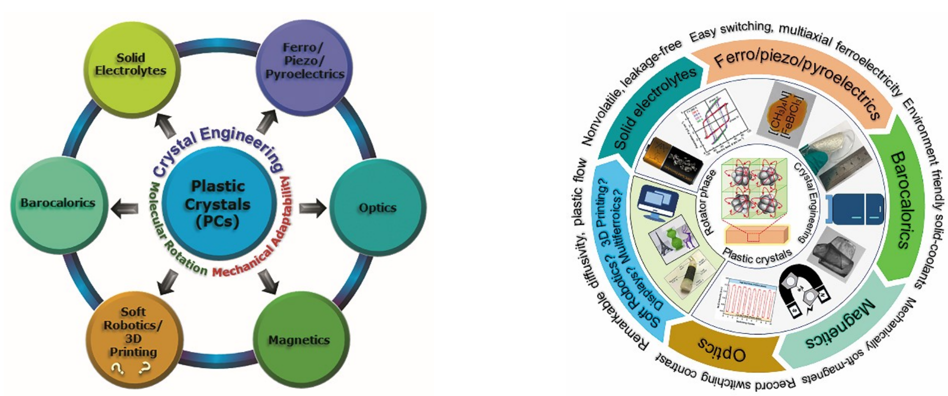

Figure 1. General overview of areas of prominence for PCs (left) and their expanding scope in material sciences with plenty of opportunities (right).

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