Supplementary Information (SI) for New Journal of Chemistry.

Supporting Information for

Formaldehyde sensing based on fluorescence and circularly polarized luminescence of polymer films

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Experimental Section

Materials and instruments

Compounds formaldehyde (FA), acetaldehyde, acrolein, methanol, and ethanol were purchased from Sinopharm Chemical Reagent Co., Ltd (Shanghai, China). *N*, *N*-Dimethylacetamide (DMAC) was purchased from J&K Scientific Co., Ltd (Beijing, China). Acetone, cyclohexanone and cyclopentanone were bought from Chinasun Specialty Products Co., Ltd. Irgacure 907 and MPD were bought from Aladdin Chemical Co., Ltd. LC242, RM105, ethylene-vinyl acetate copolymer (EVA), CA, CA-Acrylate, and PE400 were given by Wuxi Wanli Adhesive Materials Co., Ltd. Polyethylene terephthalate (PET) films were purchased from Nanya plastics Co., Ltd (Nantong, China). Mass spectrum was measured with microTOF-Q III spectrometer. FT-IR spectra were performed on a VERTEX 70 spectrometer (Bruker, Germany) at 4.0 cm^{-1} resolution by averaging over 16 scans. The photopolymerization were conducted using a UV-LED series equipment (UVSF81T, 365 nm, 400 mW cm^{-2}, output power) produced by FUTANSI Electronic Technology Co., Ltd (Shanghai, China) and a high-pressure Hg lamp (MINHIO 4012-20, 350-450 nm, 1.0 kW, input power), produced by MINHIO Intelligent Equipment Co., Ltd (Shenzhen, China). FE-SEM images were obtained using a Hitachi Regulus8230 operating (Ibaraki prefecture, Japan) at 5.0 kV. Energy dispersive spectrometer (EDS) elemental mappings for UCNPs were obtained using a Hitachi Regulus8230 operating (Ibaraki Prefecture, Japan) equipped with an Oxford EDS at 15.0 kV. CD spectra were measured by using a JASCO 815 spectrometer (Tokyo, Japan). UV–*vis* spectra were measured by a UV–*vis* spectrophotometer (UV-1900i, Shimadzu, Japan). The POM images of the target compounds were taken using a Leica Microsystems CMS GmbH fitted with a Linkam LTS420 hot stage. Fluorescence spectra and quantum yields were measured by FLS 980 (Edinburgh Instrument, UK). CPL spectra were measured on JASCO CPL-300 (JASCO, Japan). In the CPL measurements, the excitation wavelength was 420 nm, the scan speed was 500 nm/min, the number of scans was 1, the slit width was 3000 μm for excitation and the monitor, and the time constant of PMT (D.I.T.) was 1 s. The value of g_{lum} is experimentally defined as $g_{\mathrm{lum}} = \Delta I/I = \Delta I/\mathrm{PL}$ (DC in volts) = [ellipticity/(32980/ln10)] / PL (DC in volts) at a CPL wavelength, while PL (DC in volts) stands for total luminescence I, and $I = I_L + I_R$. To eliminate the effect of line polarization luminescence of the films, a plate holder was used to allow the samples to rotate 360°, and the CPL spectra from 4 scans at 45° intervals in the eight directions were algebraically averaged. Since the helical structures in all free-standing CLCN films were perpendicular to the surface, and the CPL spectra and g_{lum} values for each side of these films were similar. For CLCN-coated PET films, considering the waveguide effect of the PET substrate, the excitation light was set to pass through the PET substrate and the CLCN coating subsequently in the CPL test. The probe FAP was synthesized according to the literature.[S1] The concentration of FA vapor was determined using a FA detector DL923407 produced by Ningbo Deli Tools Co., Ltd. (Zhejiang, China).

