# Supporting Information

## Enhancing hole carrier injection via low electrochemical doping on circularly polarized polymer light-emitting diodes †

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† Dedication:To the memory of Professor Alasdair James Campbell.

¶ Deceased

| EML | Turn-on voltage (V) at 1 cd/m$^2$ | Luminance (cd/m$^2$) at 70 mA/cm$^2$ | Luminance (cd/m$^2$) at 10 mA/cm$^2$ | Luminous Efficiency (cd/A) | | Power Efficiency (lm/W) | |
|---|---|---|---|---|---|---|---|
| | | | | Peak | @100 cd/m$^2$ | Peak | @100 cd/m$^2$ |
| F8BT neat | 4.9 | 2549 | 395 | 3.8 @9.6V | 3.0 | 1.4 @7.6V | 1.3 |
| F8BT:aza[6]H | 8.3 | 1018 | 70 | 1.5 @>15V | 0.8 | 0.3 @>15V | 0.2 |
| F8BT:aza[6]H: EDA | 6.3 | 2115 | 280 | 3.1 @12.8V | 2.4 | 0.9 @10.2V | 0.8 |

**Table. S1.** Summary of PLED performance showing the turn-on voltage (at 1 cd/m$^2$), peak luminous efficiency (cd/A), and peak power efficiency (lm/W) and their values at 100 cd/m$^2$.

