Supplementary Information

Directing block copolymer self-assembly with permanent magnets: photopatterning microdomain alignment and generating oriented nanopores

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Grain size determination

The orientation distribution coefficient, or orientational order parameter P_2, **Eq. 1**, is determined experimentally from Gaussian fits to the azimuthal intensity distribution.

The dependence of the magnetostatic energy E_m (**Eq. 2**) on field strength, grain size and $\Delta\chi$ facilitates measurement of grain size, if $\Delta\chi$ is known, and if P_2 is measured as a function of field strength. Specifically, the probability of observing a grain at an angle φ relative to the field is governed by a Boltzmann factor involving the magnetostatic energy, $|\Delta E_m| = |\Delta\varepsilon_m| V_g$. The integration of this probability (**Eq. 3**) yields an orientation distribution coefficient that is a function of the field strength. A least-squares fit of the experimentally measured $P_2(B)$ thereby provides an estimate for the characteristic grain size ξ, where the grain volume $V_g = \xi^3$.

$$P_2 = \left\langle \frac{1}{2}\left(3\cos^2\varphi - 1\right) \right\rangle \quad (1)$$

$$E_m = -\left(\frac{B^2}{2\mu_0}\right)\Delta\chi\xi^3\cos^2\varphi \quad (2)$$

$$P_2 = \frac{\int_0^{\pi} \frac{1}{2}(3\cos^2\varphi - 1)e^{-E_m/k_BT}\sin\varphi\, d\varphi}{\int_0^{\pi} e^{-E_m/k_BT}\sin\varphi\, d\varphi} \quad (3)$$

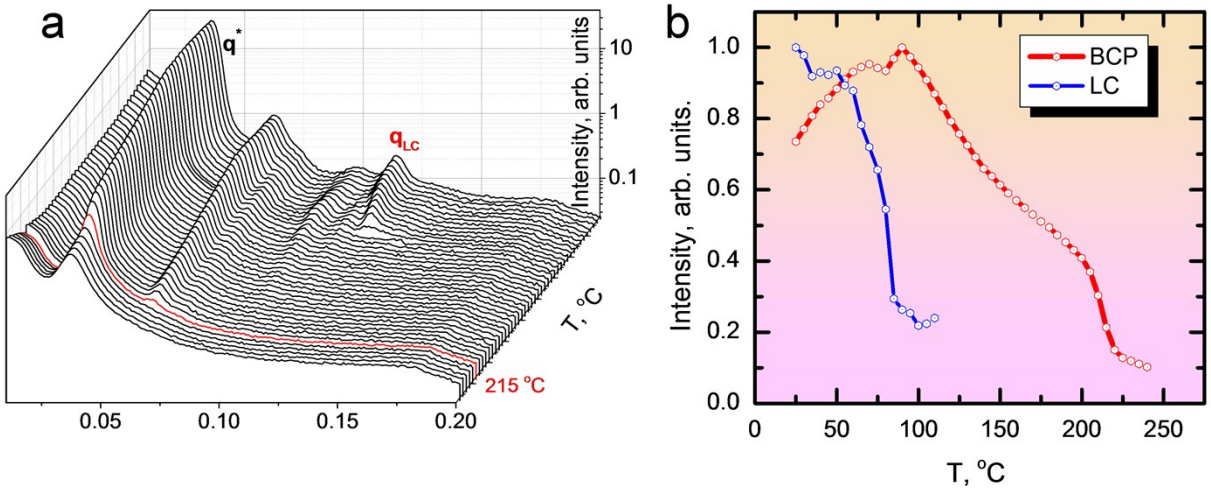

Figure S1: Temperature dependent scattering (a) and the corresponding scattering peak intensity plots of the BCP microstructure and the LC mesophase (b) from the neat block copolymer material. System shows a T_{odt} (~215 ºC) well separated from the LC clearing transition (~80 ºC).