Preparation for FAP-EVA films

Due to the poor solubility of FAP, FAP-EVA films were fabricated by mixing FAP with EVA and stirring thoroughly to achieve uniform dispersion of FAP in the EVA matrix. Specifically, 400 mg of EVA was dissolved in toluene, followed by the addition of 0.4 mg, 4.0 mg, and 12.0 mg of FAP, respectively. The mixtures were stirred for more than 3 hours to ensure homogeneous dispersion. After pouring into molds, the samples were placed in an oven and heated at 65-70 °C for over 3 hours to allow solvent evaporation, ultimately yielding FAP-EVA films with FAP concentrations of 0.1%, 1.0%, and 3.0 wt%.

Preparation of CLCN films

The CLCN films were prepared by photopolymerization reaction by mixing LC242, photoinitiator Irgacure 907, and chiral dopant CA (Table S1). The above mixture was dissolved with a solvent mixture of cyclohexanone and EA to obtain a solution with a solid content of 20 wt%. The solution was uniformly coated on a rubbing-oriented PET film using a 30 μm Mayer bar. After coating, the samples were heated at 120 °C for 3-5 minutes to evaporate the solvent. Finally, the CLCN films were obtained by curing with a high-pressure Hg lamp (1.0 kW) at 80 °C.

Preparation of CLCE films

The CLCE-coated PET films were prepared by photopolymerization reaction by mixing LC242, RM105, chain transfer agent MPD, chain extender PE400, photoinitiator Irgacure 907 and chiral dopant CA-Acrylate (Table S2). The above mixture was dissolved with a solvent mixture of cyclohexanone and cyclopentanone to obtain a solution with a solid content of 20 wt%. The solution was uniformly coated on a rubbing-oriented PET film using a 40 μm Mayer bar. After coating, the samples were heated at 120 °C for 3-5 minutes to evaporate the solvent. Finally, the CLCE films were obtained by curing upon irradiation with a 365 nm LED lamp (400 mW cm^{-2}) 20 s at 40 °C.

Preparation of FAP-CLCE films

FAP was dissolved in DMAC at a concentration of 1 mg mL^{-1}. The CLCE film was placed on a hot stage set at 90 °C, and the solution of FAP in DMAC was added dropwise slowly. After the solvent evaporated completely, the dropwise addition was repeated. This process was continued until 0.25 mL of the solution had been added, followed by complete solvent evaporation. Finally, the FAP-CLCE film was obtained.

References

S1 P. Yadav, H. Laddha, M. Agarwal and R. Gupta, *J. Mol. Liq.*, 2021, **324**, 114690.

Table S1 Mass percentages (wt%) of compounds in CLCN films with different concentrations of CA.

LC242	Irgacure 907	CA
92.60	3.00	4.40
92.80	3.00	4.20
93.20	3.00	3.80
93.35	3.00	3.65
93.50	3.00	3.50
93.90	3.00	3.10
94.2	3.00	2.80

Table S2 Mass percentages (wt%) of compounds in CLCE films with different concentrations of CA-Acrylate.

LC242	RM105	PE400	MPD	Irgacure 907	CA-Acrylate
76.73	9.13	4.57	1.37	3.65	4.55
76.88	9.13	4.57	1.37	3.65	4.40
77.03	9.13	4.57	1.37	3.65	4.25
77.18	9.13	4.57	1.37	3.65	4.10
77.33	9.13	4.57	1.37	3.65	3.95
77.48	9.13	4.57	1.37	3.65	3.80
77.63	9.13	4.57	1.37	3.65	3.65
77.78	9.13	4.57	1.37	3.65	3.50

