Supplementary information

The Synergistic Effect of Processing Solvents on Magnetic Manipulation of Orientational Order and Carrier Transport of the Semiconducting polymers

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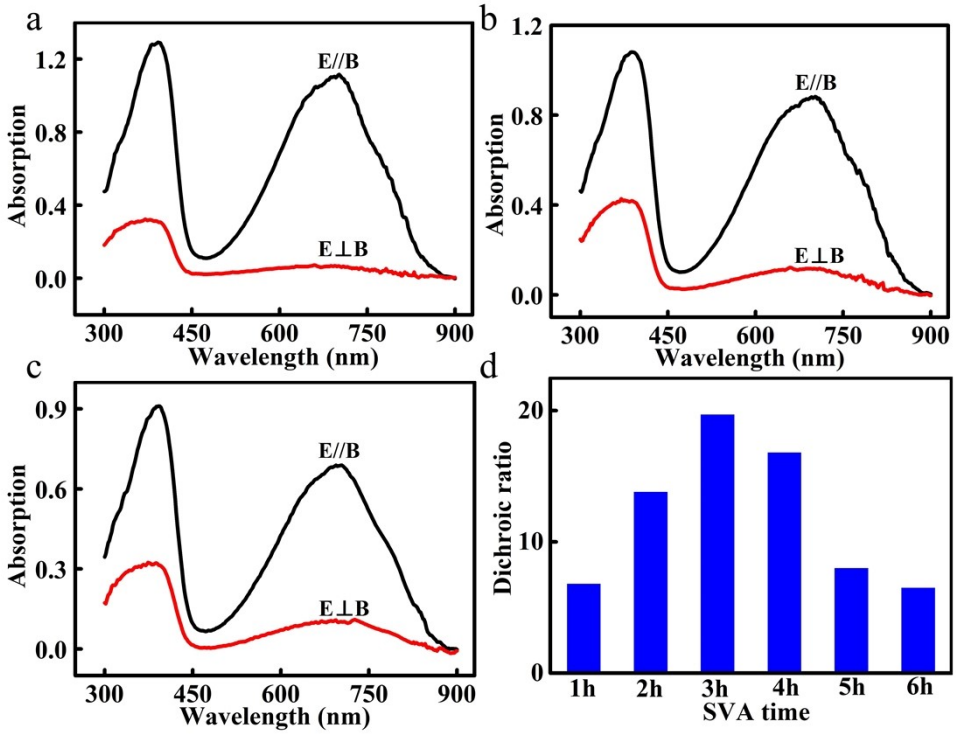

Figure S1. Polarized UV−vis absorption spectra of the P(NDI2OD-T2) films annealed via SVA-HMF (9T) in CF vapor for 4h (a), 5h (b), 6h (c), respectively. (d) Estimated dichroic ratios of the align films via SVA-HMF in CF vapor for different SVA time, based on the absorption spectra data shown in Figure S1 (a-c) and Figure 2 (a-c).