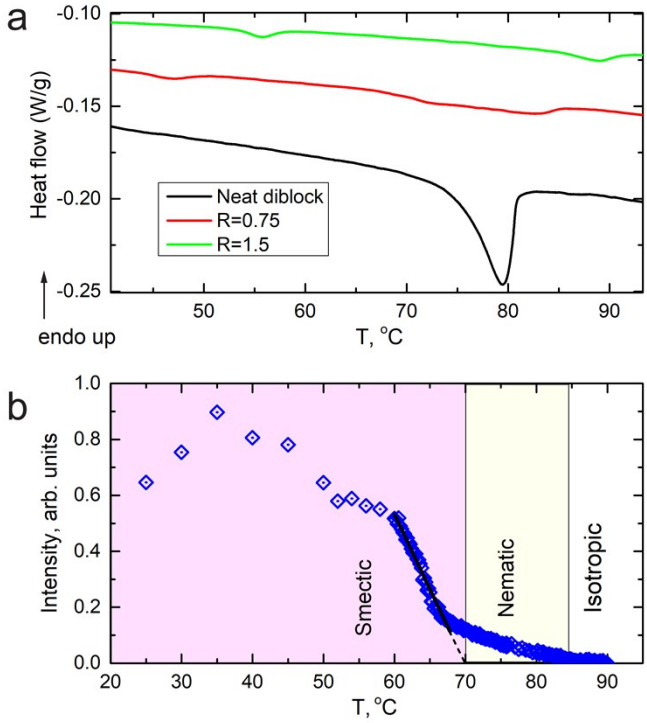

Figure S2: a) DSC data of the neat and blend materials measured during cooling at 2 ºC /min. The neat system displays a transition near 80 ºC that is attributed to the formation of a SmA phase directly from an isotropic state. R=0.75 displays 3 distinct transitions: Isotropic-Nematic transition, $T_{N\text{-}I}$~83 ºC, Nematic-SmA transition $T_{N\text{-}SmA}$~72 ºC, and crystallization at T_x~47 ºC. For R=1.5, $T_{N\text{-}SmA}$ is not readily discernible in DSC, while T_x~55 ºC and $T_{N\text{-}I}$~89 ºC. b) N-SmA transition for R=1.5 is identified from the temperature dependent scattering from the LC mesophase (blue data points) during cooling. The line shows a linear fit to the data from which the onset of N-SmA transition is identified at ~70 ºC.

