# Supplementary Materials: Carbon–Carbon Composite Membranes Derived from Small-Molecule-Compatibilized Immiscible PBI/6FDA-DAM-DABA Polymer Blends

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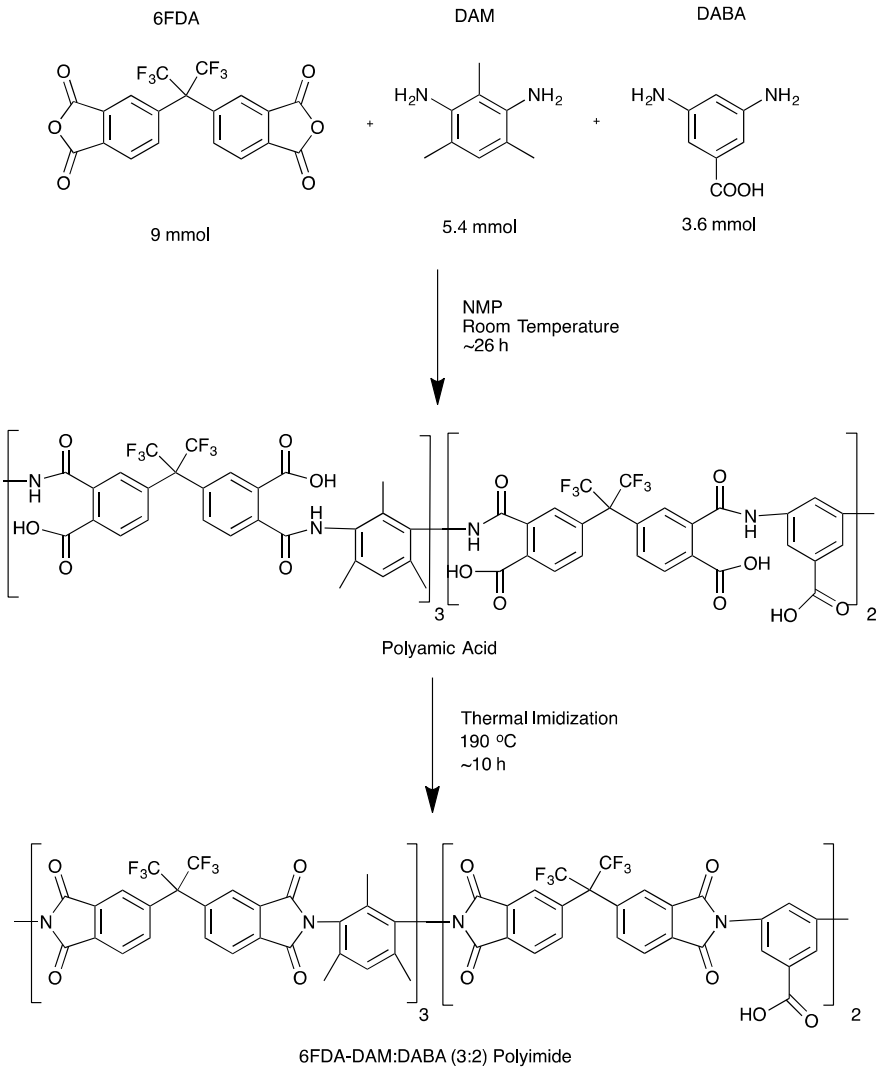