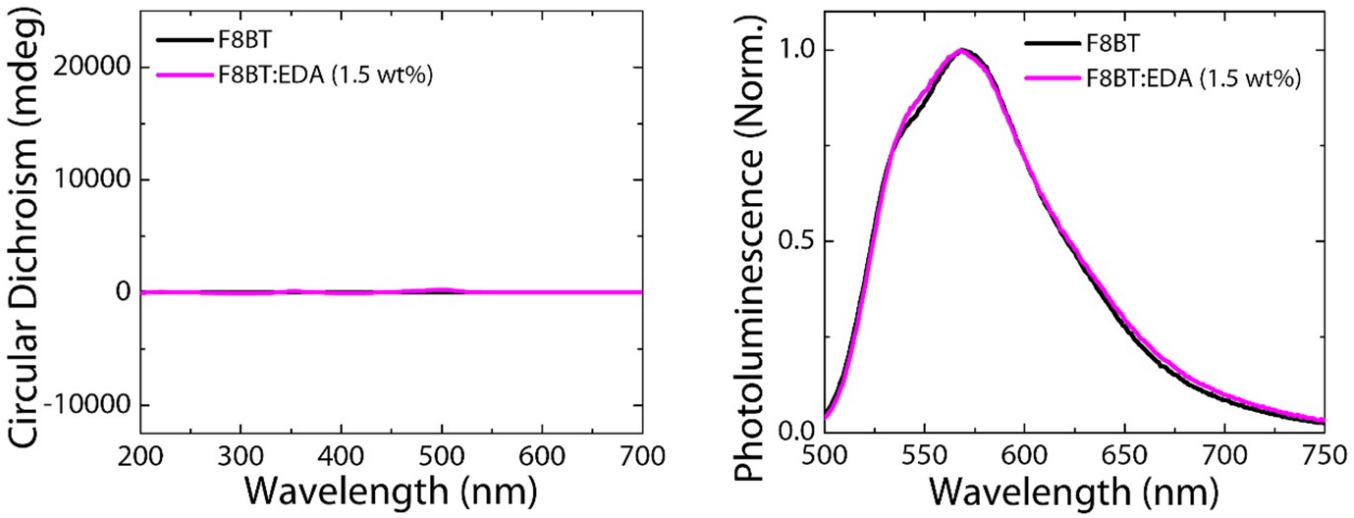


**Fig. S1.** CD spectra and normalized photoluminescence spectra of F8BT and F8BT:EDA thin films.

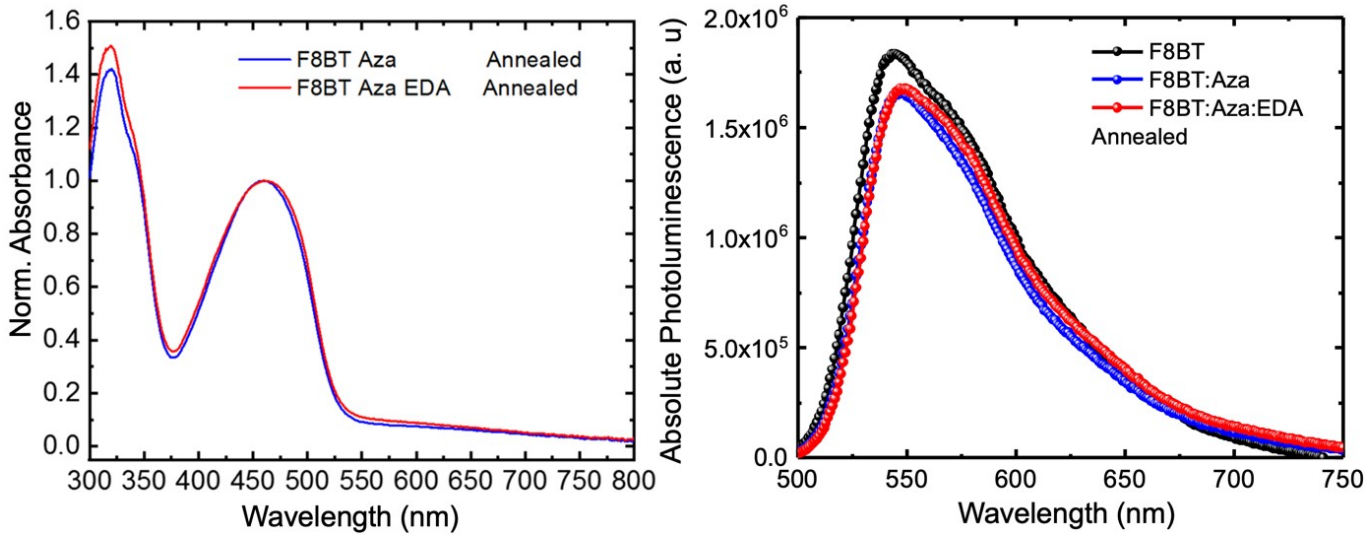


**Fig. S2.** Normalized absorption spectra and absolute photoluminescence of F8BT:aza[6]H and F8BT:aza[6]H:EDA thin films.

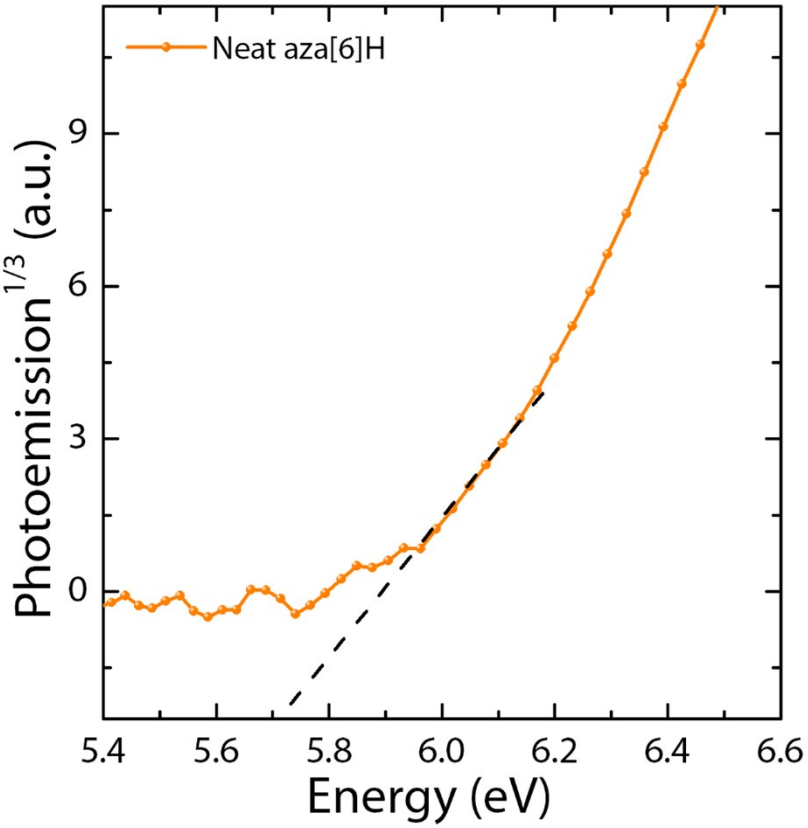


**Fig. S3.** APS spectra of the neat aza[6]H film. The dashed line (Black) indicates the HOMO level of the neat aza[6]H film.

