Electronic Supplementary Information for

Temperature for curing phthalonitrile-terminated poly(phthalazinone ether nitrile) reduced by a mixed curing agent and its curing behavior

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Fig. S1. ^1H NMR spectra (400 M, $CDCl_3$, 25 °C) of PPEN-Ph

Fig. S2. DSC curves of the curing reaction with BAS at different heating rates (1: 5 °C/min; 2: 10 °C/min; 3: 15 °C/min; and 4: 20 °C/min)

Fig. S3. DSC curves of the curing reaction with $ZnCl_2$ at different heating rates (1: 5 °C/min; 2: 10 °C/min; 3: 15 °C/min; and 4: 20 °C/min)

Fig. S4. DSC curves of the curing reaction with AMTU at different heating rates (1: 5 °C/min; 2: 10 °C/min; 3: 15 °C/min; and 4: 20 °C/min)

Fig. S5. Heating rate versus curing temperature of maximum peak line graph of BAS

Fig. S6. Heating rate versus curing temperature of maximum peak line graph of $ZnCl_2$

Fig. S7. Heating rate versus curing temperature of maximum peak line graph of AMTU

Table S1. The DSC curves with BAS at different heating rates

Table S2. The DSC curves with $ZnCl_2$ at different heating rates

Table S3. The data of DSC curves with AMTU at different heating rates

Calculate *E*a via Kissinger and Ozawa equation

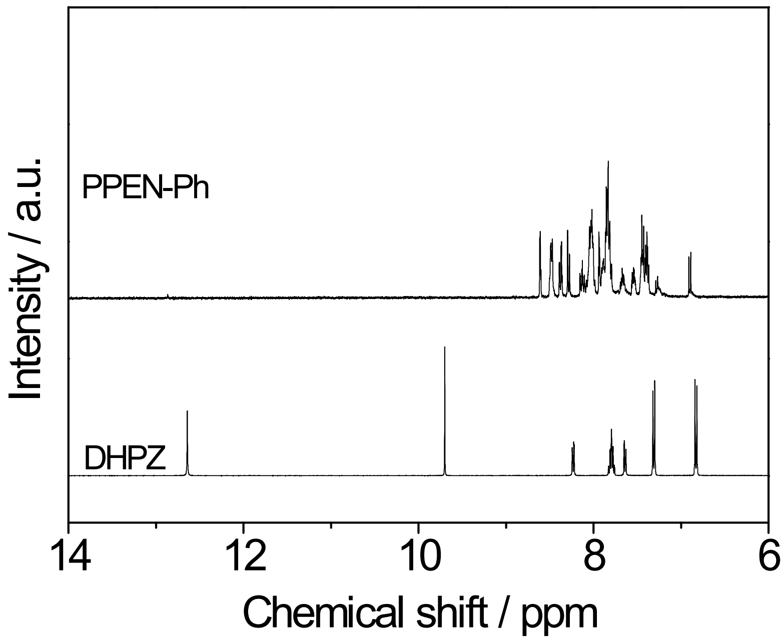

Fig. S1. ^{1}H NMR spectra (400 M, $CDCl_3$, 25 °C) of PPEN-Ph.