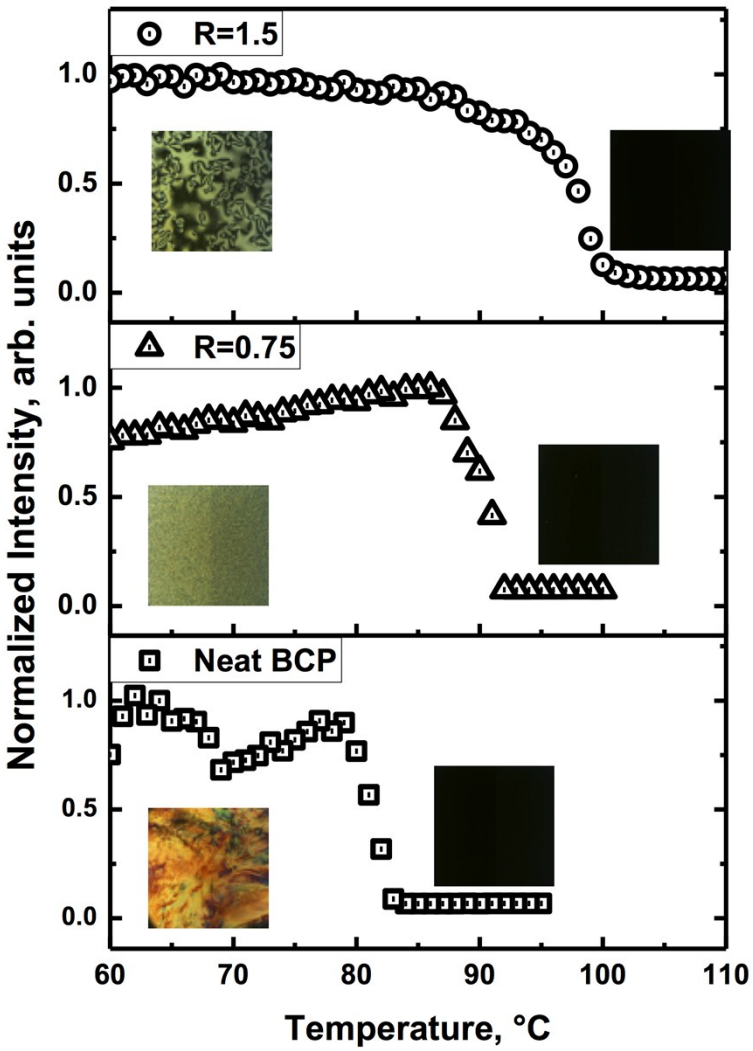

Figure S3. Temperature dependent polarized optical microscopy experiments conducted on (top to bottom) R=1.5, R=0.75 and R=0 (neat) samples Left and right insets shows POM images at 65 ºC and in the isotropic state, respectively.

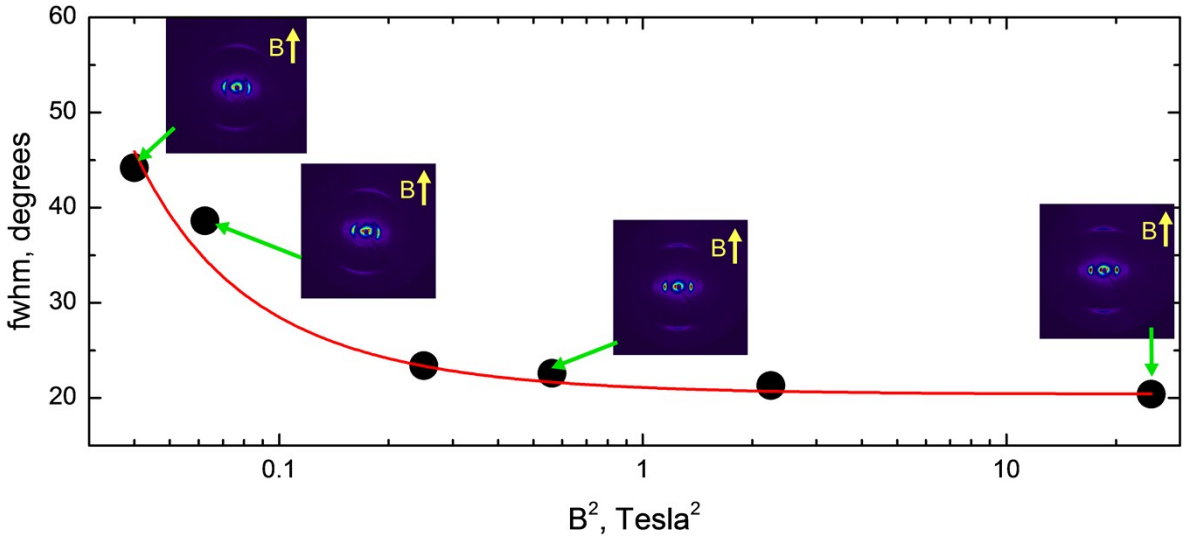

Figure S4. Field strength dependence of alignment of *NBCB$_{12}$-b-NBPLA3* material with crosslinkable LC (RM257) at a stoichiometry of R=1.5; Full width at half maximum (fwhm) of the microdomain scattering vs. B^2. The sample shows saturation of the alignment (fwhm~20 deg) at a field strength of ~0.5 T. The cooling rate chosen for these experiments was 0.5 ºC/min. The line is a visual guide.

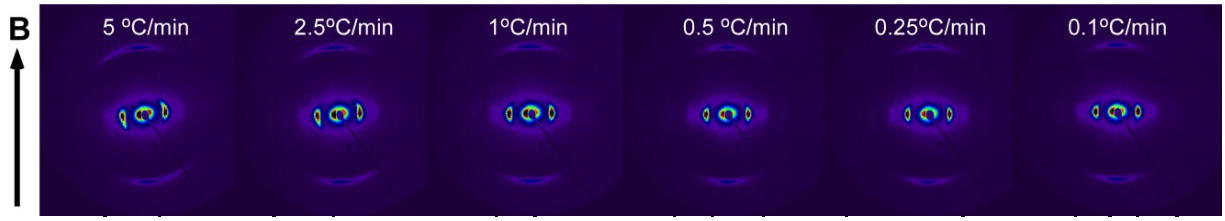

Figure S5: Cooling rate dependence of alignment of the blend material (R=1.5) at 1 T. The system aligns rapidly and the alignment quality is insensitive to cooling rates lower than ~ 1ºC/min.