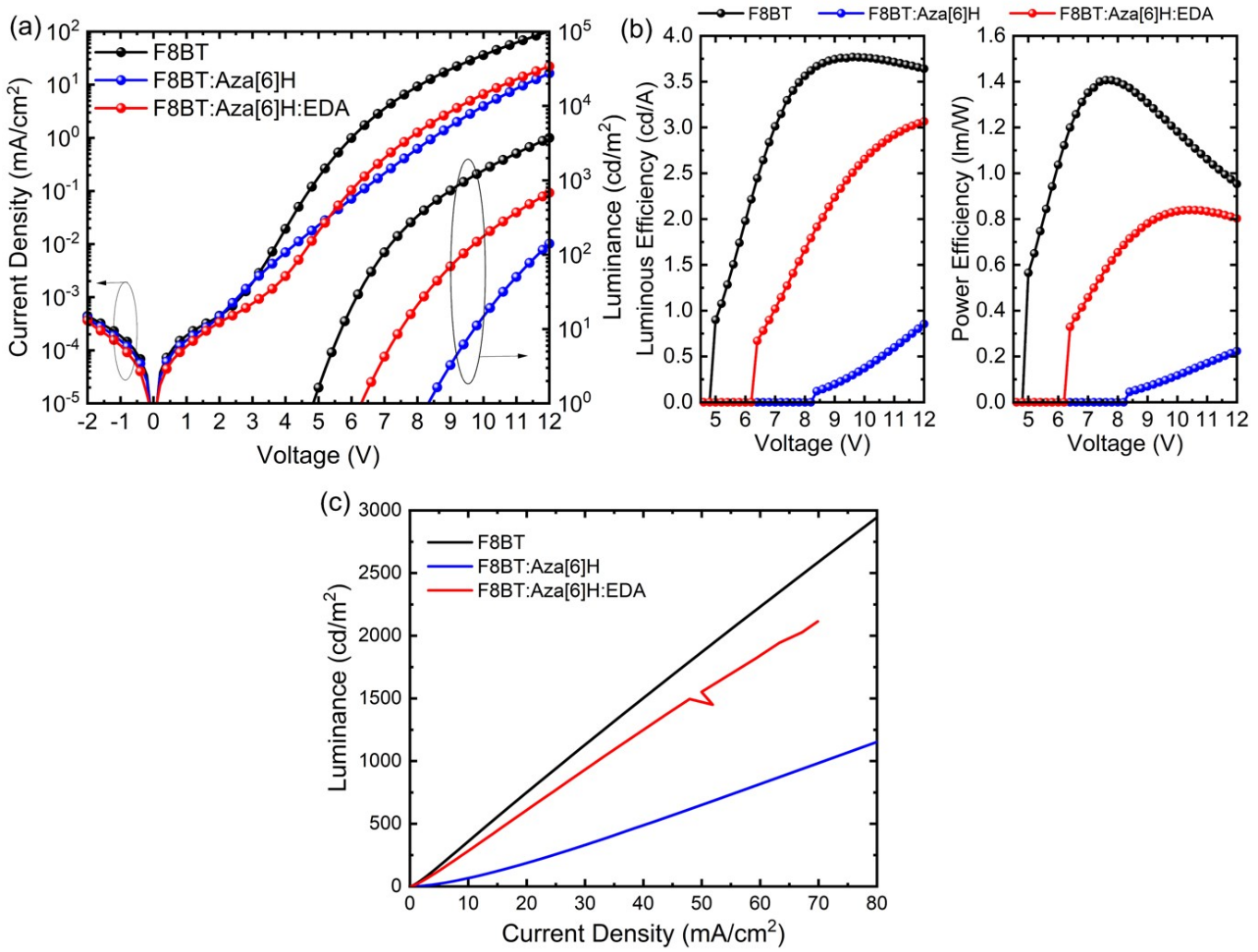


**Fig. S4.** *J-V-L* characteristics of 9K F8BT reference PLED devices (a). Corresponding luminance efficiency and power efficiency of 9K F8BT-based PLED devices (b). (c) Luminance as a function of current density. At the same current density (such as 70 mA/cm$^2$), F8BT:aza[6]H PLED had a much lower luminance (1018 cd/m$^2$) than neat F8BT PLED (2549 cd/m$^2$). Large amounts of charge carriers were injected to aza[6]H without recombination due to the shallower subgap tail states of aza[6]H. By adding the EDA, the electrochemical doping process occurring between F8BT and the EDA can enhance direct charge injection to F8BT instead of aza[6]H, thereby increasing luminance (2115 cd/m$^2$) as a manifestation of increasing charge carrier recombination.