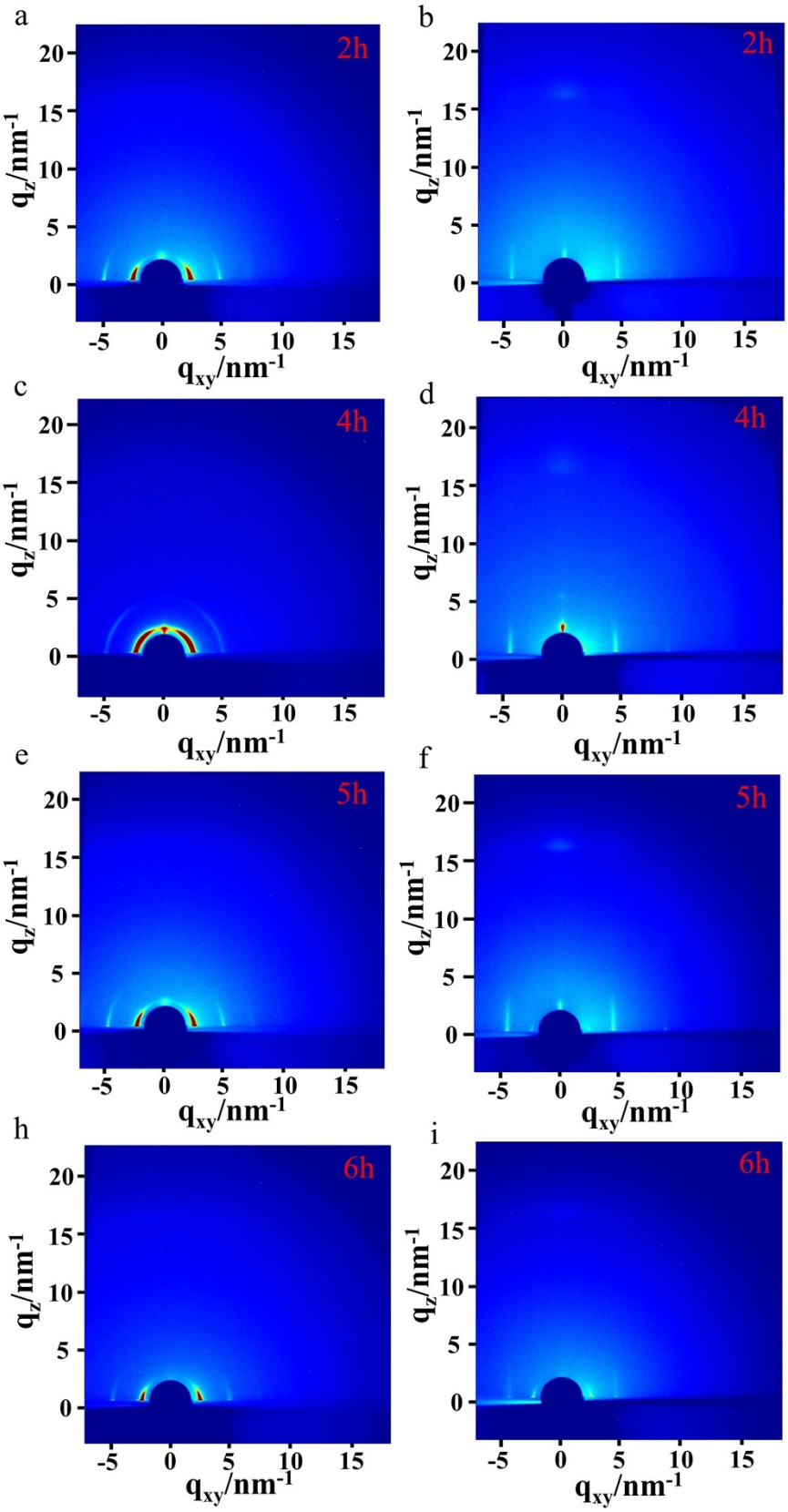

Figure S2. 2D GIXRD patterns of the P(NDI2OD-T2) films grown via SVA-HMF in CF vapor for 2h (a, b), 4h (c, d), 5h (e, f), 6h (h, i), respectively. The in-plane scatter vector q_{xy}

is perpendicular (a, c, e, h) and parallel (b, d, f, i) to the magnetic field applied during SVA, respectively.

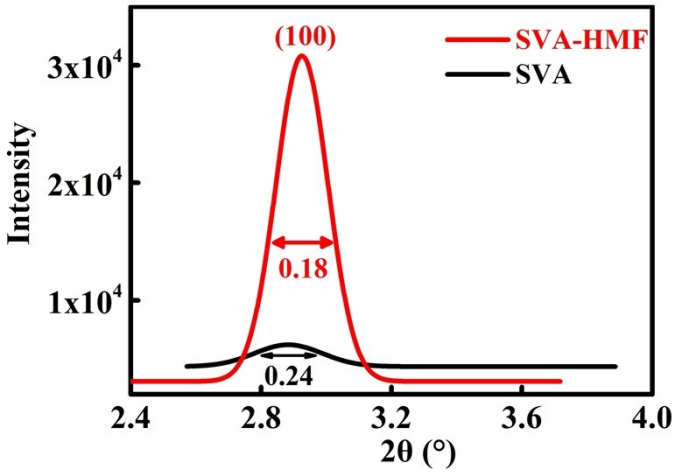

Figure S3. Cross-section profiles of the (100) reflection from the 2D-GIXRD patterns of the P(NDI2OD-T2) films grown via SVA-HMF and SVA without HMF in the CF vapor for 3h, respectively. The crystalline correlation length is estimated by Scherrer equation:

$$D = \frac{k\lambda}{B\cos\theta}$$

where D is the crystallite size, λ is the X-ray wavelength in our experiment (0.124 nm), θ is the Bragg angle of the diffraction peak, and B is the FWHM of a diffraction peak in radians.