**Figure S1.** Synthesis route for 6FDA-DAM:DABA [3:2], (6FDD).

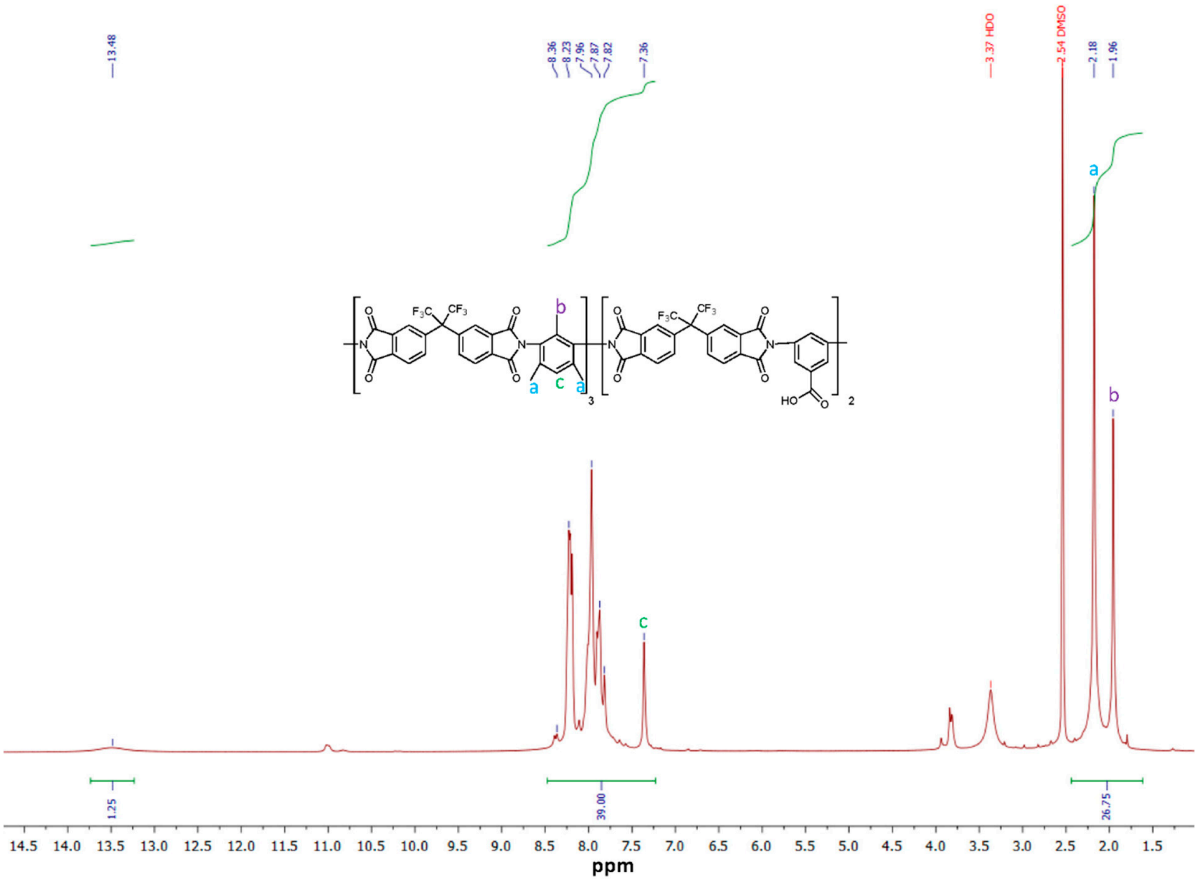


**Figure S2.** $^{1}$H NMR spectrum of 6FDD in DMSO-*d6*. Reported chemical shifts in [70,71].

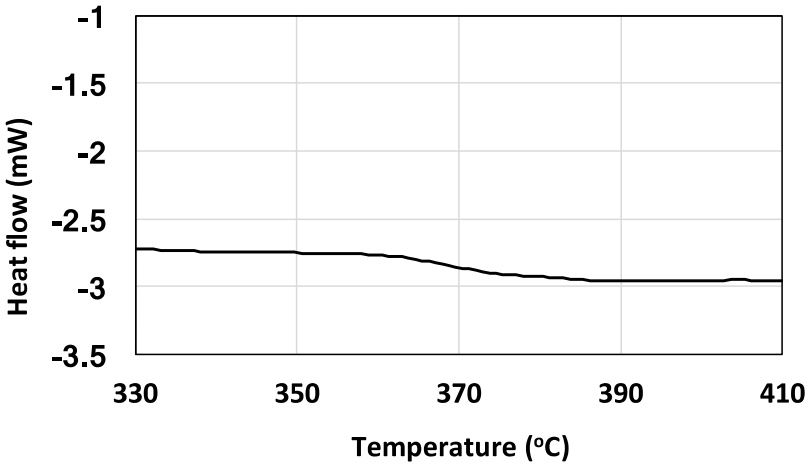


**Figure S3.** Differential scanning calorimetry of 6FDD at a scan rate of 10 °C/min in UHP $N_2$ at 50 mL/min. $T_g$ = 370 °C - 375 °C, reported $T_g$ = 387 °C [72].