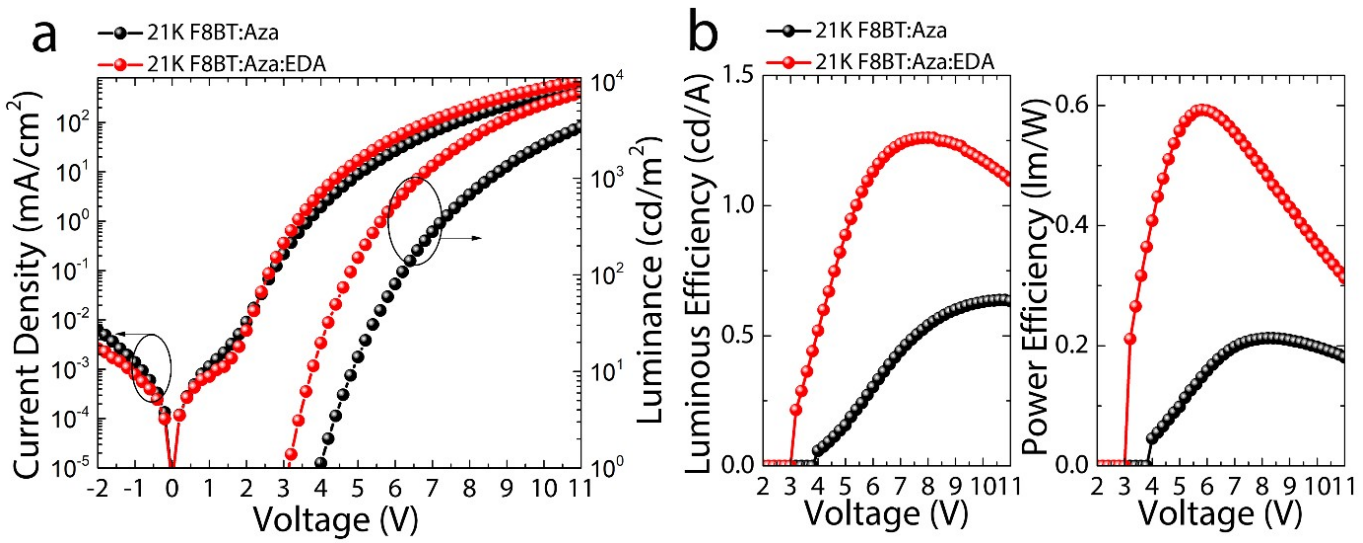


**Fig. S5.** a) Comparisons of the *J-V-L* characteristics of 21K F8BT:aza[6]H and F8BT:aza[6]H:EDA-based CP-PLED devices. b) Corresponding luminance efficiency and power efficiency.

The F8BT (MW = 21 K):aza[6]H:EDA PLED had a 1 V lower $V_L$ and a sharper current turn-on at 2 V than F8BT:aza[6]H, which indicates more efficient charge injection. Increases in the luminous and power efficiencies up to 1.3 cd/A and 0.6 lm/W, respectively, were also achieved, which are higher efficiencies than those of the F8BT:aza[6]H PLED (0.65 cd/A and 0.24 lm/W, respectively). These device improvements are consistent with those of the abovementioned 9 K F8BT device.

