

**Supplementary Information for**

**Highly enhanced the interfacial and mechanical properties of basalt fiber/poly(phthalazinone ether nitrile ketone) composite by thermoplastic sizing agents with different structures**

Hang Jia<sup>a,b</sup>, Cheng Liu<sup>a,b,d \*</sup>, Yue Qiao<sup>a,b</sup>, Yu Zhang<sup>a,b</sup>, Kaiyuan Fan<sup>b</sup>, Manxia Zhang<sup>c</sup>,  
Xigao Jian<sup>a,b,d</sup>

<sup>a</sup> State Key Laboratory of Fine Chemicals, Dalian University of Technology,  
Dalian, 116024, People's Republic of China;

<sup>b</sup> Department of Polymer Science & Materials, Dalian University of Technology,  
Dalian, 116024, People's Republic of China;

<sup>c</sup> Department of Environmental Science & Engineering, Dalian Maritime  
University, Dalian, 116026, People's Republic of China;

<sup>d</sup> Dalian Basalt Fiber Resin Matrix Composite Engineering Research Center,  
Dalian, 116012, People's Republic of China.

---

\* Corresponding author. Tel.: +86-411-84986191.

Email address: liuch1115@dlut.edu.cn (C. Liu)

### Supplementary Figures:

Figure S1. TGA curves of the sizing agents of PVP, PEN, PPEK, PPEN and PPENK.

Figure S2. Synthesis of LMW PEN.

Figure S3. The preparation process flow diagram of composite laminates.

Figure S4 XPS spectra of the desized and re-sized basalt fibers; (a) survey scan spectra and (b) narrow scan spectra in the N 1s regions.

Figure S5. Loss modulus and  $\tan \delta_{in}$  curves of BF-Desized/PPENK, BF-PVP/PPENK, BF-PEN/PPENK, BF-PPEK/PPENK, BF-PPEN/PPENK and BF-PPENK/PPENK composites.

Figure S6. Images of overall morphology of tensile failure; (a) BF-Desized/PPENK, (b) BF-PVP/PPENK, (c) BF-PEN/PPENK, (d) BF-PPEK/PPENK, (e) BF-PPEN/PPENK and (f) BF-PPENK/PPENK composites.

Figure S7. Flexural modulus of the 1: BF-Desized/PPENK, 2: BF-PVP/PPENK, 3: BF-PEN/PPENK, 4: BF-PPEK/PPENK, 5: BF-PPEN/PPENK and 6: BF-PPENK/PPENK composites.

Table S1. Tensile and compression tests of BF/PPENK composites.

Table S2 Quantification of the atomic chemical composition of the BFs.

Table S3 DMA test results of BF/PPENK composites

Table S4. Tensile and compression tests of BF/PPENK composites

Table S5. Flexural and ILSS tests of BF/PPENK composites.

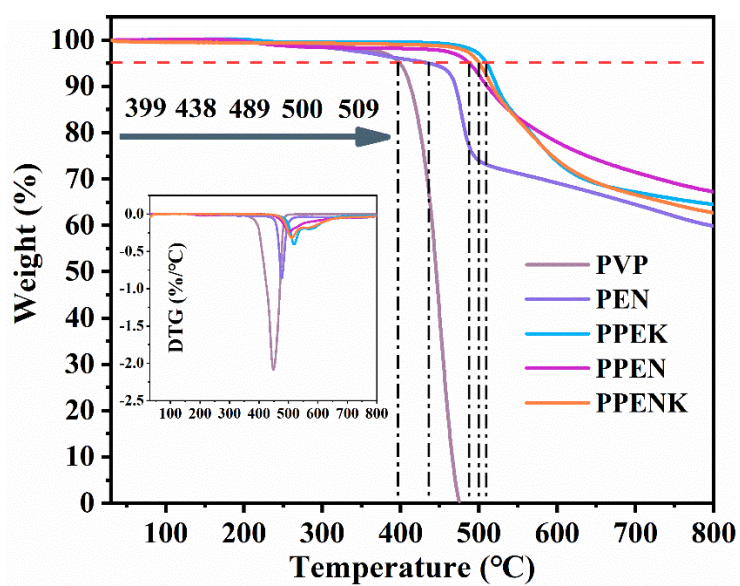


Figure S1. TGA curves of the sizing agents of PVP, PEN, PPEK, PPEN and PPENK.

