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Supplementary data

Thermally stable phthalonitrile resins based on multiple oligo (aryl ether)s with phenyl-s-triazine moieties in backbones

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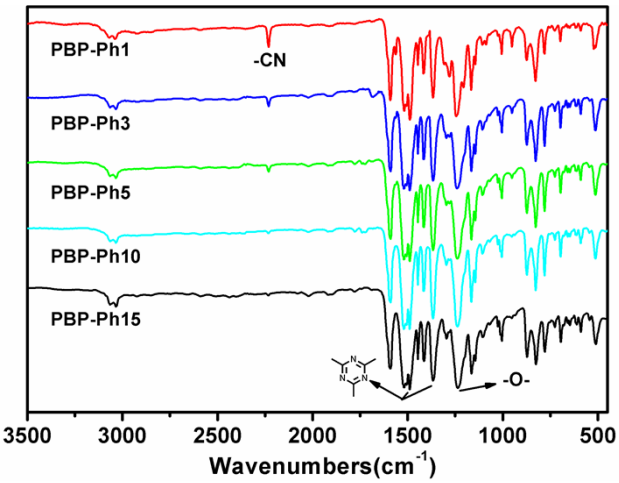


Fig. S1 FT-IR spectra of PBP-Phs.

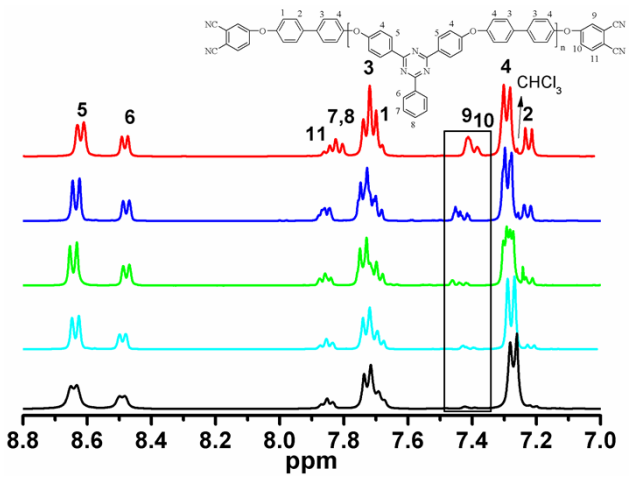


Fig. S2 1H-NMR spectra of PBP-Phs.

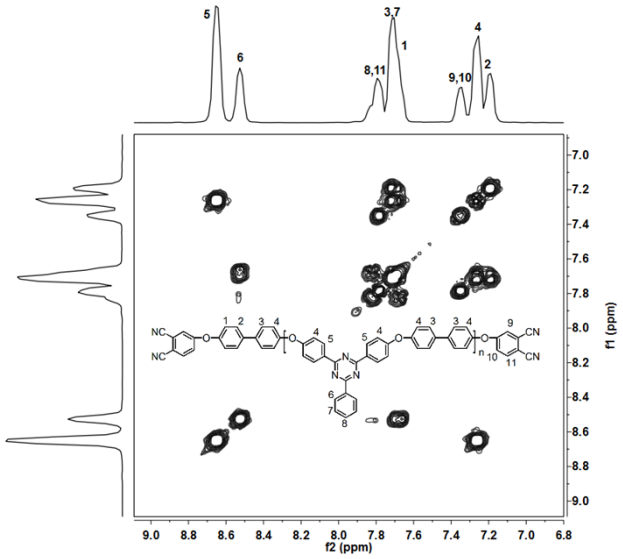


Fig. S3 ^{1}H-^{1}H gCOSY spectrum ($CDCl_3$+CF_3COOD) of PBP-Ph1, with assignments.