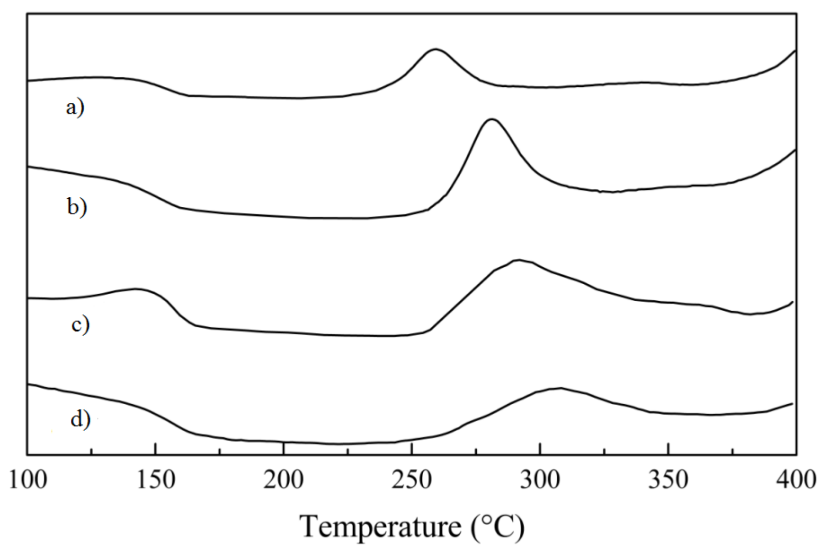

Fig. S2. DSC curves of the curing reaction with BAS at different heating rates. a): 5 °C·min^{-1}; b): 10 °C·min^{-1}; c): 15 °C·min^{-1}; d): 20 °C·min^{-1}.

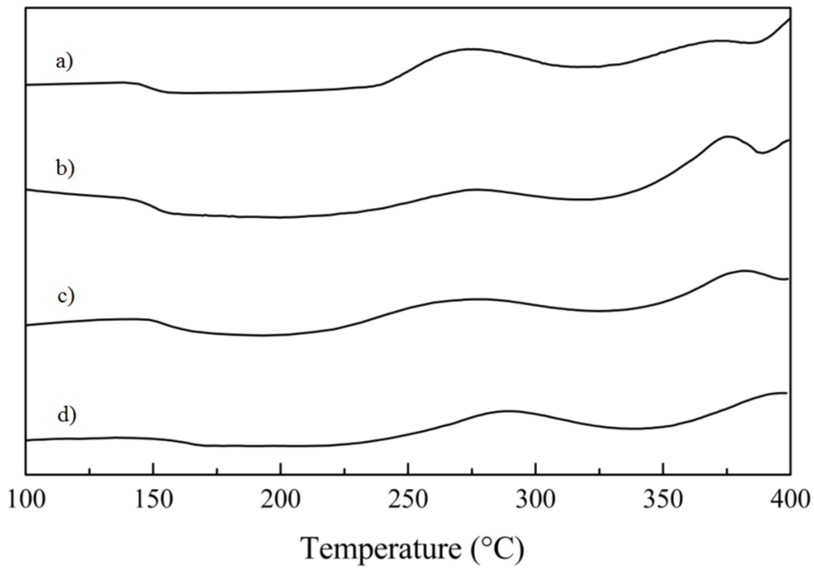

Fig. S3. DSC curves of the curing reaction with $ZnCl_2$ at different heating rates. a): 5 °C·min^{-1}; b): 10 °C·min^{-1}; c): 15 °C·min^{-1}; d): 20 °C·min^{-1}.

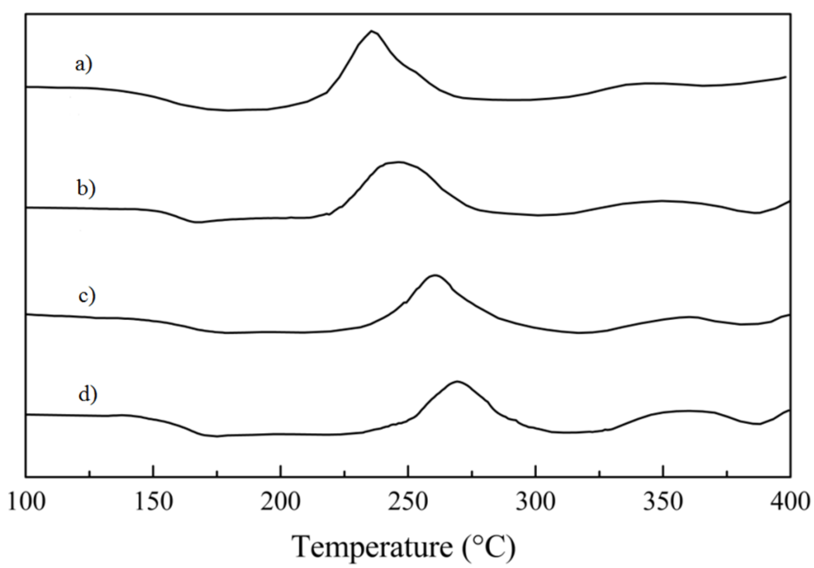

Fig. S4. DSC curves of the curing reaction with AMTU at different heating rates. a): 5 °C·min^{-1}; b): 10 °C·min^{-1}; c): 15 °C·min^{-1}; d): 20 °C·min^{-1}.

