View Article Online

ChemComm

Chemical Communications

Accepted Manuscript

This article can be cited before page numbers have been issued, to do this please use: S. Chen, S. Jiang, J. Qiu, H. Guo and F. Yang, *Chem. Commun.*, 2020, DOI: 10.1039/C9CC09826G.



This is an Accepted Manuscript, which has been through the Royal Society of Chemistry peer review process and has been accepted for publication.

Accepted Manuscripts are published online shortly after acceptance, before technical editing, formatting and proof reading. Using this free service, authors can make their results available to the community, in citable form, before we publish the edited article. We will replace this Accepted Manuscript with the edited and formatted Advance Article as soon as it is available.

You can find more information about Accepted Manuscripts in the Information for Authors.

Please note that technical editing may introduce minor changes to the text and/or graphics, which may alter content. The journal's standard <u>Terms & Conditions</u> and the <u>Ethical guidelines</u> still apply. In no event shall the Royal Society of Chemistry be held responsible for any errors or omissions in this Accepted Manuscript or any consequences arising from the use of any information it contains.



rsc.li/chemcomm

Authors

View Article Online DOI: 10.1039/C9CC09826G

Shibing Chen,^a Shengjie Jiang,^a Jiabin Qiu,^a Hongyu Guo^{*a,b} and Fafu Yang^{*a,b,c}

Affiliations

a College of Chemistry and Materials Science, Fujian Normal University, Fuzhou 350007, P. R. China

b Fujian Key Laboratory of Polymer Materials, Fuzhou 350007, P. R. China

c Fujian provincial Key Laboratory of Advanced Materials Oriented Chemical Engineering, Fuzhou 350007, P.R. China

Acknowledgements

This work was financially supported by the National Natural Science Foundation of China (No: 21406036).

Dual-responding circularly polarized luminescence based on the

thermo-induced

Journal Name

DOI:

of

cvano-

COMMUNICATION



Page 2 of 6

Received 00th January 20xx, distyrylbenzene hydrogen-bonding liquid crystal Accepted 00th January 20xx XXXX XXXX,^a XXXX XXXX,^a XXXX XXXX,^a XXXX XXXX^{*a,b} and XXXX XXXX^{*a,b,c} DOI: 10.1039/x0xx00000x www.rsc.org/

mechanic-

and

The circularly polarized luminescence controlled by both mechanic and temperature was observed for the first time. The cyanodistyrylbenzene-cholesterol liquid crystal exhibited not only mechanochromism and thermochrochromism but also mechanicinduced and thermo-induced circularly polarized luminescence, which was attributed to the sensitive response of hydrogen bond directed assemblies under different mechanic and temperature.

Circularly polarized luminescence (CPL) of organic and polymeric materials at aggregated phase has attracted considerable attention due to their promising applications in light emitting diodes, colorimage projection, optical information storage, stereoscopic displays, etc.¹ Particularly, the materials with switching CPL properties (i.e. intensity or wavelength) in response to external stimuli such as heat, light, solvent and pH are intriguing from both a fundamental and application perspective.² However, such smart materials are still quite rare and the in-depth theoretical understanding of chirality transfer and amplification for these materials with achiral fluorogens were also rather limited up to now.³

The CPL response which reflects the chirality of materials in the excited electronic state not only relies on chiral functions on the molecular level, but also depends on the architectures of the molecular assemblies for the reason that molecular aggregates have specific physicochemical behaviors different from those of individual molecules in both their ground and excited states.⁴ In principle, helically organized aggregates formed by specific intermolecular interaction showed characteristic CPL behaviors.⁵ Kawai's group reported that the one-dimensional aggregates formed in methylcyclohexane exhibited twice the value of luminescence dissymmetry factor (glum) when compared with the spherical aggregates formed in chloroform at higher concentration.⁶ Song etc presented a supramolecular assembly of nanofibers bearing a CPL response with g_{lum} of $0.6{\times}10^{\text{-}3.7}$ These studies suggested that switching CPL could be induced through

a. XXXXXXXXXXXXXX

Published on 12 June 2020. Downloaded on 6/16/2020 3:41:52 AM.

architectural regulation of these molecular assemblies in the aggregated phase, implying a feasible design direction for the development of efficient and multifunctional tunable CPL materials.