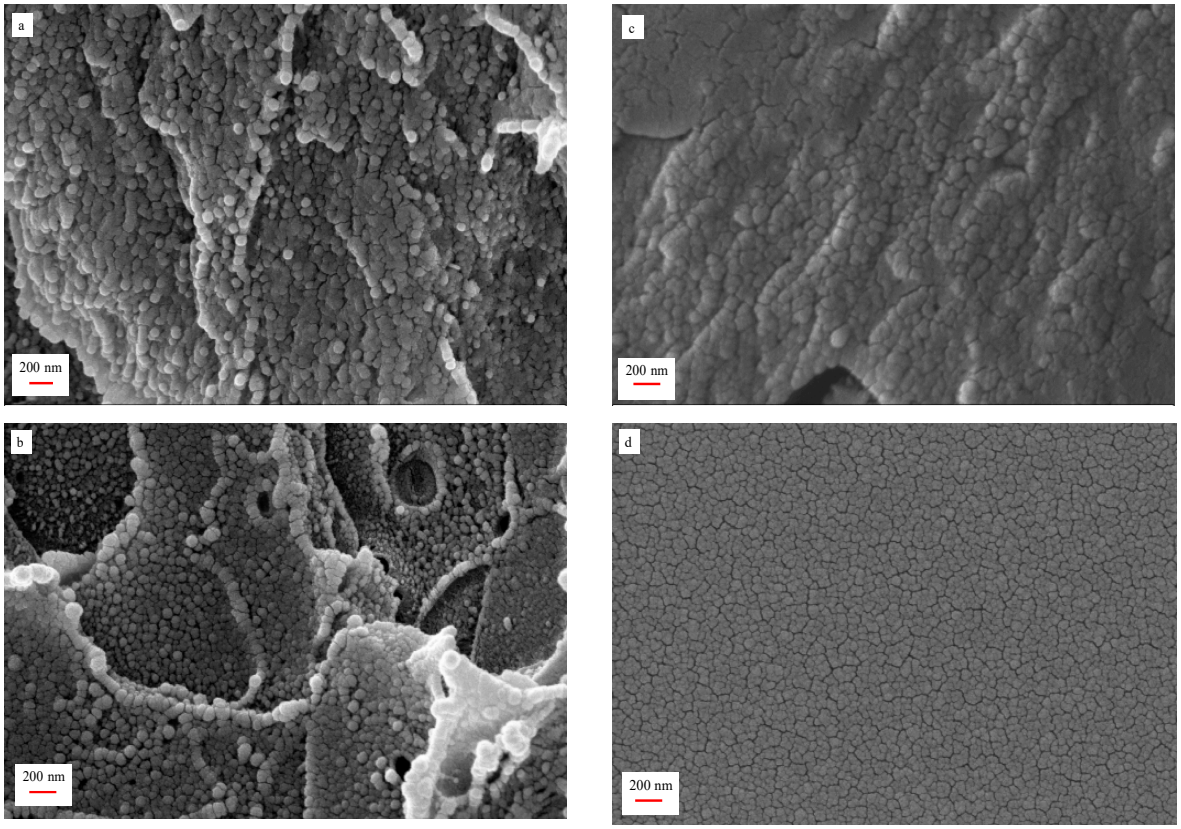


**Figure S4.** Cross-section SEM images of: a) PBI, b) 6FDD, c) PBI CMSM, d) 6FDD CMSM.

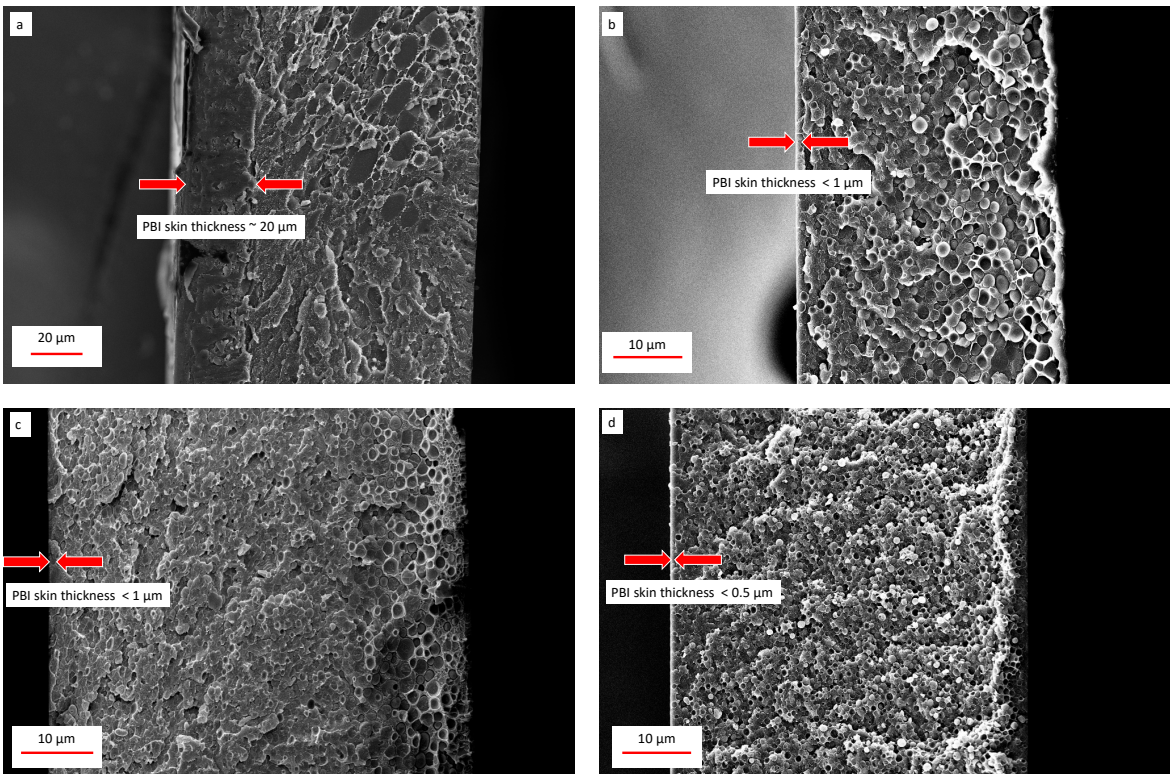


**Figure S5.** Cross-section SEM images of immiscible polymer blend membranes: a) 0DuD-6FDD:PBI, b) 5DuD-6FDD:PBI, c) 9DuD-6FDD:PBI, d) 17DuD-6FDD:PBI.