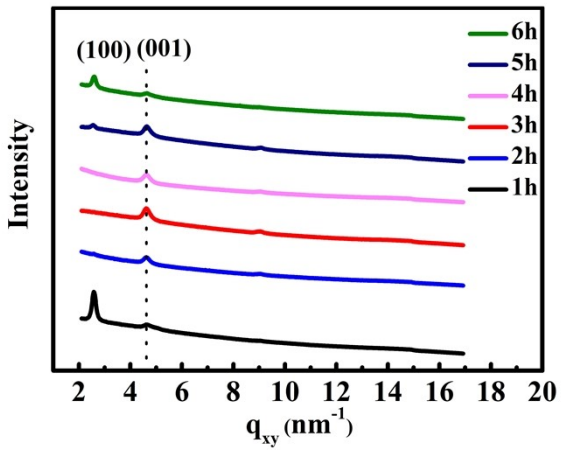

Figure S4. Cross-section profiles at q_{xy}//B along the q_{xy} direction of the aligned P(NDI2OD-T2) films treated for different SVA-HMF time, which are re-arranged from Figure 4(a-f) of main text.

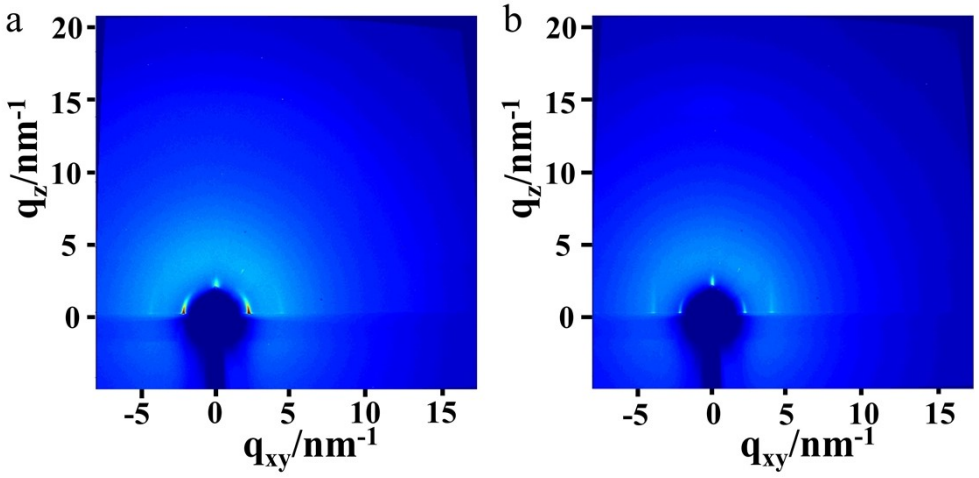

Figure S5. 2D GIXRD patterns of the P(NDI2OD-T2) films grown via SVA-HMF in the TL vapor for 6h. q_{xy} is perpendicular (a) and parallel (b) to the magnetic field applied during SVA, respectively.

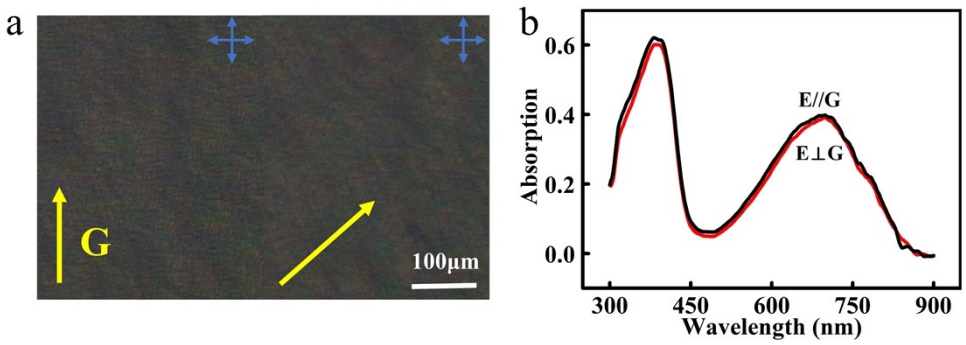

Figure S6. (a) POM images and (b) Polarized UV−vis absorption spectra of the P(NDI2OD-T2) film grown via SVA (without HMF) under the atmosphere of CF for 3h. The yellow and blue arrows in Fig S4a denote the gravity field direction and the orientation of the crossed polarizer/analyzer, respectively. **G** denotes the direction of "gravity" during SVA. The film exhibits a negligible change of brightness in the POM images when rotating the samples, revealing the isotropic (unaligned) character.