assemblies

In order to regulate the molecular assembly behaviour, mechanic and temperature were intensively used to control the mode of molecular packing instead of alteration of the chemical structure, as the noncovalent interactions were more likely to recover to original covalent state by simply heating or recrystallization.⁸ Up to now, the mechanoresponsive materials had been extensively studied with reversible luminescent color changes,9 but the mechanic-induced CPL property was not presented. On the other hand, the temperature change usually induced the molecular stacking changes of organic molecules. Especially, organic liquid crystals exhibited the thermochrochromism and CPL properties based on chirality transfer and amplification between chiral groups and achiral fluorogens at different phase under various temperature.¹⁰ However, to the best of our knowledge, the reported organic liquid crystals with CPL properties responded to the temperature only, no dual- or multi-responding CPL liquid crystal was concerned so far. Obviously, the dual- or multi-responding CPL properties have the special advantages in promising applications such as high-security system which are deserved to be studied significantly and urgently. In this paper, we wish to report the dual-responding CPL property induced by both mechanic and temperature for the first time. The cyanodistyrylbenzene-cholesterol (CDB-1Ch) showed not only mechanochromism and thermochrochromism but also mechaincinduced and thermo-induced circularly polarized luminescence based on its asymmetrical hydrogen bond-directed assemblies.

As the cholesterol unit had been used successfully for producing thermoresponsive CPL properties, 10a, 10b and hydrogen bond contributed to achieve mechanoresponsive signals,¹¹ they were combined to construct the target molecules with both mechanicinduced and thermo-induced CPL properties. Thus, compounds CDB-1Ch and CDB-2Ch were designed and synthesized in good yields (See SI). They not only fused cholesterol unit and hydrogen bond together but also possessed the asymmetrical or symmetrical structures, which were favourable for studying the relationship of structure and property for these novel AIE liquid crystals.

b. XXXXXXXXXXXXXXX

c. XXXXXXXXXXXXXXX

Electronic Supplementary Information (ESI) available: Experimental details, supporting figures and table. See DOI: 10.1039/x0xx00000x

Published on 12 June 2020. Downloaded on 6/16/2020 3:41:52 AM

COMMUNICATION



Figure 1. The structures of CDB-1Ch and CDB-2Ch.

Firstly, the initial samples and ground samples of CDB-1Ch and CDB-2Ch were prepared for mechanofluorochromism(MFC) study. For CDB-1Ch, the initial sample obtained by adding petroleum ether into its CH₂Cl₂ solution showed an intense yellow-light emission with peak at 572 nm. As expected, the fluorescence color altered from yellow to green with maximum emission at 516 nm after grinding (Figure S15). Such fluorescence modulation was attributed to mechanic-induced phase transition between crystalline state and amorphous state.^{8d,11d,12} Thereby, powder X-ray diffraction (XRD) was performed to determine the MFC mechanism. Owing to the lack of intense and sharp diffraction peaks in the XRD profile, pristine powder was more likely an amorphous state (Figure S16). Nevertheless, the vanishment of Bragg reflection at 14.9° and the emergence of 16.3° unequivocally implied that pristine and ground powder adopted distinctly different assembled structures. On considering that hydrogen bond among adjacent molecules seemed to be a critical driving force to induce the formation of the two distinctive assemblies, the FT-IR spectrometry was applied to provide structural insight into the two molecular aggregates and an in-depth understanding of the change in emission behavior. As illustrated in Figure S17, the peak at 1711 cm⁻¹ for pristine powder shift to a higher wavenumber region at 1726 cm⁻¹ upon grinding, indicating the partial destruction of hydrogen bonds stemmed from C=O and the transformation of assembled structures. However, it seemed counterintuitive that the N-H stretching vibration shift to 3339 cm⁻¹ after grinding, lower than that of the pristine powder (3364 cm⁻¹) obviously, suggesting the formation of much stronger hydrogen bonds. Careful examination of the structure of CDB-1Ch might account that this shift could be ascribed to another H-donor derived from amino group but not amide group (Figure 2a). Formation of intermolecular H-bonds between amino groups would require rotation of superimposed molecules by a certain angle. Such twisted organization resulted in a less linear H-bond between amide groups, agreeing with a weaker H-bond illustrated by increasing wavenumber of C=O. Monomer to excimer transition mechanism had been well documented in MFC mechanism.^{11b-11d} For excimers, emission bands were always located at wavelengths higher than monomer emission bands and substantial π - π overlap of luminescent cores was indispensable for excitonic and excimeric coupling. Based on the above model, it was possible that the large fluorescence spectral discrepancy between the pristine and ground state of CDB-1Ch might originate from different emitting species in the excited states. For pristine state, parallel molecular-packing architectures rendered it substantial π - π overlap of fluorophore, resulting in higher wavelengths emission. However, due to the dramatically reduced π - π overlap between adjacent molecules as a result of twisted organization in ground state, the formation of a photoexcited excimer was prohibited, leading to the predominant monomeric pholuminescence. This proposal was also, confirmed by that its emission of monomer after grinding was confirmed by that in THF-H₂O solution (as shown in Figure S41 for AIE property with green emission at 513 nm in THF-H₂O solution). Moreover, by exposing the ground sample to a vapor of CH₂Cl₂ for 5 min, the "yellow" fluorescence state was restored, indicating the reversible MFC property for **CDB-1Ch**. The same emission color and XRDpattern suggested that the fumed sample had the same molecular arrangement as that of pristine sample (Figure S15 and S16).