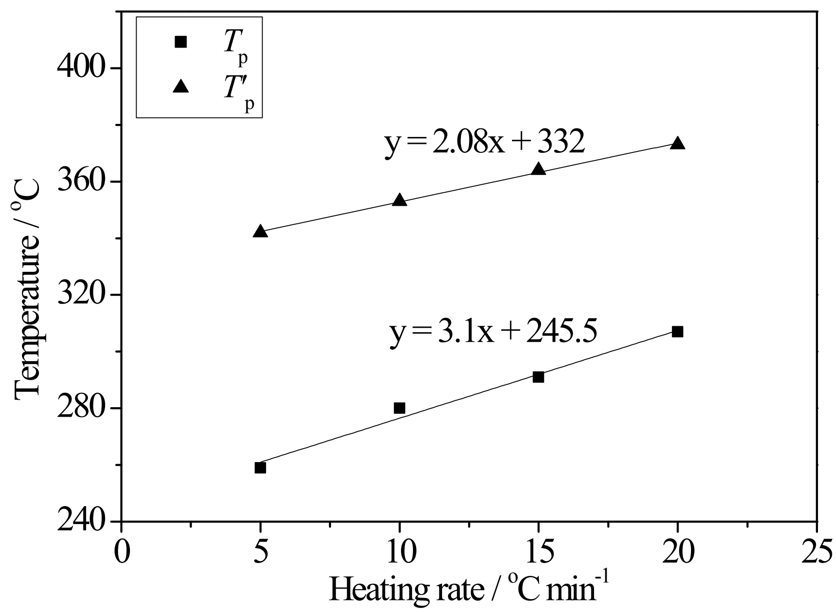

Fig. S5. Heating rate versus curing temperature of maximum peak over BAS.

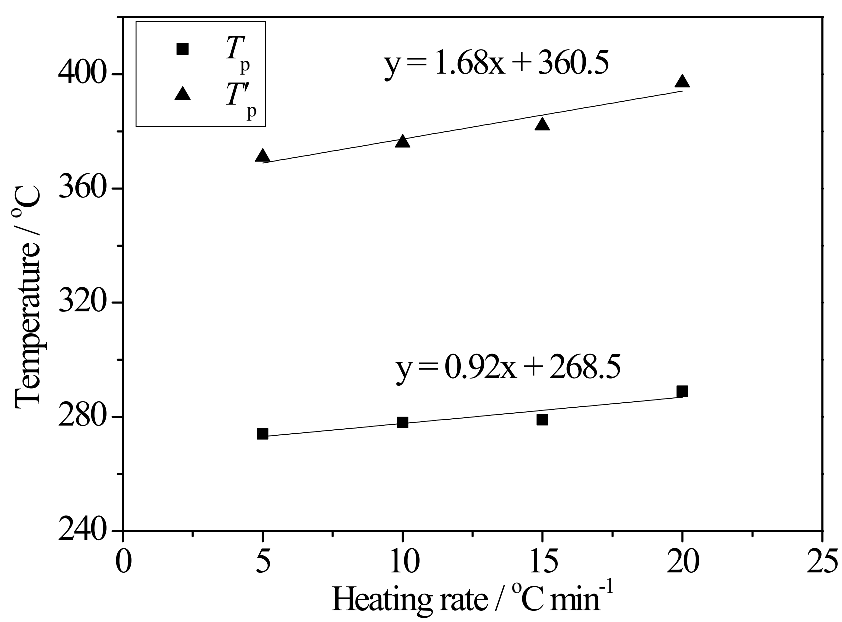

Fig. S6. Heating rate versus curing temperature of maximum peak over $ZnCl_2$..

