



## Article

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*Liao, Dui-Jun, Xu, Qi-Kui, McCabe, Richard W., Babu, Heeralal Vignesh, Hu, Xiao-Ping, Pan, Ning, Wang, De-Yi and Hull, T Richard orcid iconORCID: 0000-0002-7970-4208 (2017) Ferrocene-Based Nonphosphorus Copolymer: Synthesis, High-Charring Mechanism, and Its Application in Fire Retardant Epoxy Resin. Industrial & Engineering Chemistry Research, 56 (44). pp. 12639-12643. ISSN 1520-5045*

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# Ferrocene-Based Non-phosphorus Copolymer: Synthesis, High-charring Mechanism and Its Application in fire retardant Epoxy Resin

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## **Additional Supporting Data**

### **Table caption**

**Table S1.** Chemical structures of pyrolysis compounds for PDPFDE at 700 °C under N<sub>2</sub>

### **Figure captions**

**Figure S1.** FTIR spectrum of DAF

**Figure S2.** <sup>1</sup>H NMR spectrum of DAF.

**Figure S3.** <sup>13</sup>C NMR spectrum of DAF.





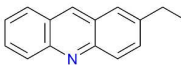

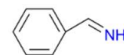
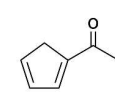




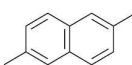

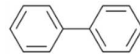
**Figure S4.** <sup>1</sup>H NMR spectrum of DCF.

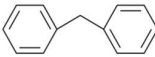
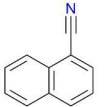
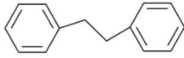

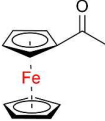
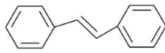
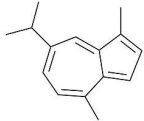
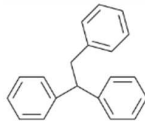
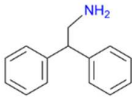
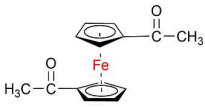
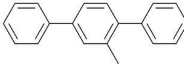
**Figure S5.** GPC curve of PDPFDE.

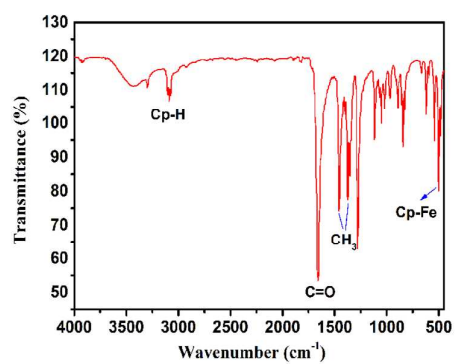
**Figure S6.** DSC curve of PDPFDE in N<sub>2</sub> atmosphere.

**Figure S7.** The SEM image of the char residue of PDPFDE under nitrogen at 700 °C in muffle furnace for 30 min.

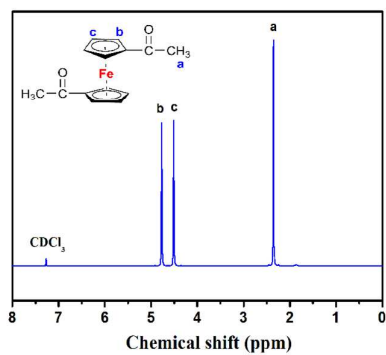
**Table S1.** Chemical structures of pyrolysis compounds for PDPFDE at 700 °C under N<sub>2</sub>