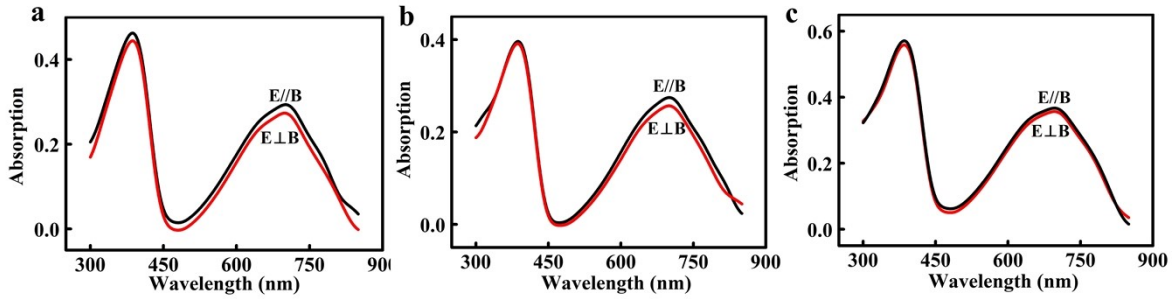

Figure S7. Polarized UV−vis absorption spectra of the P(NDI2OD-T2) films prepared via SVA-HMF in acetone vapor for 1h (a), 3h (b), 6h (c), respectively.

As shown in Figure S7, although the strength of absorption the magnetic field direction during solvent annealing is parallel to the polarization direction of the incidence light is negligible, the faint difference of absorption illustrates that HMF also have positive effect on the alignment of P(NDI2OD-T2) in dry films.

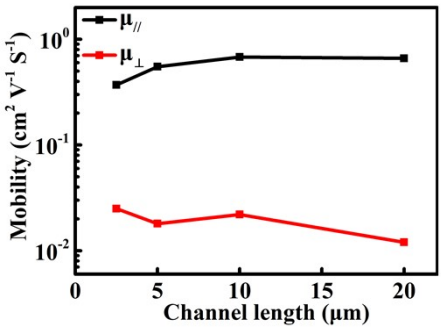

Figure S8. Dependence of electron mobility on channel length for both current directions. $\mu_{//}$ and $\mu_{\perp}$ are extracted from the transfer curves of the TG/BC FETs shown in Figure 7b and Figure S8.

The reduced $\mu_{//}$ on the shorter channel (below 10 μm) devices is revealed, which should be attributed to the enhanced contribution from contact resistance (at the polymer/S (D) electrode) to total device resistance when the channel length is shrunk.[1, 2] The huge impact of contact resistance is also manifested from a clear super-linearity of the I_D-V_D curves at low V_D regime for the parallel devices (in Figure 7C). In contrast, the $\mu_{\perp}$ values exhibit a weak dependence on channel length. It may originate from inferior carrier transport properties perpendicular to the chain alignment (consequently dominant contribution of the

channel resistance). The lowering of contact resistance can be expected if modifying the source/drain contacts by self-assembly monolayers.[3]