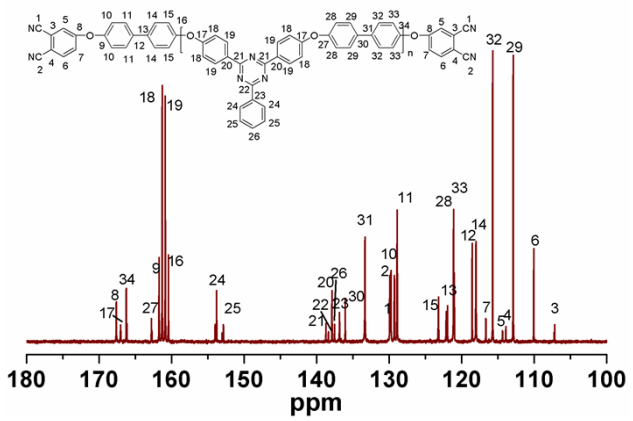


Fig. S4 ^{13}C-NMR spectrum ($CDCl_3$+CF_3COOD) of PBP-Ph5, with assignments.

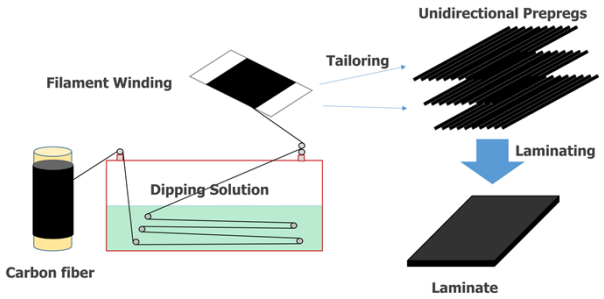


Fig. S5 The schematic diagram for the fabrication of the CF/Th-PBP composite laminates.

Fabrication process of the 7/T300 composites

All CF (T300) reinforced composites were fabricated *via* a similar procedure described as follows. 7.0 g oligomer was added to a three-necked flask and heated to melt at 250 °C (PBP-Ph1) or 280 °C (PBP-Ph3-10). 0.35 g BAPS was then added to the melted oligomer under vigorous stirring. The mixture was maintained at the melting temperature for 3-7 min, and then quenched to room temperature. The obtained B-stage resin was dissolved in 15 mL NMP. (The dipping solution of PBP-Ph15 was prepared by directly dissolving PBP-Ph15 and BAPS into NMP without undergoing B-stage resin formation.) The solution was equally poured onto sixteen plies of T300 CF weaves of 60×60×0.15 mm^3. After dried at 60 °C on a horizontal heating board, all the prepregs were moved into a vacuum oven and maintained at 180 °C for 36 h and 200 °C for 1h. Then, the dried prepregs were compacted in a tight steel mold with a pressure of 2.5 MPa at 250 °C (PBP-Ph1) or 280 °C (PBP-Ph3-15) for 2 h. Then the steel mold was removed, and the laminate was cured at 250 °C for 1 h, 285 °C for 1 h, 325 °C for 3 h, 350 °C for 2 h, and 375 °C for 8 h in a muffle furnace. The thicknesses of all the finished laminates were approximately 2 mm. They should be sawed and sanded into 30×10×2 mm^3 size for DMA test. The cross-sectional images of the laminates are shown in Fig. S6.

