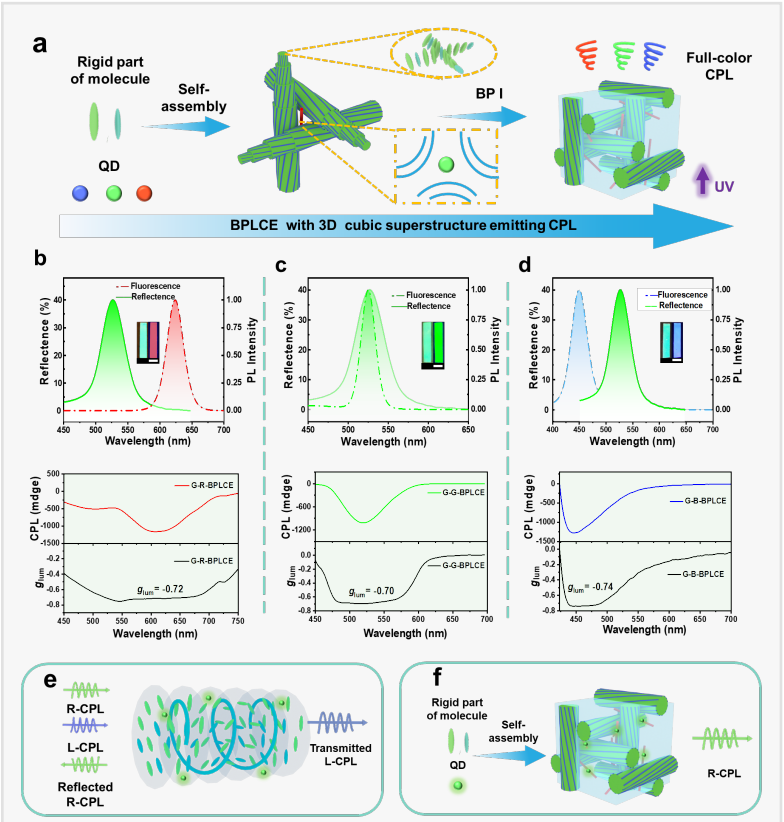
When QDs Meet BPLCEs: Visualized Full-Color and Mechanically-Switchable CPL

USA, June 14, 2024 /EINPresswire.com/ -- Full-color CPL is achieved by doping different quantum dots (QDs) into reconfigurable blue phase liquid crystal elastomers (BPLCE). Unlike with CPL in the cholesteric phase, BPLCE induces opposite CPL signal, entirely independent of photonic bandgaps (PBGs) and yielding a higher glum value even without matching between PBGs and emission bands of QDs. Furthermore, mechanical stretching enables "on-off" CPL signal switching, followed by permanent fixation via thermal activation.