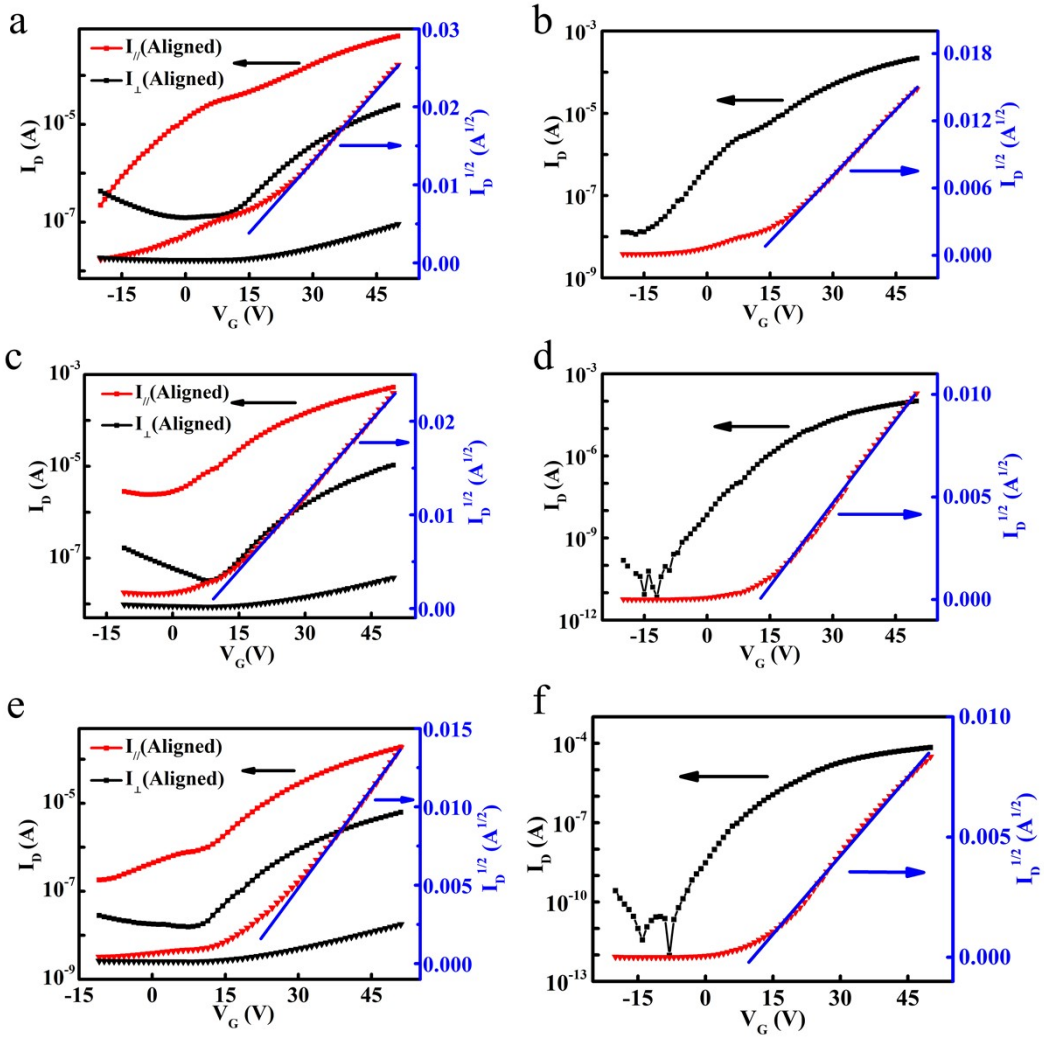

Figure S9. Transfer curves of the TG/BC OFETs (W=2 mm) employing the aligned P(NDI2OD-T2) films via 3h SVA-HMF in chloroform (CF) vapor (a, c, e) as well as isotropic P(NDI2OD-T2) films annealed by CF vapor for 3h in absent of HMF (b, d, f). The devices are characteristic of different channel length: 2.5 μm (a-b), 5 μm (c-d), 10 μm (e-f). The channel current is parallel ($I_{//}$) and perpendicular ($I_{\perp}$) to the magnetic alignment direction, respectively.