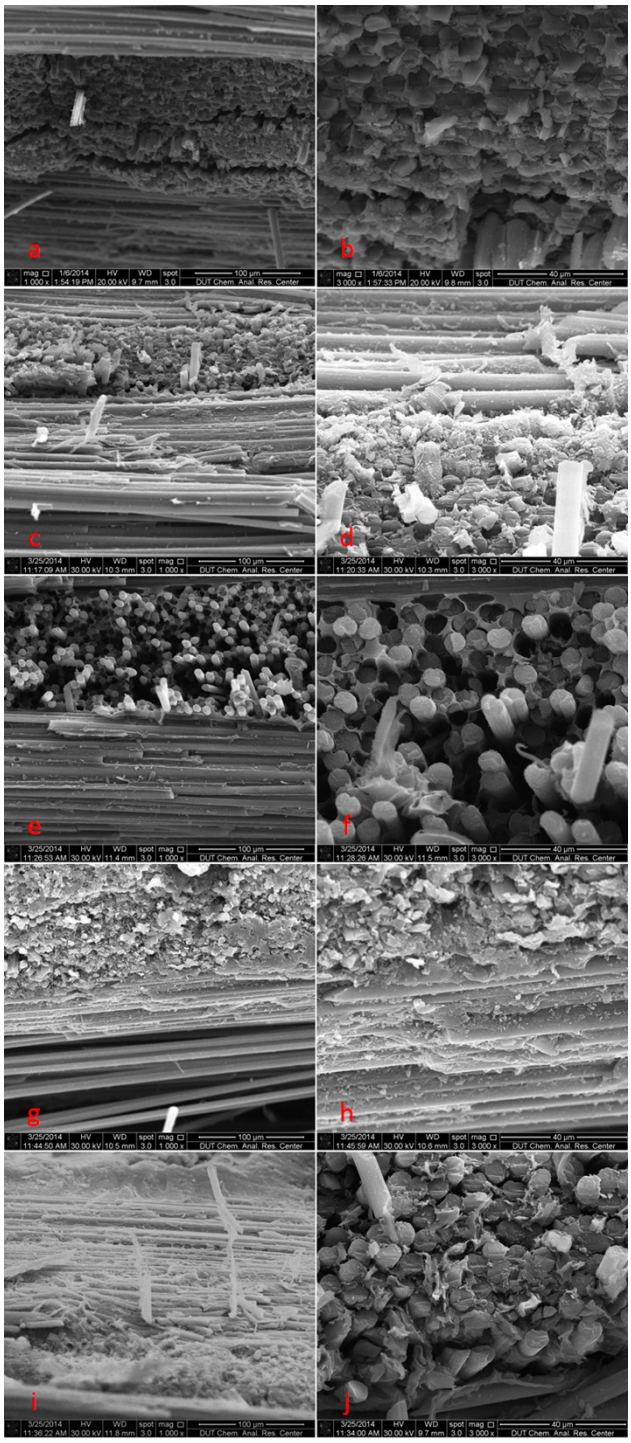


Fig. S6. The cross-sectional images for T300/Th-PBP laminates monitored by SEM instrument: (**a, b**) T300/Th-PBP1; (**c, d**) T300/Th-PBP3; (**e, f**) T300/Th-PBP5; (**g, h**) T300/Th-PBP10; (**i, j**) T300/Th-PBP15.

Table S1 Rheologic parameters of PBP-Phs

Sample	T_m(℃)[a]	|η* lowest|(Pa·s)[b]	$T_{\eta<100}$(℃)[b]	t_{gel280}(min)[c]	|η* ini280|(Pa·s)[c]
PBP-Ph1	211	2.7	218	9.3	7.0
PBP-Ph3	265	12.4	275	7.3	175.7
PBP-Ph5	265	34.7	316	5.9	195.8
PBP-Ph10	265	37.6	331	3.9	4414.0

a: detected by DSC; b: detected by rheometer without BAPS; c:detected by rheometer at 280℃ with 5wt% BAPS.

Table S2 Thermal data of Th-PBPs.

Polymer	T_g(°C)[a]	$T_{5\%}$(°C)[b]	$T_{10\%}$(°C)	T_{max}(°C)	C_{y800} °C (%)	C_{y900} °C (%)	Gel Content (%)[c]
Th-PBP1	400	538(543)[d]	570(577)	589	71(16)	71(2)	97
Th-PBP3	349	559(574)	582 (596)	596	68(21)	68(3)	97
Th-PBP5	302	562(575)	579(594)	594	61(11)	60(3)	96
Th-PBP10	298	571(575)	587(593)	593	62(0)	61(0)	95
Th-PBP15	294	582(575)	592(589)	601	61(0)	60(0)	95

[a] The values was recorded on DMA at the heating rate of 3 °C/min.

[b] The values was recorded on TGA at the heating rate of 20 °C/min in N_2 or air.

[c] The gel contents were measured according to the ASTM D2765-11 standard.

[d] The values in the brackets were recorded on TGA under air atomosphere.