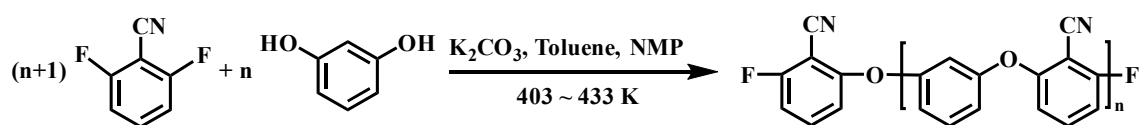


Figure S2. Synthesis of LMW PEN.

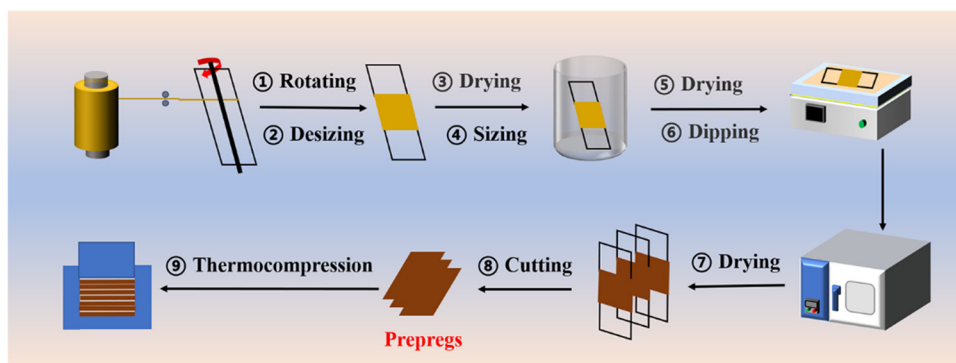


Figure S3. The preparation process flow diagram of composite laminates.

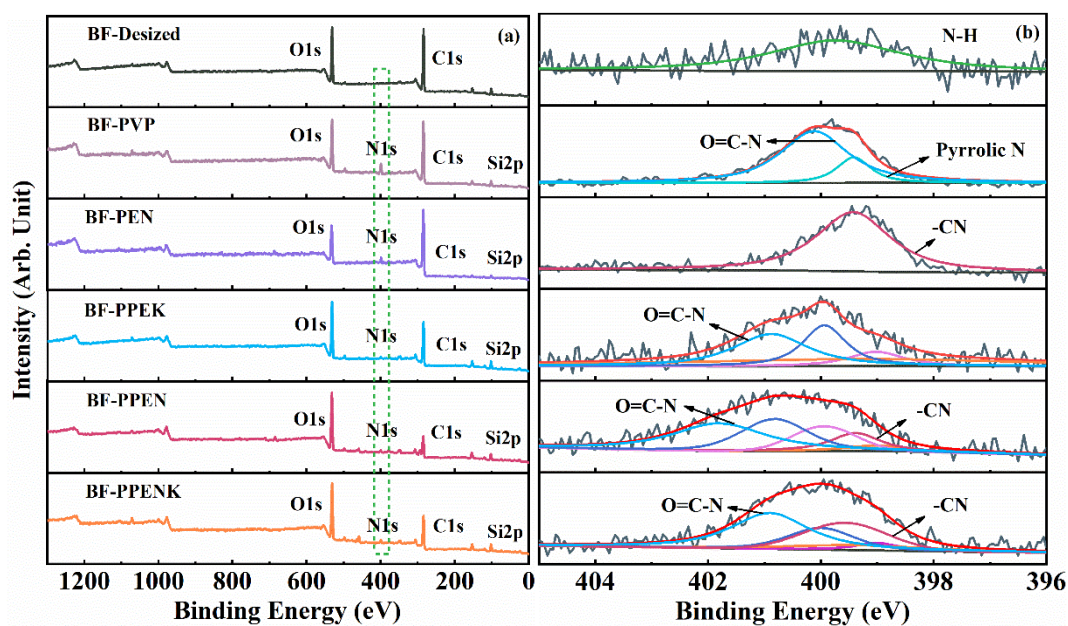


Figure S4. XPS spectra of the desized and re-sized basalt fibers; (a) survey scan spectra and (b) narrow scan spectra in the N 1s regions.