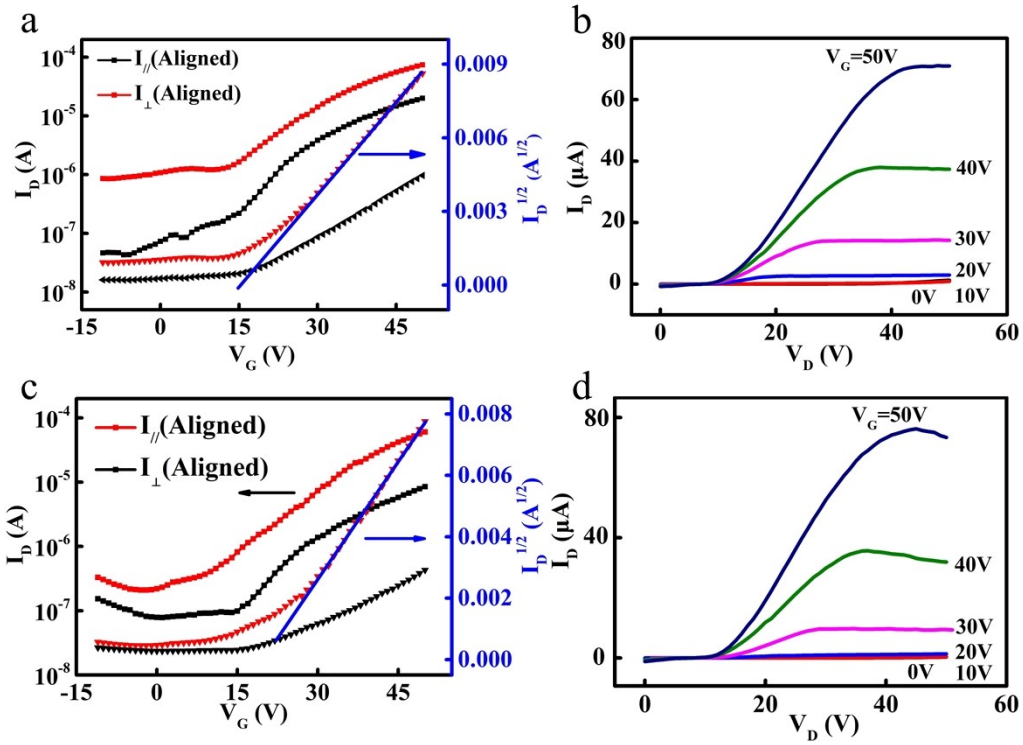

Figure S10. (a, c) Typical transfer curves of the top-gate/bottom-contact (TG/BC) OFETs (W = 2.0 mm and L = 20 μm) made of the aligned P(NDI2OD-T2) films via 1h (a) and 6h (c) SVA-HMF in CF vapor. $I_{//}$ and $I_{\perp}$ denote the channel current parallel and perpendicular to the direction of applied magnetic field during the SVA-HMF. (b, d) Corresponding output curves of the TG/BC devices with channel current parallel to the alignment direction.

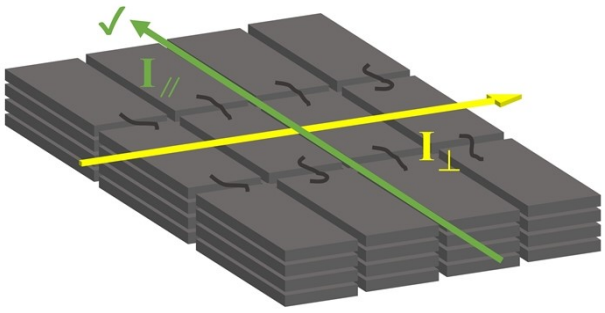

Figure S11. Schematic diagram of carrier transport pathways in the aligned P(NDI2OD-T2) films with respective to the orientation of crystalline domains consisting of the aligned polymer chains.