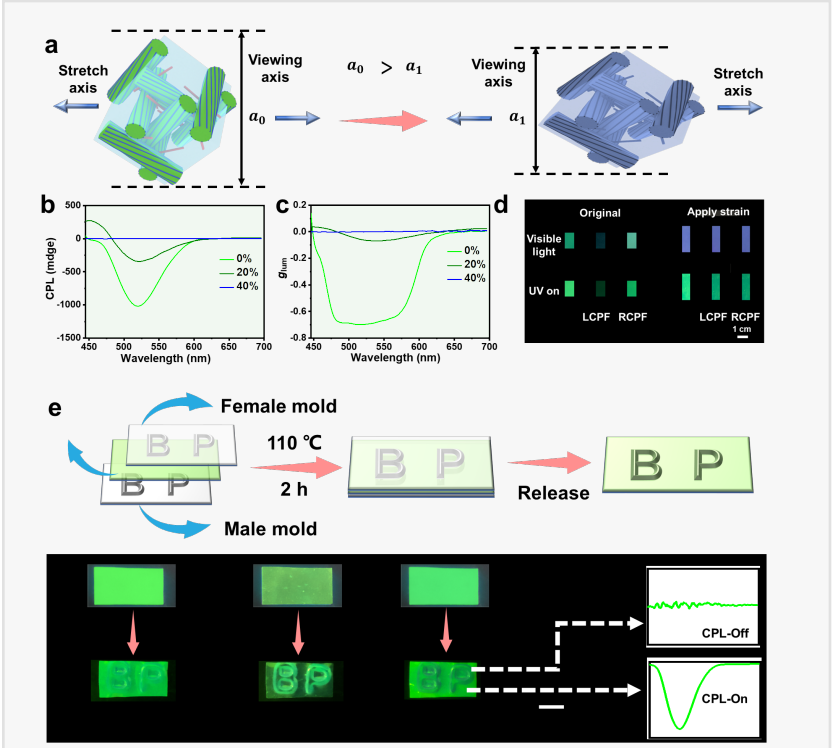


Fabrication and characterization of QD-BPLCE.

Circularly polarized luminescence (CPL) materials have attracted tremendous attention for their potential applications in many fields, such as molecular sensors, information encryption, and optical storage. So far, using cholesteric liquid crystals (CLCs) with helical superstructure has proved to be an effective media of amplifying glum value. However, CPL materials constructed by small molecule CLCs are often confined to LC cells, limiting their practical applications in certain scenarios. CLCs polymer films have limited responsiveness to external stimuli due to their frozen helical superstructure in solid states. Meanwhile, whether in CLCs polymers or small-molecule CLCs, magnified glum values of CPL are generally achieved by matching between emission band and the reflection band of the system, it requires precise modulation of the amount of chiral agent added to the system.

In a new paper (https://doi.org/10.1038/s41377-024-01479-1) published in Light Science & Applications, a team of scientists, led by Professor Jinbao Guo from College of Materials Science and Engineering, Beijing University of Chemical Technology, China and Professor Quan Li from Institute of Advanced Materials and School of Chemistry and Chemical Engineering, Southeast University, China have demonstrated a novel solid-state CPL-active material by incorporating

quantum dots (QD) into blue phase liquid crystal elastomers (BPLCE). Visualized full-color CPL with the largest glum absolute value of up to 0.74 is achieved by doping red, green, and blue QDs emitters, respectively. More interestingly, the CD signals of BPLCE and CLCE are similar, while their CPL signals are opposite, demonstrating that the mechanisms inducing CPL signals in BPLCEs and CLCEs are not the same. In particular, right-handed CLCEs selectively reflect RCP and transmit LCP. When the photonic bandgap of the CLCEs partially or completely match the emission spectrum of the luminescent molecules, the excited right-handed CPL is reflected. At the same time, only the generated left-handed CPL is transmitted. Consequently, right-handed CLCEs generated a left-handed CPL signal. However, selective reflection is not the cause for inducing CPL signals in BPLCEs. As well known, BPLCEs exhibit a highly ordered 3D structure and a strongly chiral environment. Once the QDs are in the BPLCE mixture, they participate in the self-assembly process with the molecules to form supramolecular 3D structures. As a result, right-handed BPLCEs induce a right-handed CPL signal and yielding a higher glum value even when there is no matching between PBGs and emission bands of QDs.



Stimulus response of CPL in QD-BPLCE.

The sample exhibits good thermal stability, maintaining strong reflectance and fluorescence signals up to 80 °C due to the fully polymerized network. Moreover, due to the introduction of flexible crosslinker, the sample exhibits excellent stretching capabilities. These scientists investigated the influence of mechanical force stimulation on the CPL signal of the sample.

“When the sample undergoes uniaxial mechanical stretching, its lattice experiences longitudinal extension, leading to the disruption of its chiral structure. As a consequence, there is a noticeable change in the CPL signal, transitioning from being observable to becoming undetectable.”

“The disappearance of the CPL signal induced by mechanical force is temporary. When the external force is removed, QD-BPLCE automatically returns to its initial state, and the CPL signal reappears. In our work, by activating the dynamic disulfide bonds within the QD-BPLCE, lattice changes induced by stretching can be fixed, ultimately leading to the permanent extinction of CPL signals.” they added.

“This study demonstrates the potential of developing CPL functional materials through photonic structures of BPLCEs, suggesting the advancement of BPLCEs-based CPL-active materials for optical coding and information storage applications.” the scientists forecast.

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