Figure 2. The MFC mechanism of (a) DCB-1Ch and (b) DCB-2Ch.

As for CDB-2Ch, both the ground and initial states show yellow emission and only a small blue shift (10 nm) appeared under mechanical grinding (Figure S18), suggesting that the symmetric substitution of cholesterol units induced different stacking mode from that of CDB-1Ch. The microstructure of pristine and ground samples could not be distinguished by XRD measurements and FT-IR spectra because of little difference (Figure S19 and S20). These results suggested the similar hydrogen-bond modes between the two adjacent molecules in these two assemblies of CDB-2Ch (Figure 2b). The slightly twisted organization of ground sample resulted in little decrease of π - π overlap of fluorophore by compared with that of **CDB-1Ch**. Owing to the substantial π - π overlap of luminescent cores in both the two assemblies, excimer to excimer transition mechanism accounted for the little wavelength shift. Their yellow excimer emission was different from the characteristical blue monomer emission in dilute THF solution (as shown in Figure S42 for AIE property of CDB-2Ch with green emission at about 513 nm).

Next, it was interesting to study the CPL properties and circular dichroism spectra (CD) based on the twisted organization of ground sample in comparison with the parallel stacked molecules in pritine sample. For CDB-1Ch, the pristine powder has no CPL signal, implying its molecular packing mode was unfavorable for helical structures (Figure S21). However, dramatically enhanced CPL signal with a g_{lum} value of -1.1 x 10⁻³ appeared upon the application of mechanical force (Figure S22), suggesting the generation of a mechanic-induced helical assemblies. The high-contrast CPL switching was supported by CD data which reflected the chiral nature of the aggregates in the ground state. The ground sample showed strong cotton effect ($g_{abs} = 5.73 \times 10^{-3}$) while the pristine sample has no CD signal in UV-vis spectra (Figure S24, S25 and S46). The silent CPL response for fumed sample indicated the CPL "OFF" state can be restored by exposing it to DCM vapors (Figure S23). Hence, the reversible mechanic-induced CPL property was achieved

COMMUNICATION

Published on 12 June 2020. Downloaded on 6/16/2020 3:41:52 AM

by modulation of the assembled structure for the first time. The experimental results of emission anisotropic spectra were also in accordance with the CD and CPL results (Figure S48).

On the other hand, **CDB-2Ch** showed negative cotton effect (g_{abs} = 2.46×10⁻³) in CD spectra, implying the effective transfer of chirality from the peripheral cholesterol moiety to achiral aromatic rigid core in the ground state because of the small twisted organization (Figure S26, S27 and S47). But both the pristine and ground solid state exhibited silent CPL response, which might be explained by that the small twisting was not enough for CPL induction (Figure S28 and 29). Hence, the effective π - π overlap based on symmetrical structure offered the ground sample of **CDB-2Ch** a totally different electronic nature in the excited state although it possessed the same luminescent core with **CDB-1Ch**.