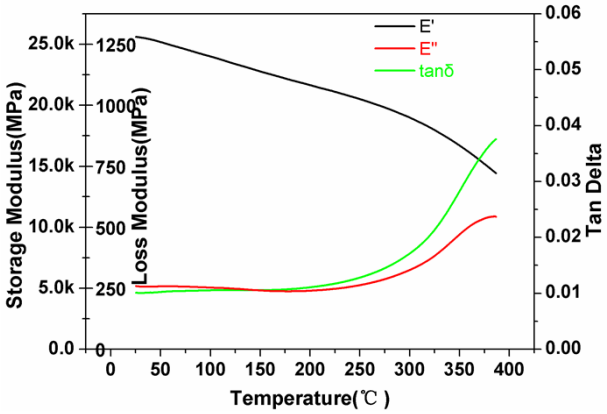
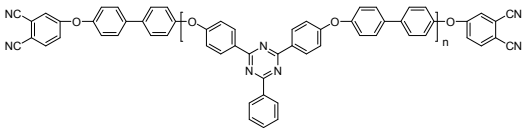
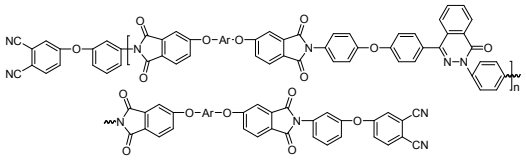
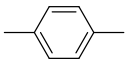
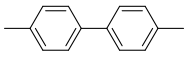
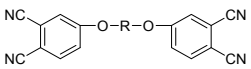
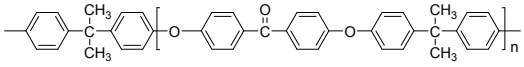
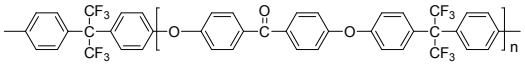
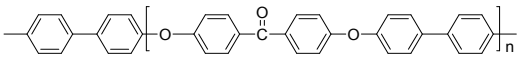
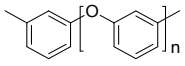
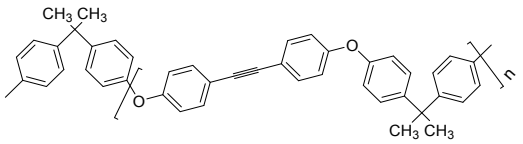
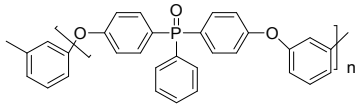
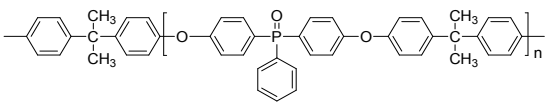
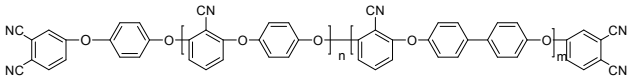
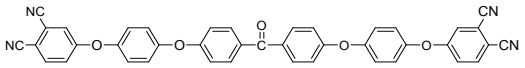
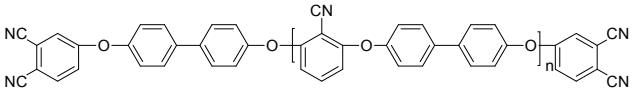
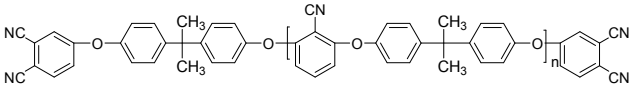
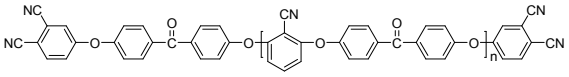
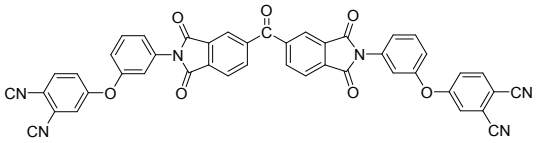


Fig. S7 DMA curves of T700/Th-PBP1 laminate.

Table S3 Thermal property and processability comparison of PN resins.