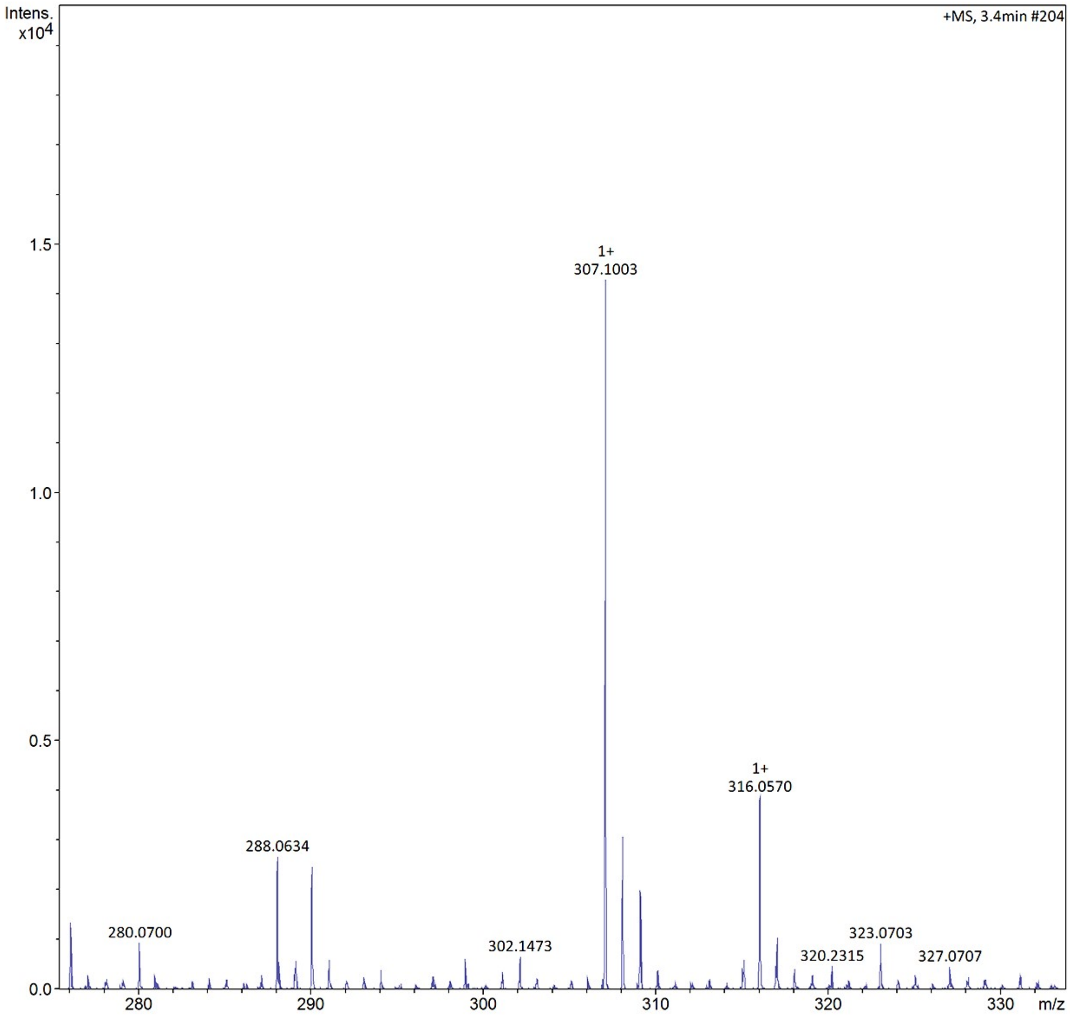

Fig. S1 Mass spectrum of FAP after the reaction with FA.