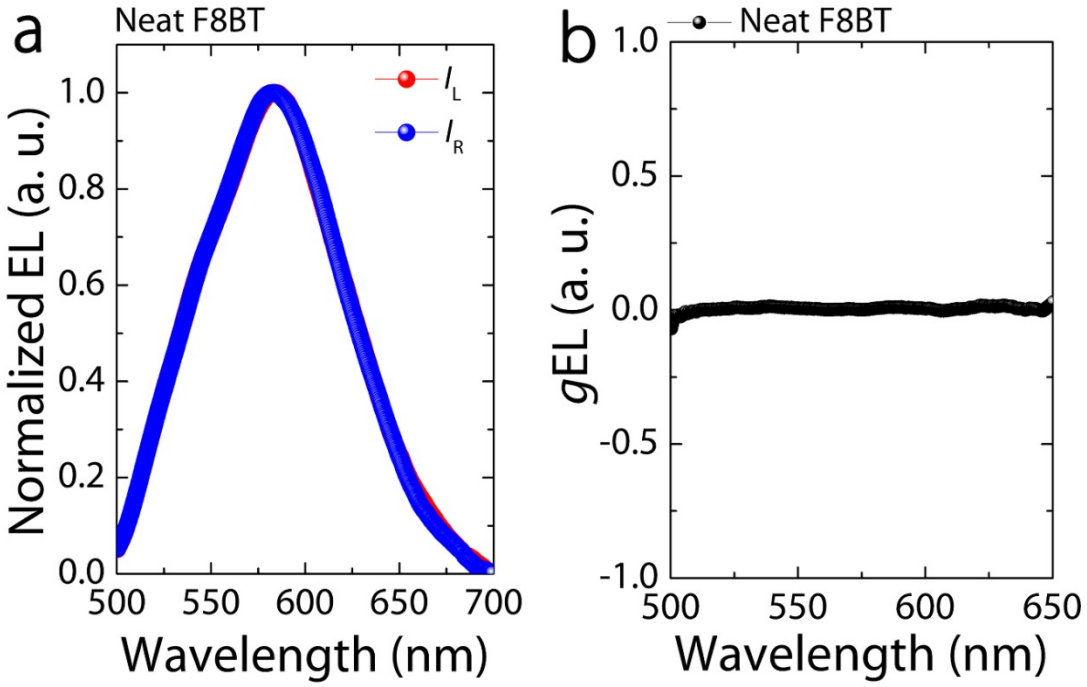


**Fig. S6.** Measured CP-EL spectra (a) and corresponding calculated $g_{EL}$ values (b) obtained for neat F8BT reference PLEDs. No CP emission was emitted from neat F8BT PLEDs

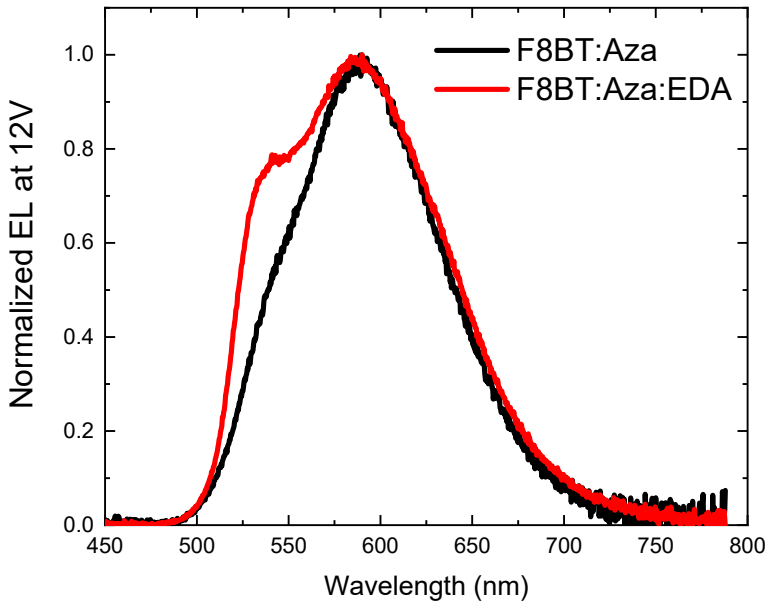


**Fig. S7.** Normalized EL spectra of F8BT:aza[6]H and F8BT:aza[6]H:EDA at 12 V with a 190-nm-thick active layer. The relative EL intensity at 525-530 nm increases with EDA doping, possibly indicating a change in the recombination zone.