Furthermore, the thermochrochromism and thermo-induced CPL properties based on their liquid crystalline behaviors were studied. Their DSC, POM and XRD analysis were exhibited in Figure S30-34 and Table S1. CDB-1Ch displayed thermochrochromism and an endothermic peak at 79 °C on the second heating, suggesting that the luminescent color change from yellow (571 nm) to green (510 nm) was related to the phase transition from solid to a birefringent mesomorphic (M) phase (Figure S35). Broken fan-shaped texture appeared at thermotropic mesophase from 79 °C to 162 °C, which could be also assigned to columnar phase (Figure S31). The observed XRD pattern was characteristic for a columnar rectangular mesophase (Colr) of p2mm symmetry with lattice parameters a = 61.4 Å and b = 42.7 Å (Figure 3 and Table S1).¹³ Based on equation Z = $\rho N_A Ah/M_r$ (ρ , N_{A_r} A and h are the density of the mesophase, Avogadro's constant, columnar cross section (a×b) and the height of the columnar unit, respectively),14 the number of molecules per columnar slice was estimated to be 10. On the other hand, CPL property of this mesophase (Col_{r1}) was investigated and the negative CPL signal with g_{lum} value of 1.0 x 10⁻² (Figure 3 and S37), implying a highly ordered helical column in contrast to the silent response at ambient temperature. The higher g_{lum} value than that of ground state indicated the more ordered helical stacks in columnar mesophase (Figure 4). The adjacent molecule required relative rotation to accommodate them in a tilted column which confined the orientation of CDB-1Ch to a partially overlapped architecture in the excited state. The green luminescence was assigned to monomer emission, which was consistent with the model in Figure 2 since the assembled structure of pristine powder contained such twisted structure unit as well.



Figure 3. CPL spectra of DCB-1Ch and DCB-2Ch at mesophase.

When further heated to 160 °C, the Col_{r1} of **CDB-1Ch** became unstable and the molecule blocks were rearranged into another Col mesophase confirmed by an endothermic peak at 162 °C, the

collapsing broken fan-shaped texture (Figure S32), and the formation of new Col texture at 165 °CD(FigUre0533)9CTHe8XRD pattern at 165 °C showed a large number of Bragg reflections, agreeing well with a rectangular columnar (col_{r2} , a = 55.0 Å, b = 34.3 Å) lattice (Figure 5 and Table S1). Based on XRD data, the Z value for per columnar slice of Col_{r2} was calculated as 8, which was smaller than that of Col_{r1}. The g_{lum} value (-4.2 x 10⁻³, Figure S38) for Col_{r2} was almost only half that for col_{r1} . The decline of g_{lum} value was ascribed to the decrease of packing order of intracolumnar helical arrangement due to the longer interlayer distance compared to that of col_{r1}. The weaker H-bond and other intermolecular interaction such as cholesterol-cholesterol and π - π interaction resulted in a longer interlayer distance at higher temperature. Owing to the similar stacking mode but loser helical-like architectures which inhibited the formation of excimers, the molecules in col_{r2} behaved as monomer and showed green luminescese similar to that of col_{r1} (Figure S35). The texture of Col_{r2} transferred to isotropic liquid at 220 °C although no obvious endothermic peak was detected at about 220 °C in DSC profile. The weak and random intermolecular interaction leaded to destruction of helical assembled structure and a silent CPL response (Figure S39). The coexistence of excimeric and monomeric emission might explain the fluorescence at 527 nm due to such random orientation.



Figure 4. The XRD trace of **DCB-1Ch** in mesophase at 145 °C and the proposed molecular stacking in rectangular columnar mesophase.



Figure 5. The XRD trace of DCB-1Ch in mesophase at 165 °C and the proposed molecular stacking in rectangular columnar mesophase.

This journal is © The Royal Society of Chemistry 20xx

COMMUNICATION

Page 5 of 6



Figure 6. The XRD trace of **DCB-2Ch** in mesophase at 240 °C and the proposed molecular stacking in rectangular columnar mesophase.