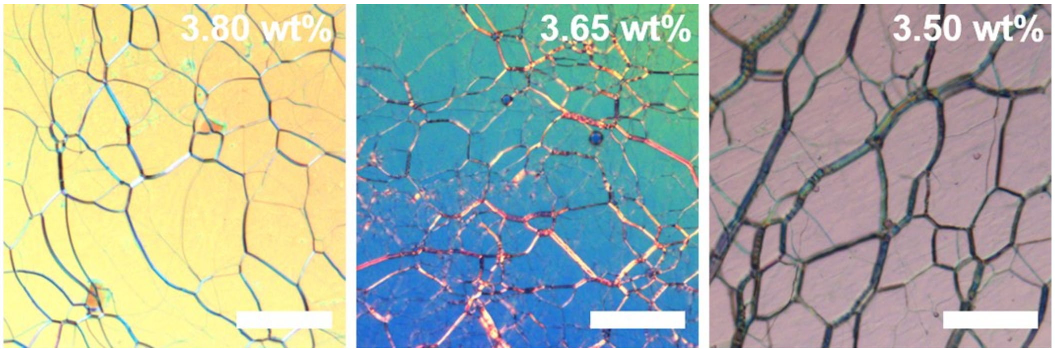

Fig. S2 POM images of CLC mixtures at different concentrations of CA at 80.0 °C. Scale bar: 100 μm.

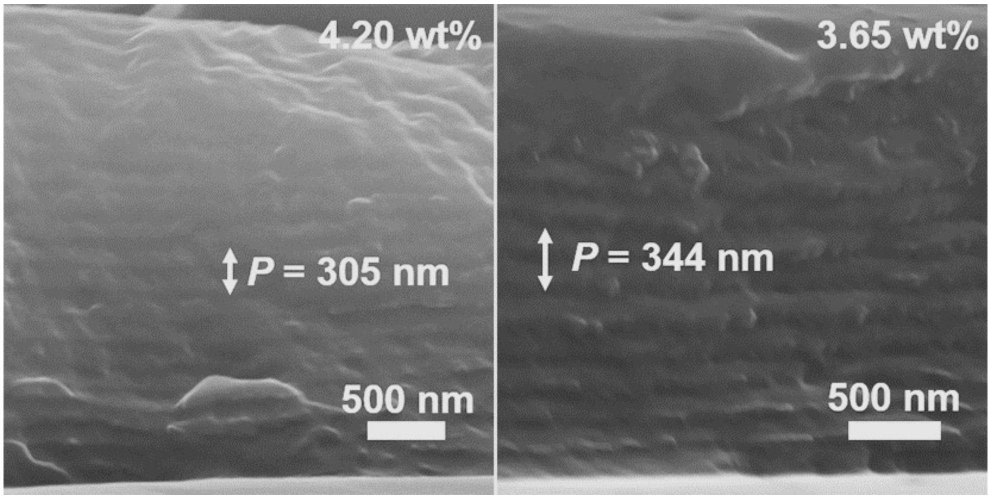

Fig. S3 Cross-sectional FE-SEM images of CLCN films with different concentrations of CA.

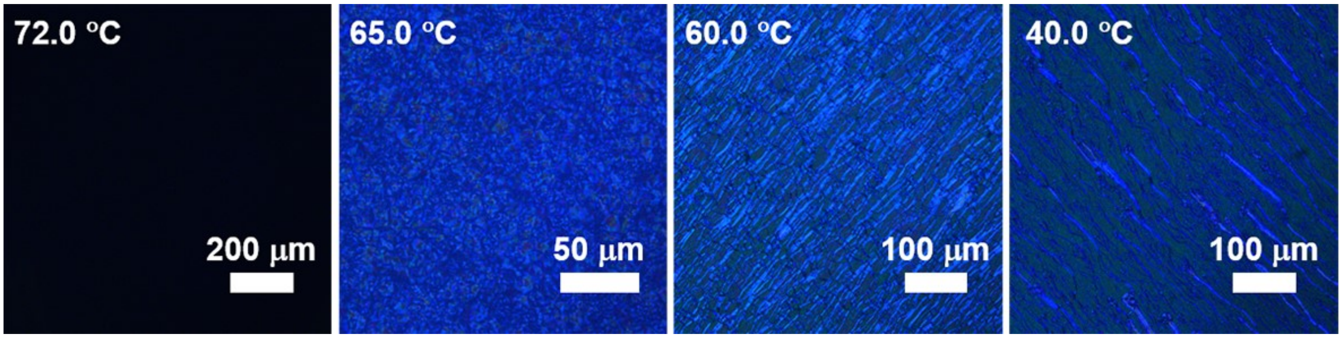

Fig. S4 POM images of the CLC mixture (LC242/RM105/Irgacure 907/PE400/MPD/CA-Acrylate, w/w/w/w/w/w, 77.63/9.13/4.57/1.37/3.65/3.65) taken at different temperatures during the cooling process.