PN precursors	Chemical structure	T_g (°C)	$T_{d5\%,N2}$ (°C)	$T_{d5\%,air}$ (°C)	Refs.
	PN oligomer				
5		ca.400	538	543	-
5		ca.400	555	552	-
					1
xo-HEI(1)	Ar: 	-	540	-	1
xo-REI(5)		-	521	-	1
xo-BEI(1)		-	550	-	1
					
6	R: 	370	ca.500[f]	ca.525	2
6A		>310	ca.500[f]	-	3
6A'		>310	ca.500[f]	-	3
N=2		240	506	501	4
1		ca. 450	495	505	5
1a		>400	490	490	6
1b		>400	490	495	6

PEN-t-Ph		188	525	-	7
2CN-o-PEEK		208	517	-	8
2PEN-BPh		>450	560	518	9
2PEN-BAPh		-	512	512	10
PAEK-CN		>400	515	516	11
5		>300	ca.540[f]	ca500	12
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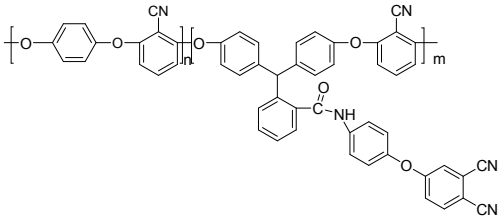
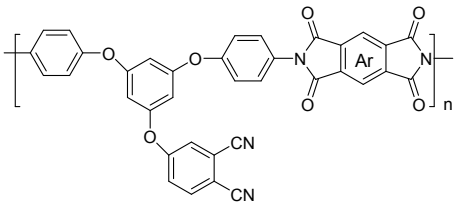
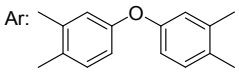
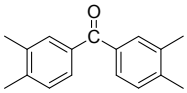
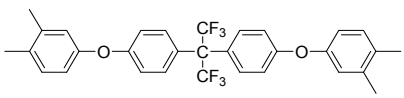
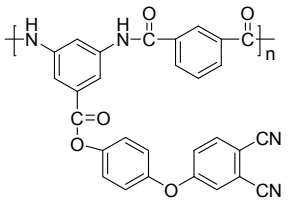
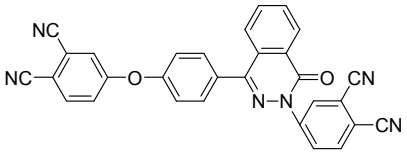
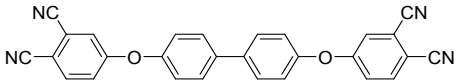
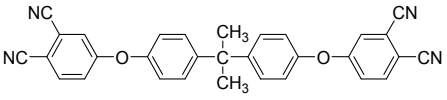
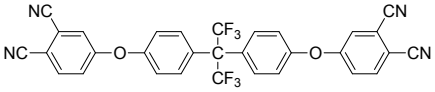
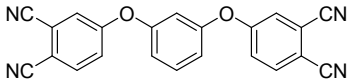
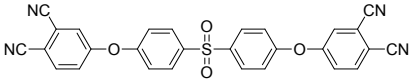
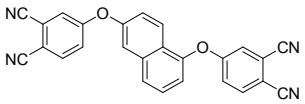
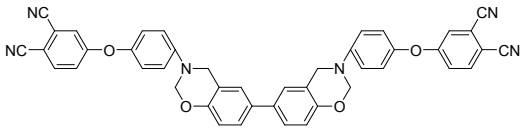
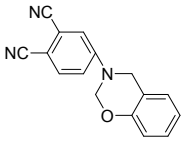
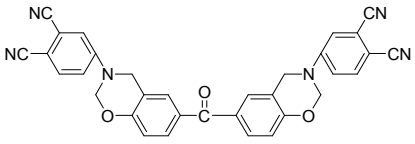
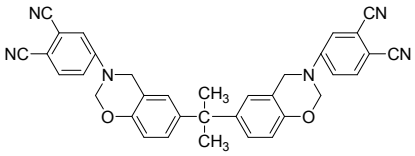
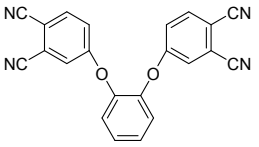
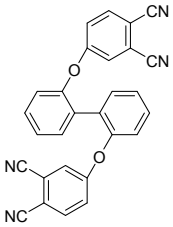
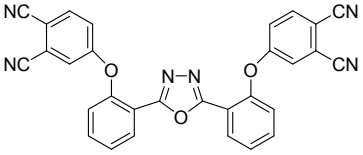
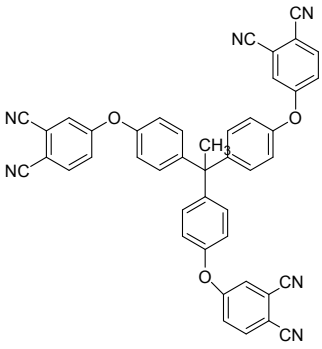
PEN-CN3		213	475	-	13
					14
PI-4a		220	509	-	14
PI-4b		234	529	-	14
PI-4c		209	520	-	14