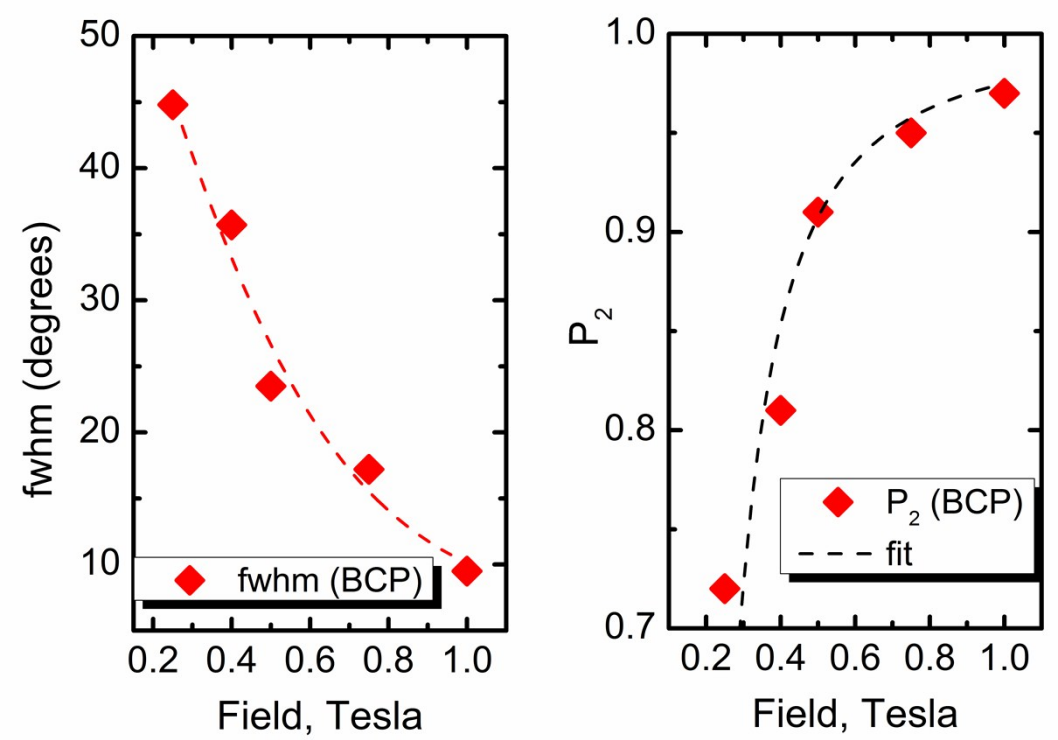

Figure S6: Field dependent alignment quality of R=1.2 sample measured by SAXS at 55 ºC with a cooling rate of 0.25 ºC/min. Left) Full-width at half maximum (fwhm) of the BCP scattering peak as a function of field strength. The red dotted line is a visual guide. Right) Field dependent orientation distribution coefficient, or orientational order parameters, P_2, determined by Gaussian fits of the azimuthal intensity distribution. The solid line is a fit of the data using the field and grain-size dependent magnetostatic energy as a Boltzmann factor in the integration of the orientation probability that yields P_2. From the fit the characteristic grain size is 925 nm.