As for CDB-2Ch, it showed a blue-shift up to 32 nm for fluorescence emission at 240 °C, implying thermochrochromism and the transformation of different phase (Figure S36). The DSC curve showed a small endothermic peak at about 233 °C in the 2nd heating corresponding to this transition. The clearing point couldn't be observed before it decomposed. A birefringent mesomorphic phase appeared at 240 °C but it was not typical Col mesophase (Figure S34, 1500 nm for the film thickness in Figure S44). Nevertheless, the Bragg reflection in XRD pattern could be indexed with a rectangular lattice defined by two orthogonal vector a (38.3 Å) and b (20.8 Å) (Figure 6 and Table S1). The low correlated core-core interaction (h = 4.99 Å) suggested H-bond directed columnar assembly with a wider interplane distance while disk-shaped aromatics tended to be closely packing. There was a pair of CDB-2Ch molecules arranged side-by-side in each column stratum based on lattice parameters of XRD results. Amazingly, by compared with the silent response under mechanical force, dramatically high g_{lum} of +5.6 x 10⁻² (Figure 3, S40 and Figure S45) was observed at Col_r phase, which was the result of the intracolumnar helical arrangement driven by thermodynamic transformation. This value was high among CPL organic molecules $(10^{-4}-10^{-2} \text{ usually})$ ¹⁵ Furthermore, due to the reduced π - π overlap, the emission of Col_r phase showed blue shift with green luminescene. The B3LYP density functional theory suggested the similar orbital distribution and HOMO-LUMO energy levels for CDB-1Ch and CDB-2Ch (Figure S43), implying their similar electronic state for single molecule. The modulation of emission was caused by their different molecular packing mode. Hence, it could be deduced that both CDB-1Ch and CDB-2Ch possessed the thermochrochromism and thermo-induced CPL with high glum values based on various molecular assemblies of different H-bonds.

In conclusion, this paper prepared two cyanodistyrylbenzenecholesterol liquid crystal with asymmetrical or symmetrical Hbonding structures. **CDB-1Ch** with asymmetrical structure displayed not only mechanochromism and thermochrochromism but also mechanic-induced and thermo-induced CPL properties based on the sensitive mechanic and thermal response of molecular assemblies directed by H-bond. This phenomenon was observed for the first time, opening an new strategy for design and synthesis of new CPL materials with multi-response abilities for external stimuli.

This work was financially supported by XXXXXXXXXXX.