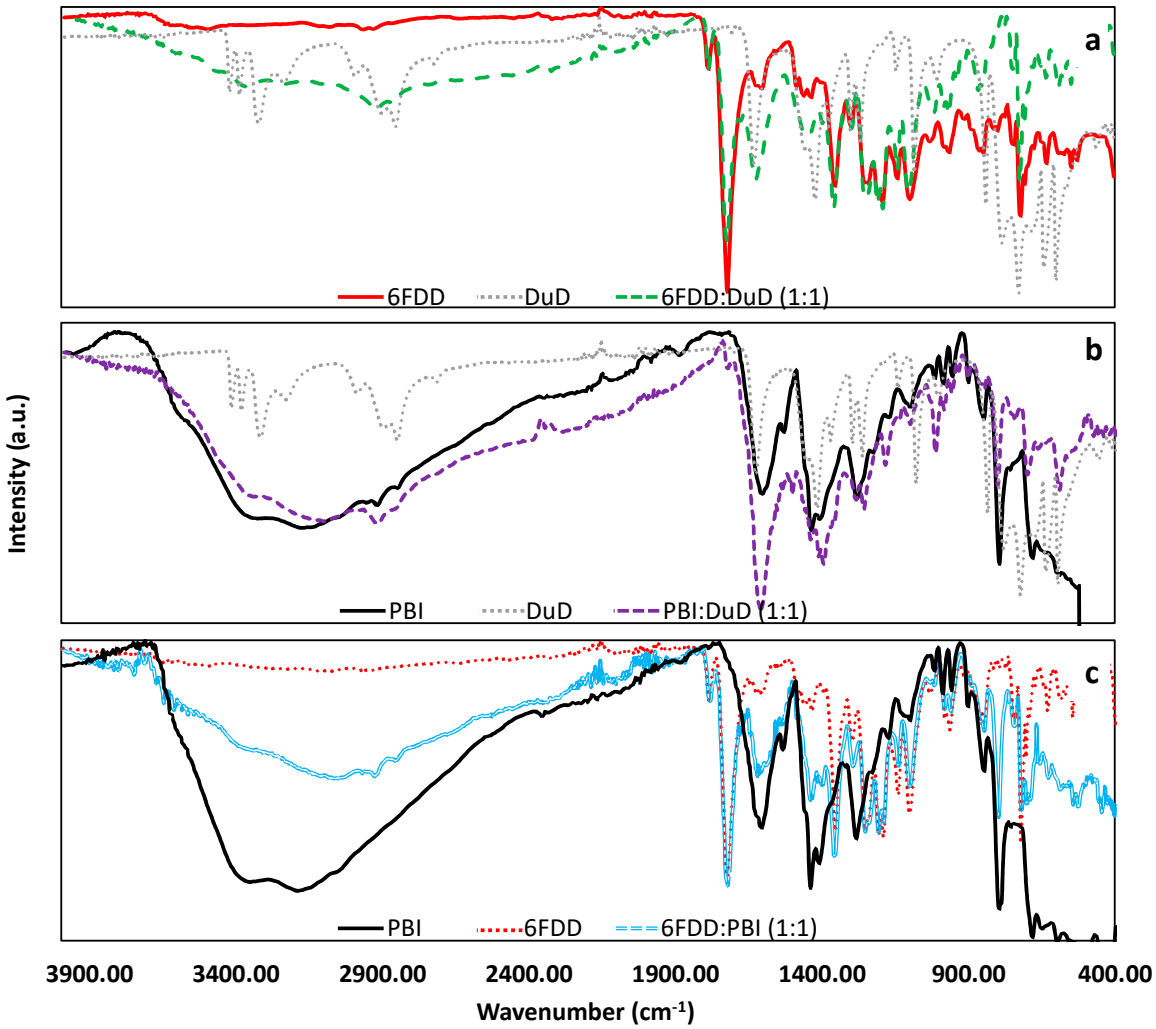


**Figure S6.** ATR-FTIR spectra of the prepared membranes: a) 6FDD:DuD, b) PBI:DuD, c) 6FDD:PBI.

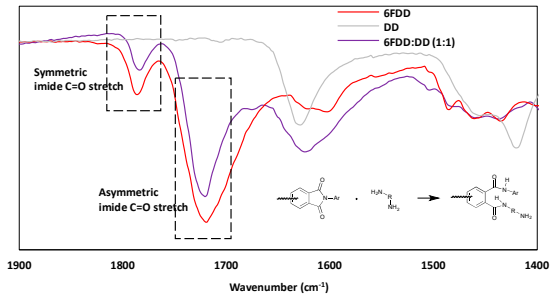


**Figure S7.** FTIR spectra of 6FDD, DD, and 6FDD:DD [1:1]

**Supplementary equations**

Gas transport models for immiscible polymer blends [58]:

**a) Parallel model:**

$$P = \Phi_c P_c + \Phi_d P_d \qquad \textbf{Eq.1}$$

**b) Series model:**

$$P = P_c P_d / (\Phi_c P_d + \Phi_d P_c) \qquad \textbf{Eq. 2}$$

**c) Maxwell's model:**

$$P = P_c \left[ \frac{P_d + 2P_c - 2\Phi_d (P_c - P_d)}{P_d + 2P_c + \Phi_d (P_c - P_d)} \right] \qquad \textbf{Eq. 3}$$

Where $P$ is the permeability of the blend, $\Phi_c$ and $\Phi_d$ are the volume fractions of the continuous and discontinuous phases, respectively, and $P_c$ and $P_d$ are their experimental permeabilities.

**d) Equivalent box model:**

$$P = P_1 \Phi_{1p} + P_2 \Phi_{2p} + \Phi_S^2 \Big/ \left[ \frac{\Phi_{1s}}{P_1} + \frac{\Phi_{2s}}{P_2} \right] \qquad \textbf{Eq. 4}$$

where:

$$\Phi_s = \Phi_{1s} + \Phi_{2s}$$

$$\Phi_{1p} = [(\Phi_1 - \Phi_{1cr})/(1 - \Phi_{1cr})]^{T_1}$$

$$\Phi_{2p} = [(\Phi_2 - \Phi_{2cr})/(1 - \Phi_{2cr})]^{T_2}$$

$$\Phi_{1s} = \Phi_1 - \Phi_{1p}$$

$$\Phi_{2s} = \Phi_2 - \Phi_{2p}$$

and $P_1$ and $P_2$ are the permeabilities of components 1 and 2, $\Phi_{1cr}$ and $\Phi_{2cr}$ are the critical threshold percolation values, and $T_1$ and $T_2$ are the critical universal exponents.

## References:


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