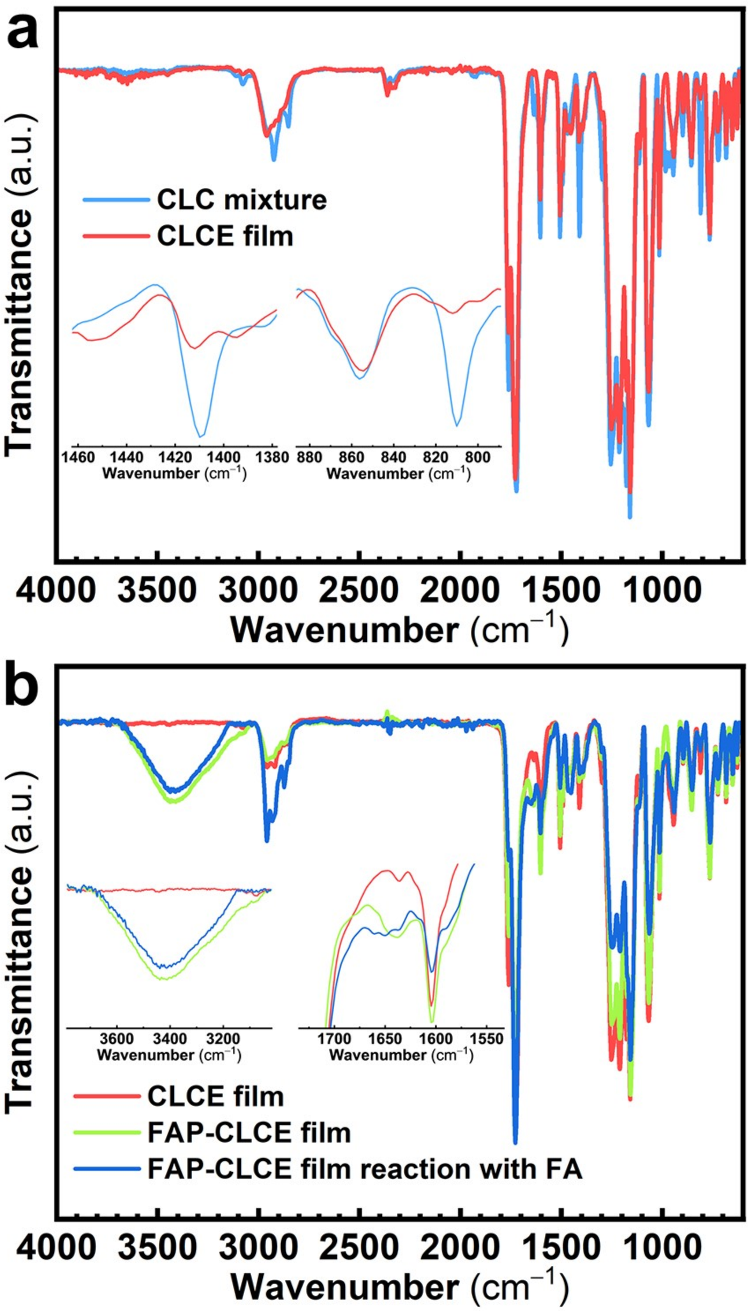

Fig. S5 FT-IR spectra of (a) the CLC mixture before and after photopolymerization, and (b) the CLCE film, FAP-CLCE film, and the FAP-CLCE film after treatment with FA.