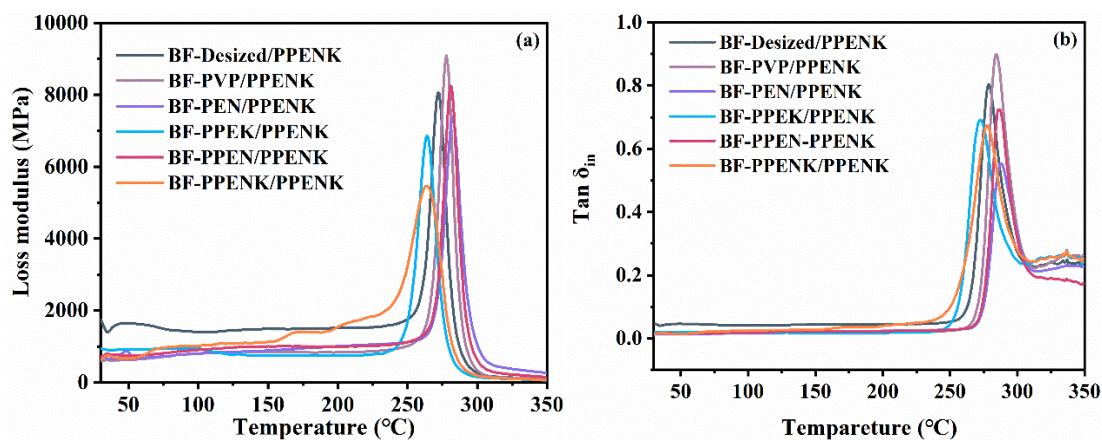


Figure S5. Loss modulus and  $\tan \delta_{in}$  curves of BF-Desized/PPENK, BF-PVP/PPENK, BF-PEN/PPENK, BF-PPEK/PPENK, BF-PPEN/PPENK and BF-PPENK/PPENK composites.

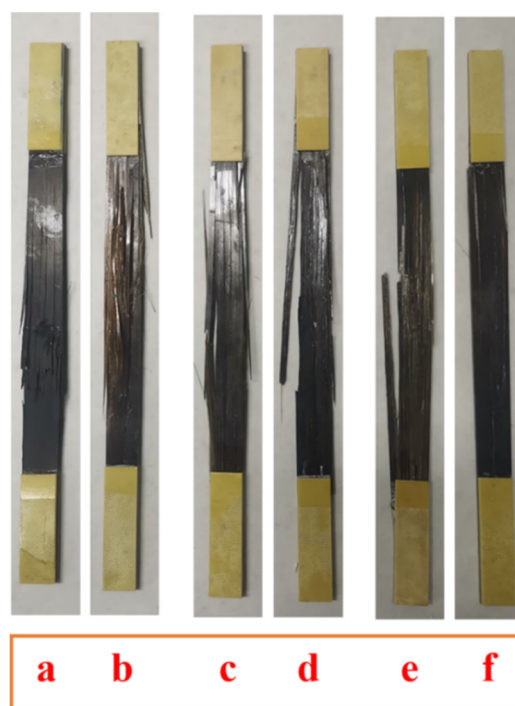


Figure S6. Images of overall morphology of tensile failure; (a) BF-Desized/PPENK, (b) BF-PVP/PPENK, (c) BF-PEN/PPENK, (d) BF-PPEK/PPENK, (e) BF-PPEN/PPENK and (f) BF-PPENK/PPENK composites.

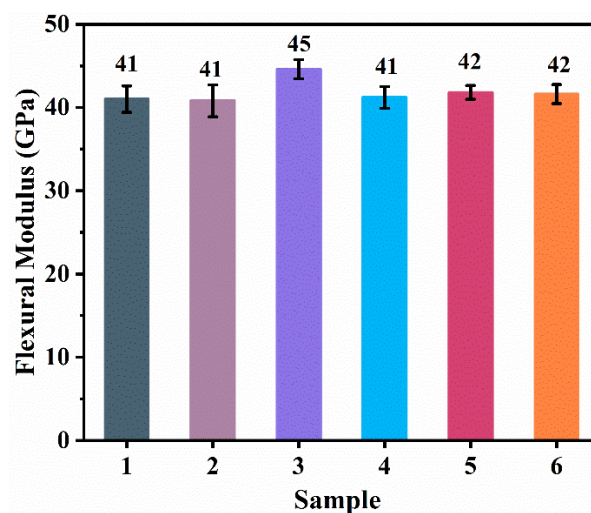


Figure S7. Flexural modulus of the 1: BF-Desized/PPENK, 2: BF-PVP/PPENK, 3: BF-PEN/PPENK, 4: BF-PPEK/PPENK, 5: BF-PPEN/PPENK and 6: BF-PPENK/PPENK composites.