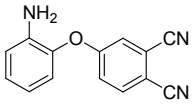
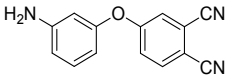
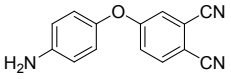
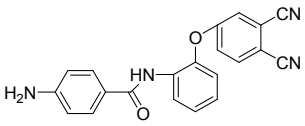
CN-PA		325	380	-	[15]

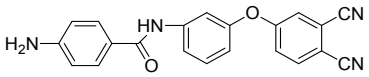
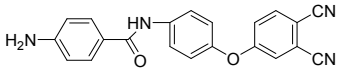
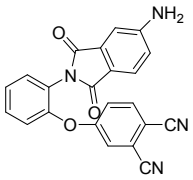
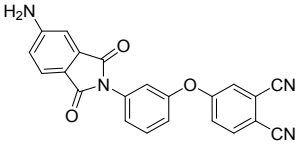
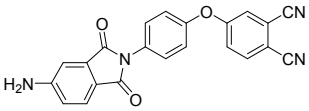
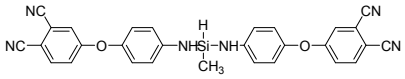
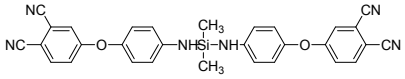
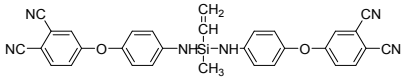
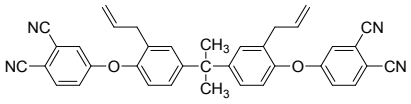
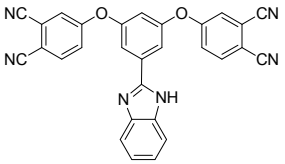
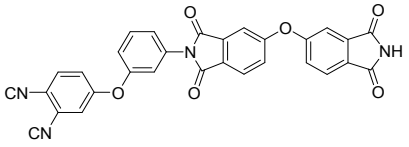
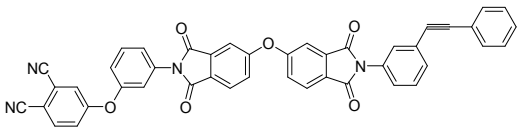
PN monomer

HHPZ-PH		-[a]	514	528	[16]
BPh		>450	511	517	[17]
BAPh		>450	ca.515[f]	ca.545[f]	[17]
6FPH		>450	485	485	[17]
RPh		>400	ca.505[f]	ca.510[f]	[18]
BDS		337	436	441	[19]
1,6-BDCN		>465	553	549	[20]
BZBPH		-	478	482	[21]
I		316	450	420	[22]
III		-	544	390	[22]

Ⅳ		330	423	-	[22]
1		350	444	437	[23]
2		>450	490	488	[23]
3		>500	512	500	[23]
TDPE		>380	556	543	[24]

Self-promoted PN monomer

2O		582	527	505	[25]
2M		565	524	512	[25]
2P		580	528	518	[25]
3a		>500	517	496	[26]

3b		>500	506	501	[26]
3c		>500	531	502	[26]
4O		450	529	520	[27]
4M		420	525	514	[27]
4P		450	528	514	[27]
HSiPN		>450	535	558	[28]
MeSiPN		424	541	543	[28]
ViSiPN		428	570	562	[28]
DBPA-Ph		>350	478	464	[29]
BIPN		>325	540	535	[30]
PIPN		-	516	518	[31]
3PN3PEODPA		>400	516	-	[32]

[a] The specific data was not mentioned or different to read from the relevant figures.

[f] The values were roughly read from the relevant figures in order to make comparisons.

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