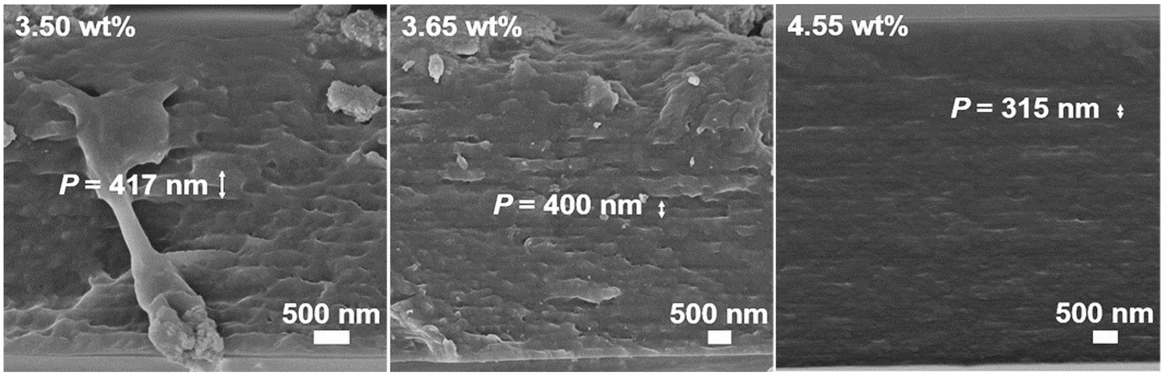

Fig. S6 Cross-sectional FE-SEM images of CLCE films with different concentrations of CA-Acrylate.

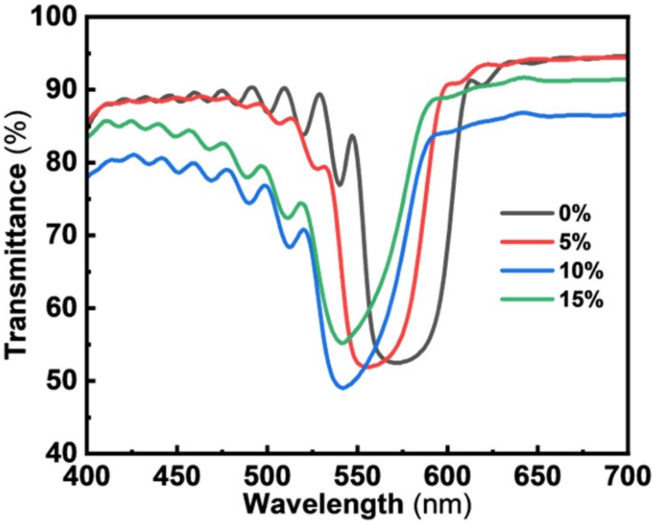

Fig. S7 UV-vis spectra of the CLCE/TPU film taken under different uniaxial stretching strains.

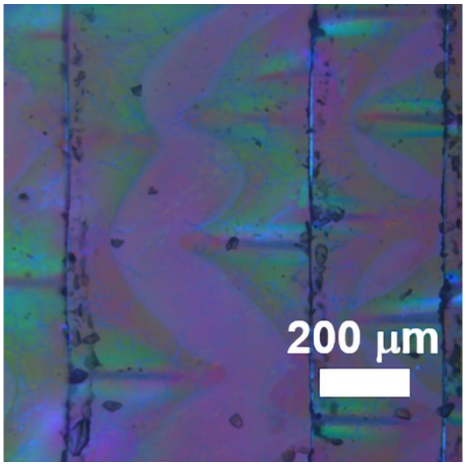

Fig. S8 POM images of the CLCE/TPU film taken upon 15% of uniaxial stretching strain.