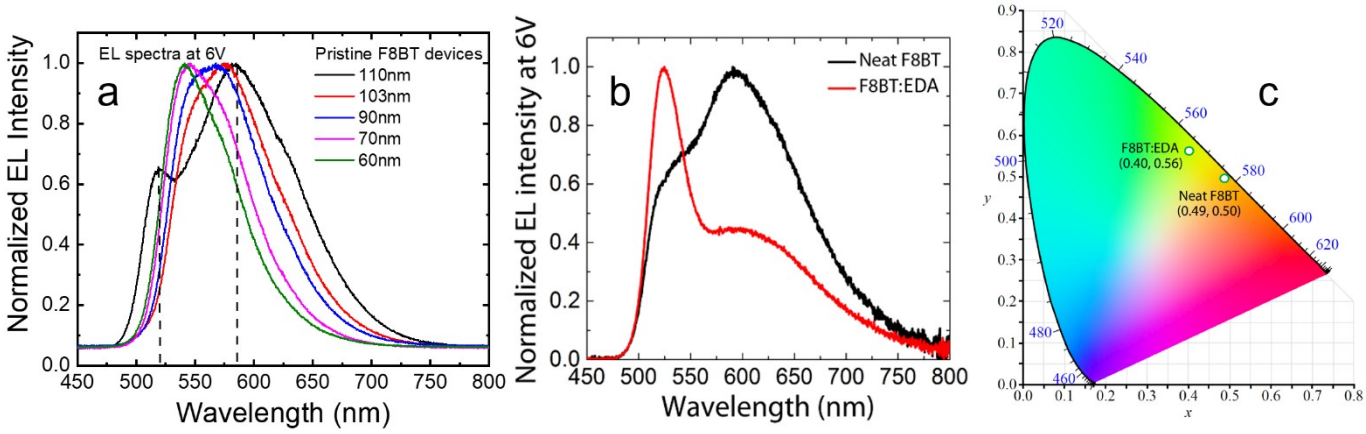


**Fig. S8.** (a) Thickness-dependent EL spectra of pristine F8BT PLEDs. (b) EL spectra of neat F8BT and F8BT:EDA PLEDs. (c) CIE coordinates for F8BT and F8BT:EDA PLEDs.

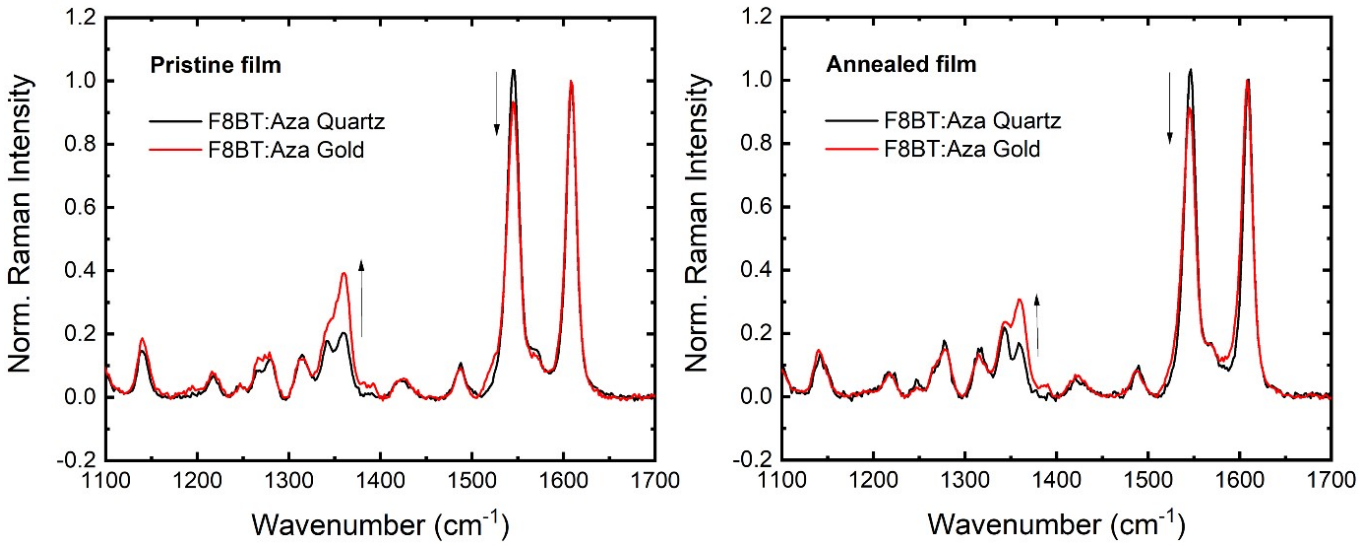


**Fig. S9.** Surface-enhanced Raman spectroscopy (SERS) for F8BT:aza pristine and annealed films on quartz or gold substrates. Compared with quartz substrates, the selective peak intensity increase at 1360 $cm^{-1}$ on gold substrates indicates the presence of aza[6]H, implying that aza[6]H mainly accumulates at the gold/F8BT interface of annealed films.