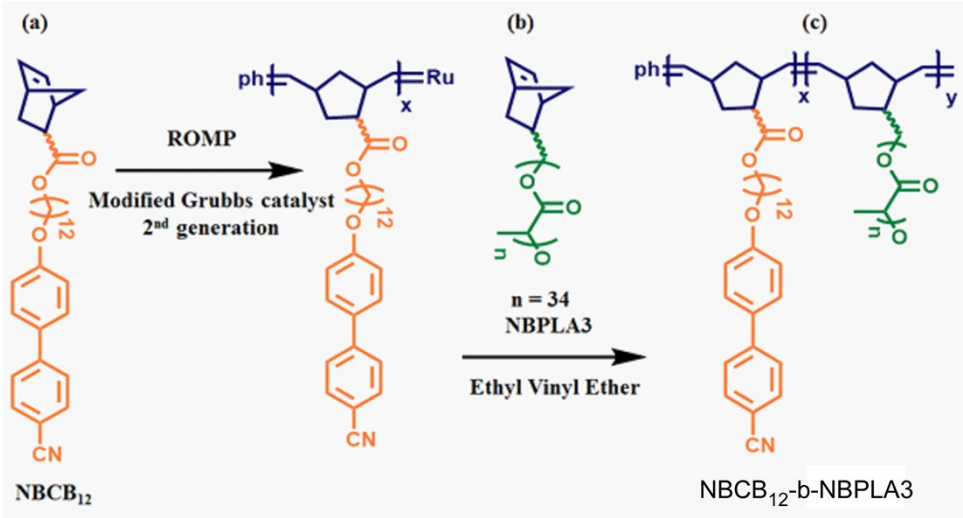

Figure S7: Scheme showing synthesis of the *$NBCB_{12}$-b-NBPLA3* LC BCP by sequential ring

opening metathesis polymerization (ROMP) of side chain functionalized (a) $NBCB_{12}$[1] and (b) NBPLA3[1] monomers. $NBCB_{12}$ volume fraction is ~73%.

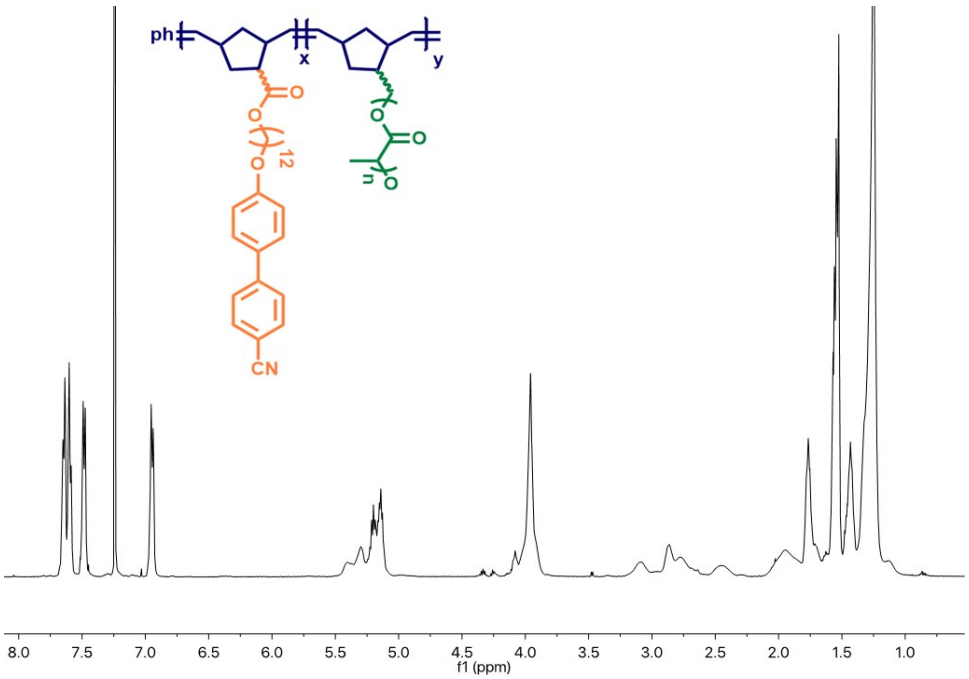

Figure S8: Chemical structure and ^{1}H NMR spectrum of *$NBCB_{12}$-b-NBPLA3* polymer sample in $CDCl_3$ at room temperature. Detailed NMR investigation of the monomers can be found in the published data[1].

REFERENCES

1. P. Deshmukh, M. Gopinadhan, Y. Choo, S. K. Ahn, P. W. Majewski, S. Y. Yoon, O. Bakajin, M. Elimelech, C. O. Osuji and R. M. Kasi, *ACS Macro Lett.*, 2014, **3**, 462-466.