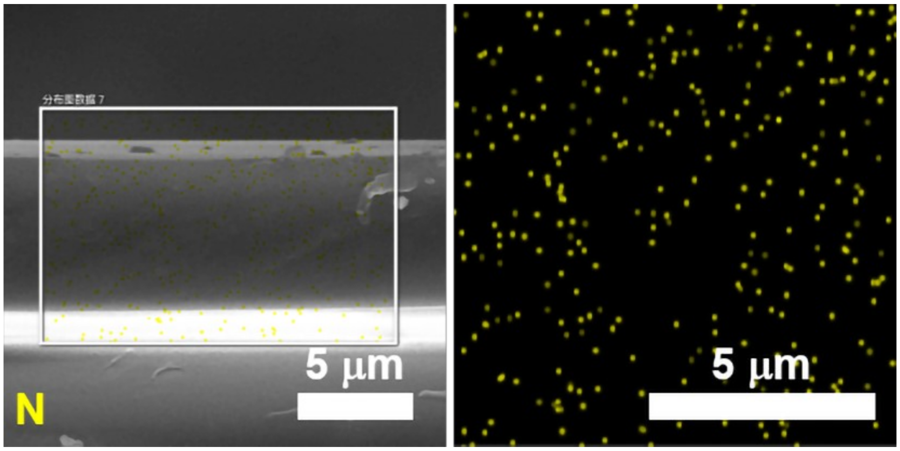

Fig. S9 Cross-sectional EDS nitrogen mapping of FAP-CLCE film.

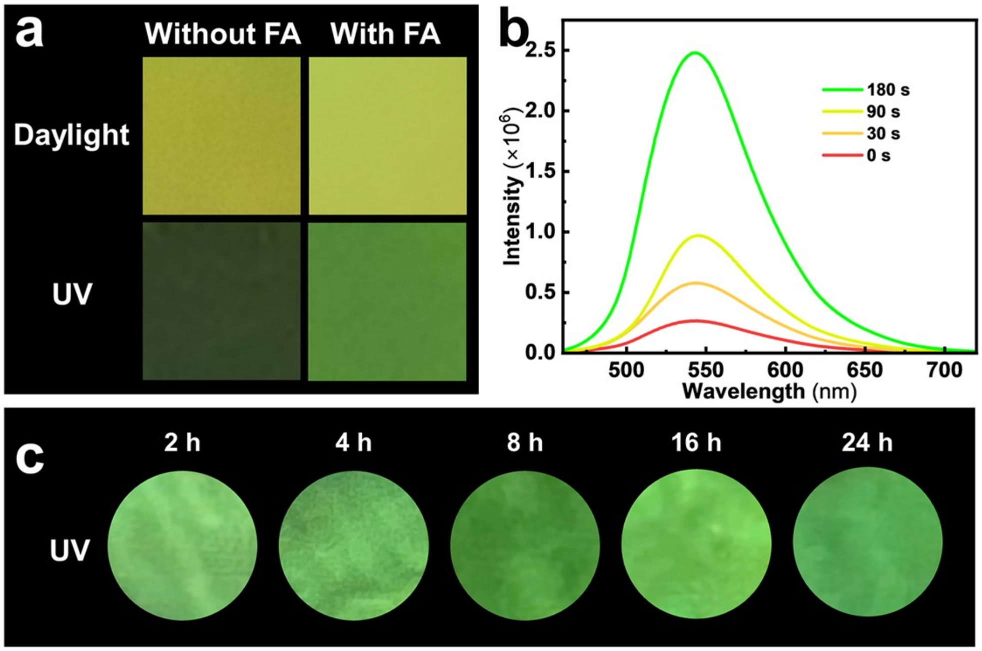

Fig. S10 (a) Photographs of FAP-CLCE films under daylight and 365-nm UV light before and after the FA treatment for 180 s, and (b) the time-dependent emission spectra during the diffusion of FA vapor; (c) photographs of the FAP-CLCE film after the treatment with FA upon leaving the formaldehyde environment at different times under 365 nm UV light.

