2-6-8. Circularly Polarized Luminescence

Overview

Circularly polarized luminescence (CPL) is the luminescence comprising of different amounts of left- and right-circularly polarized light components (I_L and I_R). Circularly polarized light can be obtained by overlapping two orthogonal polarized light with $\pm 1/4\lambda$ difference, where the sign determines the helicity sense of the resulting circularly polarized light. Left- and right-circularly polarized light are mirror images of each other, thereby enabling us to intuitively understand that CPL is expected to be observed from chiral luminophores. A wide range of applications is available for CPL in areas of emission devices for 3D displays, information devices, and sensor technologies.

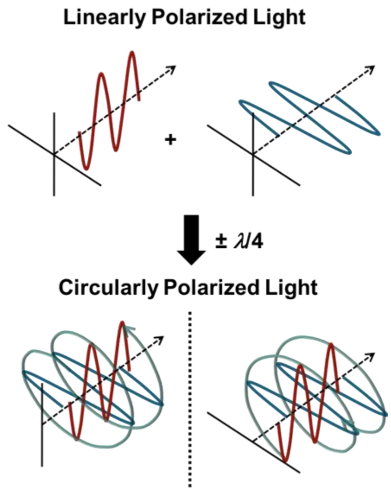

Figure 1. Left- and right-circularly polarized light.

Current Status and Frontiers

CPL activity has long been evaluated in terms of luminescence dissymmetry factor (g_{lum}). Here, g_{lum} represents $g_{lum} = 2(I_L - I_R)/(I_L + I_R)$, therefore the absolute maximum values of g_{lum} (+2 and −2) can be gained when $I_L > 0$ with $I_R = 0$, or $I_L = 0$ with $I_R > 0$. Chiral europium (Eu^{3+}) complexes are widely accepted CPL-active compounds exhibiting extraordinarily large g_{lum} values due to their magnetic dipole transition nature, in which Kaizaki et al. reported $g_{lum} = +1.38$ in 2008, while very recently Hasegawa achieved $g_{lum} = -1.54$. Chiral Eu^{3+} complexes with large g_{lum} values are promising for emission devices. In this context, Di Bari et al reported circularly polarized electroluminescence (CPEL) with the use of chiral Eu^{3+} complexes. In this way, CPL-active compounds have been designed so that the compounds would exhibit large g_{lum} values. However, recently CPL-active compounds are also often evaluated by the brightness CPL factor (BCPL), which is the half value obtained by multiplication of g_{lum} and molar extinction coefficient and emission quantum yield. This avenue suggests that large g_{lum} as well as strong emissive characters are desired for CPL-active compounds, especially for their practical use in emissive devices.

Besides, CPL has been used for a unique sensor methodology with the use of orthogonality of left- and right-circularly polarized light. Until now, CPL-used analytical technologies have been widely utilized for structure analysis on supramolecular architectures in nature (e.g., proteins and DNA) comprising of natural chiral building blocks. Conversely, we proposed CPL-based smart sensing methodology for achiral analytes by using the orthogonality of left- and right-circularly polarized light. Figure 2 represents the concept of the CPL-used smart sensing methodology, where non-target achiral luminophores (E) co-exist with target analytes (A). Our synthesized probe (P) becomes to show strong CPL upon binding with A ($I_L - I_R \neq 0$). Conversely, achiral luminophores (E) exhibit non-polarized luminescence ($I_L - I_R = 0$), thereby capable of eliminating the emission from E by CPL measurement ($I_L - I_R$) to exclusively obtain the emission signal from P·A. Object identification is feasible by CPL mapping.

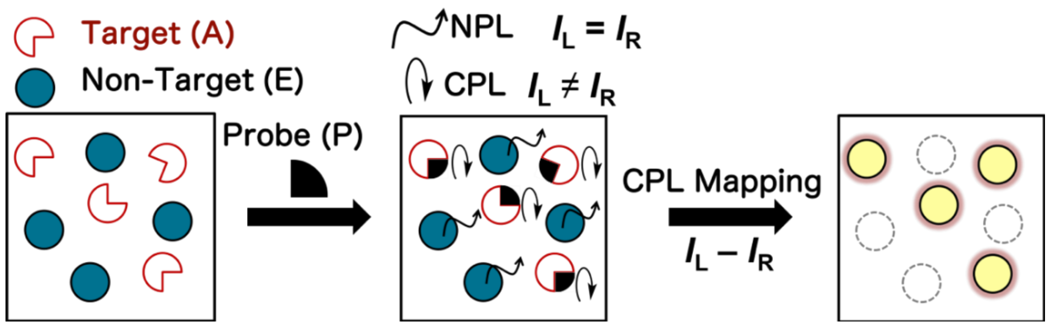

Figure 2. Object identification by CPL.

References

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Future Perspectives and Directions

The issues to be solved within 10 years: CPL-active compounds exhibiting $|g_{lum}| = 2$. CPL-based single molecule detection.

(Author: Junpei Yuasa)