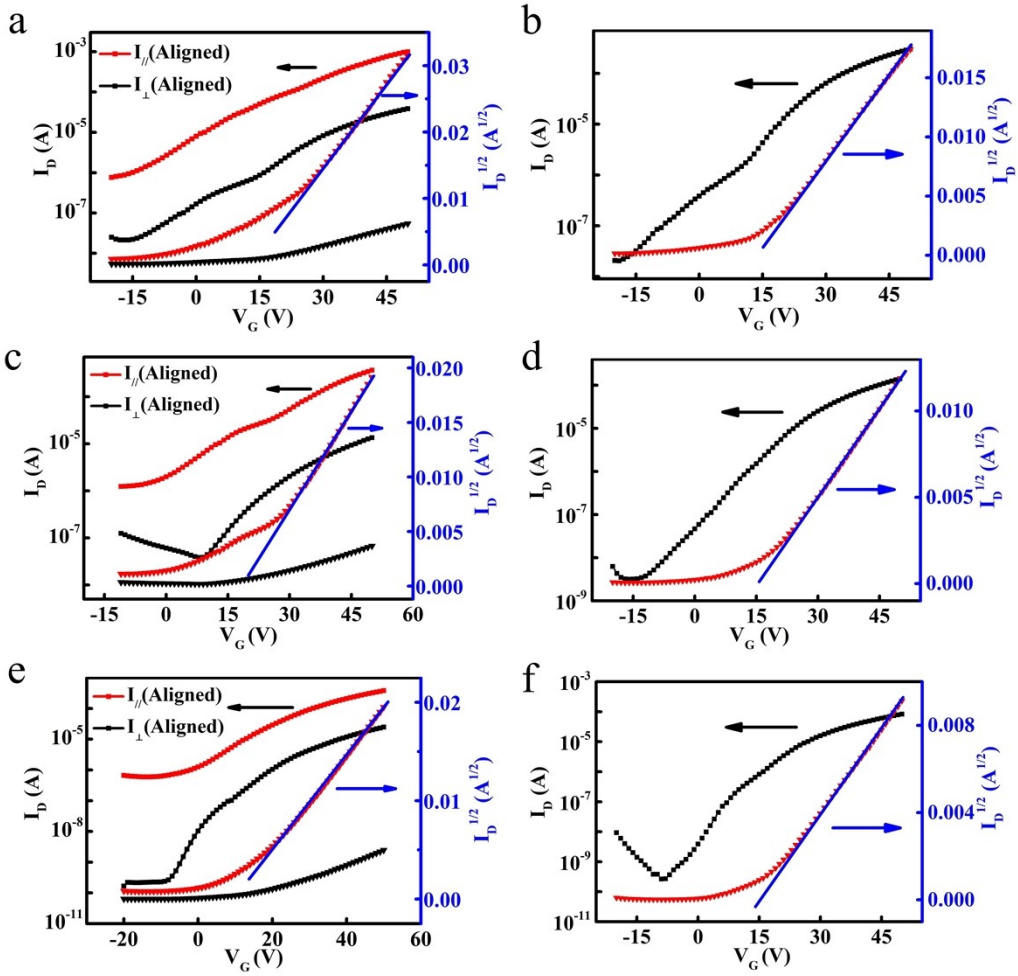

Figure S12. Transfer curves of the TG/BC FETs (W = 2 mm) employing the aligned P(NDI2OD-T2) films prepared via SVA-HMF in toluene (TL) vapor for 6h (a, c, e, h) as well as isotropic P(NDI2OD-T2) films annealed by TL vapor for 6h via SVA in absent of HMF (b, d,f, i). The devices are characteristic of different channel length: 2.5 μm (a-b), 5 μm (c-d), 10 μm (e-f) and. The channel current is parallel ($I_{//}$) and perpendicular ($I_{\perp}$) to the magnetic alignment direction, respectively.

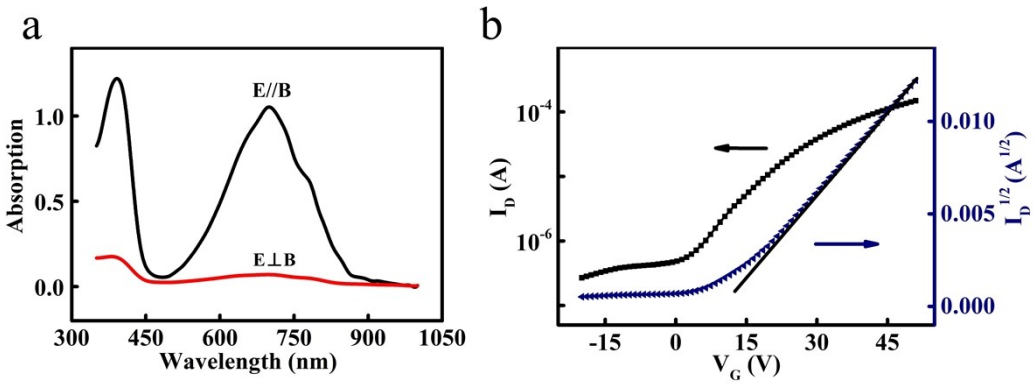

Figure S13. (a) Polarized UV−vis absorption spectra of the aligned P(NDI2OD-T2) films which is cast from the TL solution and treated via SVA-HMF in CF vapor for 6h; (b) Transfer curves of the TG/BC OFET (W = 2 mm and L = 20μm) employing such an aligned film. The channel current is parallel to the magnetic alignment direction.

References

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2 C. Kim, *Applied Physics Reviews*, 2020, **7**, 31306.

3 D. Natali and M. Caironi, *Adv. Mater.*, 2012, **24**, 1357-1387.