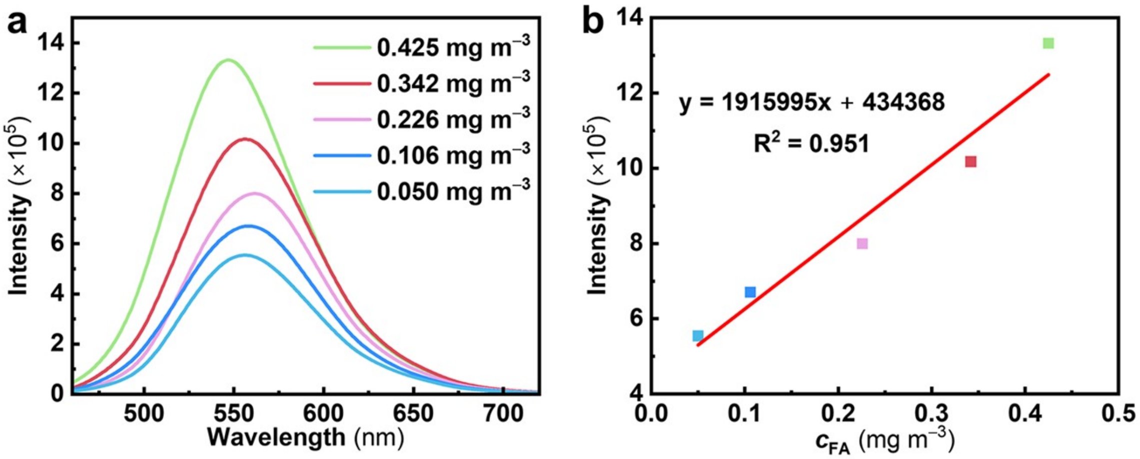

Fig. S11 (a) Emission spectra of FAP-CLCE film after exposure to FA vapor for 180 s, and (b) linear correlation between emission maxima and FA concentration.

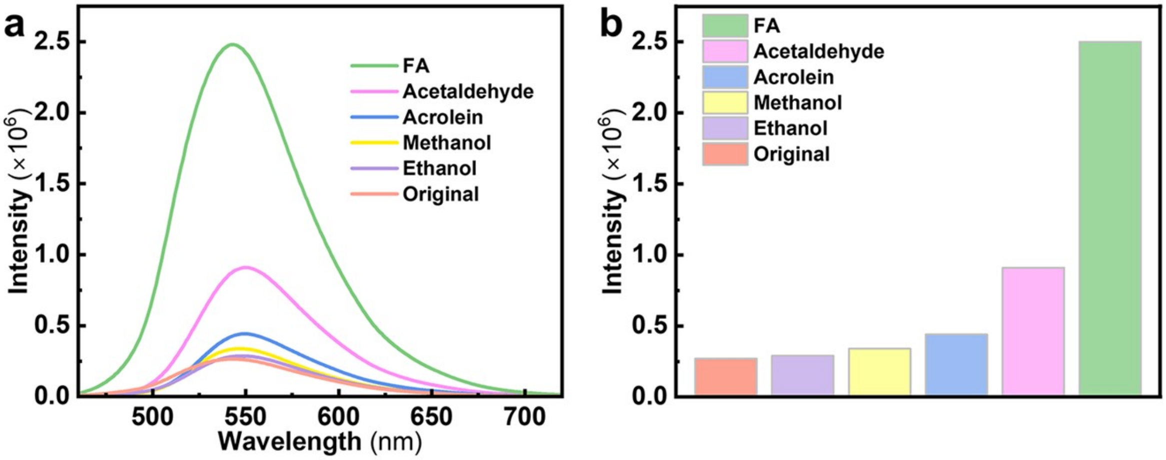

Fig. S12 (a) Emission spectra and (b) intensity maxima of FAP-CLCE films before and after exposure to FA, acetaldehyde, acrolein, methanol, and ethanol for 180 s, respectively.