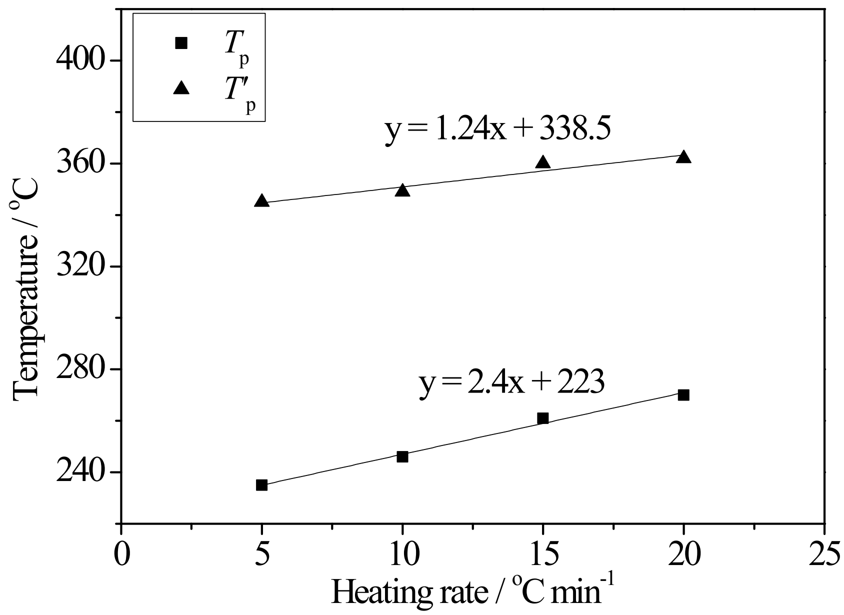

Fig. S7. Heating rate versus curing temperature of maximum peak over AMTU.

Table S1 The DSC curves with BAS at different heating rates

Heating rate / °C·min^{-1}	T_p / °C	T'_p / °C
5	259	342
10	280	353
15	291	364
20	307	373

Table S2 The DSC curves with $ZnCl_2$ at different heating rates

Heating rate / °C·min^{-1}	T_p / °C	T'_p / °C
5	274	371
10	278	376
15	279	382
20	289	397

Table S3 The data of DSC curves with AMTU at different heating rates

Heating rate / °C·min^{-1}	T_p / °C	T'_p / °C
5	235	345
10	246	349
15	261	360
20	270	362

Calculate *E*a via Kissinger and Ozawa equation

The apparent activation energy *Ea* of the curing reaction is an important parameter to measure the curing reactivity of a curing system. It reflects the difficulty level of the curing reaction. The larger the *Ea* is, the higher curing temperature is generally required. This makes the reaction rate more sensitive to temperature. Thus, the apparent activation energy has a very vital significance to the research of curing reaction.[1] The apparent activation energy of the curing reaction in resin systems could be calculated via the Kissinger equation[2,3] and the Ozawa equation.[4]

Kissinger equation:

$$\frac{\mathrm{d}\left[\ln\left(\beta/T_{\mathrm{p}}^{2}\right)\right]}{\mathrm{d}\left(1/T_{\mathrm{p}}\right)}=-\frac{Ea}{R}$$

where β is the heating rate, °C·min^{-1}; T_{p} is the temperature of maximum peak, K; *Ea* is the apparent activation energy, kJ/mol; and *R* is the Gas constant, 8.314 J·K^{-1}·mol^{-1}.

Ozawa equation:

$$\frac{\mathrm{d}\left[\ln\beta\right]}{\mathrm{d}\left(1/T_{\mathrm{p}}\right)}=-\frac{1.052Ea}{R}$$

where β is the heating rate, °C·min^{-1}; T_{p} is the temperature of maximum peak, K; *Ea* is the apparent activation energy, kJ·mol^{-1}; and *R* is the Gas constant, 8.314 J·K^{-1}·mol^{-1}.

References

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4 T. Ozawa, *Bull. Chem. Soc. Jpn,* 1965, **38**, 1881.