Table S1. Tensile and compression tests of BF/PPENK composites

Radical	$F_{di}$	$F_{pi}$	$E_{hi}$	$V_i$
	$J^{1/2} cm^{3/2} mol^{-1}$	$J^{1/2} cm^{3/2} mol^{-1}$	$J mol^{-1}$	$cm^3 mol^{-1}$
=N-	347	712	2816	5.0
-C <sub>6</sub> H <sub>4</sub> -	1270	110	0	65.5
-CN	430	1100	2500	23.1
-O-	100	400	3000	10
-CO-	290	770	2000	13.4
-N-	20	800	5000	6.7
=C-	70	0	0	7.18
=CH-	200	0	0	13.18
-CH <sub>2</sub> -	270	0	0	15.55
-CH-	80	0	0	9.56
Ring	190	-	-	-

Table S2 Quantification of the atomic chemical composition of the BF.s.

Fiber	Chemical composition (%)						
	C	O	N	Al	C/Al	O/Al	N/Al
BF-Ddesized	65.28	25.58	0.99	1.88	34.72	13.61	0.53
BF-PVP	45.91	42.8	7.11	0.64	71.73	66.88	11.11
BF-PEN	53.68	38.56	5.27	0.48	111.83	80.33	10.98
BF-PPEK	35.83	56.02	1.71	1.07	33.83	52.35	1.60
BF-PPEN	21.25	67.96	2.47	1.34	15.85	50.72	1.84
BF-PPENK	28.16	61.39	3.22	1.28	22.00	47.96	2.52

Table S3 DMA test results of BF/PPENK composites

Composites	Storage modulus (30 °C, GPa)	$T_g$ (°C)	$\tan\delta_{max}$
BF-Desized/PPENK	36.65	279	0.8251
BF-PVP/PPENK	46.78	285	0.9046
BF-PEN/PPENK	50.14	288	0.5559
BF-PPEK/PPENK	45.74	273	0.7489
BF-PPEN/PPENK	49.50	286	0.7255
BF-PPENK/PPENK	44.81	277	0.7189

Table S4. Tensile and compression tests of BF/PPENK composites

Composites	Tensile test			Compression test		
	Strength	Modulus	Strain	Strength	Modulus	Breaking train
	MPa	GPa	%	MPa	GPa	%
BF-Desized/PPENK	547±23	28±1.4	2.25±0.23	403±52	34±3.1	1.61±0.21
BF-PVP/PPENK	751±22	34±0.8	2.78±0.09	490±25	40±3.1	1.44±0.13
BF-PEN/PPENK	778±65	33±0.8	2.86±0.24	600±41	36±1.5	2.24±0.15
BF-PPEK/PPENK	662±61	28±1.7	2.57±0.27	568±39	40±0.5	1.81±0.24
BF-PPEN/PPENK	722±39	31±0.6	2.76±0.22	695±34	43±0.8	2.03±0.15
BF-PPENK/PPENK	608±58	29±1.8	2.71±0.14	452±57	36±2.2	1.84±0.28

Table S5. Flexural and ILSS tests of BF/PPENK composites

Composites	Flexural test		ILSS test
	Strength (MPa)	Modulus (GPa)	Strength (MPa)
BF-Desized/PPENK	927±32	41±1.6	44±2.6
BF-PVP/PPENK	878±26	41±1.9	50±2.3
BF-PEN/PPENK	1115±32	45±1.1	57±2.7
BF-PPEK/PPENK	874±73	41±1.3	52±1.1
BF-PPEN/PPENK	1095±32	42±0.8	54±2.1
BF-PPENK/PPENK	921±32	42±1.1	51±2.4