Notes and references

- (a) E. Peeters, M. P. T. Christiaans, R. A. J. Janssen, H. F. M. Schoover, Heile Ohi Me Dekkers and E. W. Meijer, *J. Am. Chem. Soc.*, 1997; 119,0306-3910; 187 Me
 Oda, H. G. Nothofer, G. Lieser, U. Scherf, S. C. J. Meskers and D. Neher, *Adv. Mater.*, 2000, 12, 362-365; (c) S. H. Chen, D. Katsis, A. W. Schmid, J. C. Mastrangelo, T. Tsutsui and T. N. Blanton, *Nature* 1999, 397, 506-508; (d) H. Z. Zheng, W. R. Li, W. Li, X. Wang, Z. Tang, S. X. Zhang and Y Xu, *Adv. Mater.*, 2018, 30, 1705948.
- 2 (a) H. Isla, M. Srebro-Hooper, M. Jean, N. Vanthuyne, T. Roisnel, J. L. Lunkley, G. Muller, J. A. G. Williams, J. Autschbach and J. Crassous, *Chem. Commun.*, 2016, 52, 5932-5935; (b) K. Nakabayashi, T. Amako, N. Tajima, M. Fujiki and Y. Imai, *Chem. Commun.*, 2014, 50, 13228-13230; (c) T. Hamamoto and M. Funahashi, *J. Mater. Chem. C*, 2015, 3, 6891-6900.
- 3 (a) J. Liu, H. Su, L. Meng, Y. Zhao, C. Deng, P. Lu, J. W. Y. Lam, X. Huang, H. Wu,
 K. S. Wong and B. Z. Tang, *Chem. Sci.*, 2012, **3**, 2737-2747; (b) J. L. Han, P. F.
 Duan, X. G. Li and M. H. Liu, *J. Am. Chem. Soc.*, 2017, **139**, 9783-9786.
- 4 (a) H. Tsumatori, T. Nakashima and T. Kawai, Org. Lett., 2010, 12, 2362-2365;
 (b) J. Roose, B. Z. Tang and K. S. Wong, Small, 2016, 12, 6495-6512.
- 5 (a) X. H. Gao, X. J. Qin, X. F. Yang, Y. G. Li and P. F. Duan, *Chem. Commun.*, 2019,
 55, 5914-5917; (b) D. Y. Zhao, X. H. He, X. G. Gu, L. Guo, K. S. Wong, J. W. Y. Lam and B. Z. Tang, *Adv. Optical. Mater.*, 2016, 4, 534-539; (c) X. F. Yang, J. L. Han, Y. F. Wang and P. F. Duan, *Chem. Sci.*, 2019, 10, 172-178; (d) B. A. S. Jose, S. Matsushita and K. Akagi, *J. Am. Chem. Soc.*, 2012, 134, 19795-19807.
- 6 J. Kumar, T. Nakashima, H. Tsumatori and T. Kawai, J. Phys. Chem. Lett., 2014, 5, 316-321.
- 7 F. Y. Song, Y. H. Cheng, Q. M. Liu, Z. J. Qiu, J. W. Y. Lam, L. B. Lin, F. F. Yang and B. Z. Tang, *Mater. Chem. Front.*, 2019, **3**, 1768-1778.
- 8 (a) M. Mitani, S. Ogata, S. Yamane, M. Yoshio, M. Hasegawab and T. Kato, J. Mater. Chem. C, 2016, 4, 2752-2760; (b) J. W. Chung, Y. You, H. S. Huh, B. K. An, S. J. Yoon, S. H. Kim, S. W. Lee and S. Y. Park, J. Am. Chem. Soc., 2009, 131, 8163-8172; (c) J. Zhao, Z. Chi, Y. Zhang, Z. Mao, Z. Y. Yang, E. Ubba and Z. G. Chi, J. Mater. Chem. C, 2018, 6, 6327-6353; (d) Y. Sagara, T. Mutai, I. Yoshikawa and K. Araki, J. Am. Chem. Soc., 2007, 129, 1520-1521.
- 9 (a) Y. Sagara and T. Kato, *Nat. Chem.*, 2009, 1, 605-610; (b) J. Zhao, Z. H. Chi, Z. Y. Yang, Z. Mao, Y. Zhang, E. Ubba and Z. G. Chi, *Mater. Chem. Front.*, 2018, 00, 1-3; (c) Z. G. Chi, X. Q. Zhang, B. G. Xu, X. Zhou, C. P. Ma, Y. Zhang, S. W. Liu and J. R. Xu, *Chem. Soc. Rev.*, 2012, 41, 3878-3896.
- 10 (a) S. Jiang, J. Qiu, L. Lin, H. Guo and F. Yang, *Dyes Pigm.*, 2019, **163**, 363-370;
 (b) Q. Ye, D. Zhu, H. Zhang, X. Lu and Q. Lu. *J. Mater. Chem. C*, 2015, **3**, 6997-7003; (c) D. Yang, P. Duan, L. Zhang and M. Liu, *Nat. Commun.*, 2017, **8**, 15727.
- 11 (a) Y. Sagara, T. Mutai, I. Yoshikawa and K. Araki, *J. Am. Chem. Soc.*, 2007, **129**, 1520-1521; (b) M. J. Teng, X. R. Jia, X. F. Chen and Y. Wei, *Angew. Chem.*, 2012, **124**, 6504 -6507; (c) Z. Y. Ma, M. G. Teng, Z. J. Wang, S. Yang and X. R. Jia, *Angew. Chem.*, 2013, **125**, 12494 -12498; (d) W. Yuan, X. K. Ren, M. W. Li, H. S. Guo, Y. Han, M. J. Wu, Q. Wang, M. M. Li and Y. L. Chen, *Angew. Chem. Int. Ed.*, 2018, **57**, 6161-6165.
- 12J. Kunzelman, M. Kinami, B. R. Crenshaw, J. D. Protasiewicz and C. Weder, Adv. Mater., 2008, 20, 119-122.
- 13 (a) T. Wöhrle, I. Wurzbach, J. Kirres, A. Kostidou, N. Kapernaum, J. Litterscheidt, J. C. Haenle, P. Staffeld, A. Baro, F. Giesselmann and S. Laschat, *Chem. Rev.*, 2016, **116**, 1139-1241; (b) R. K. Gupta, S. K. Pathak, J. De, S. K. Pal and A. S. Achalkumar, *J. Mater. Chem. C*, 2018, **6**, 1844-1852.
- 14 M. Lehmann, C. Köhn, H. Meier, S. Renker and A. Oehlhof, J. Mater. Chem., 2006, 16, 441-451.
- 15 (a) F. Song, Z. Zhao, Z. Liu, J. W. Y. Lam and B. Z. Tang, J. Mater. Chem. C, 2020,
 8, 3284-3301; (b) M. Li, W. B. Lin, L. Fang and C. F. Chen, Acta Chim. Sinica, 2017, 75, 1150-116.

ChemComm Accepted Manuscript



The circularly polarized luminescence controlled by both mechanic and

temperature was observed for the first time