Peak	t <sub>R</sub> (min)	Name of compounds	molecular formula	M.W (g/mol)
1	1.52	carbon dioxide	CO <sub>2</sub>	44
2	1.89	cyclopentadiene		66
3	2.51	1-methyl-cyclopentadiene		80
4	2.74	benzene		78
5	4.46	toluene		92
6	5.41	2-ethylacridine		207
7	6.32	ethylbenzene		106
8	6.94	benzenemethanimine		105
9	8.47	1-actylcyclopentadiene		108
10	9.48	indane		118
11	9.79	indene		116
12	11.68	1-methylindene		130
13	12.11	naphthalene		128
14	13.66	2,6-dimethylnaphthalene		156
15	14.07	ferrocene		186
16	14.89	biphenyl		154

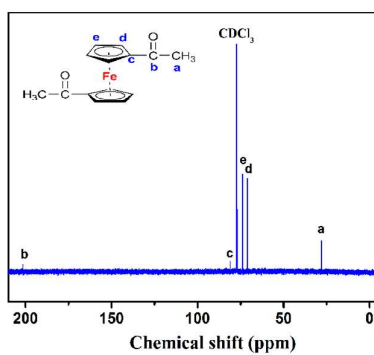
17	15.17	diphenylmethane		168
18	15.30	1-naphthalene-carbonitrile		153
19	16.66	bibenzyl		182
20	17.49	1H-phenalene		166
21	18.72	1-acetyl ferrocene		228
22	18.90	(E)-stilbene		180
23	19.28	1,4-dimethyl-7-(1-methylethyl) azulene		198
24	20.03	1,1',1''-(1-ethanyl-2-ylidene) tris-benzene		258
25	20.60	2,2'-diphenylethylamne		196
26	22.09	1,1'-diacetyl-ferrocene		270
27	22.39	Iron	<b>Fe</b>	56
28	23.99	3-methyl terphenyl		244



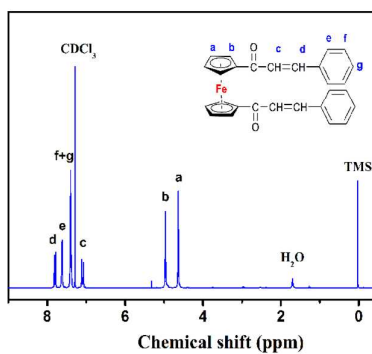
**Figure S1.** FTIR spectrum of DAF



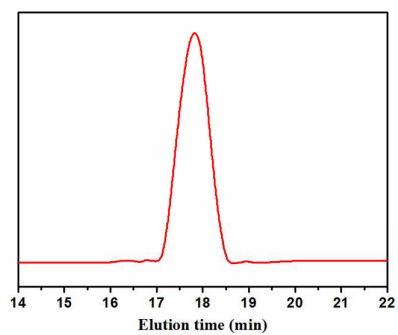
**Figure S2.** <sup>1</sup>H NMR spectrum of DAF



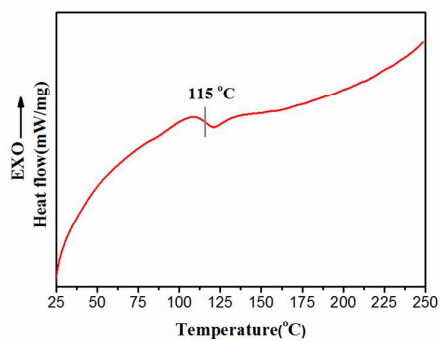
**Figure S3.** <sup>13</sup>C NMR spectrum of DAF



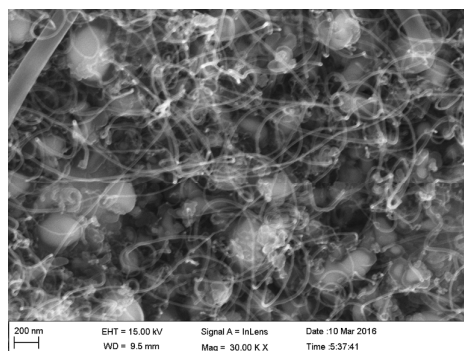
**Figure S4.**  $^1\text{H}$  NMR spectrum of DCF



**Figure S5.** GPC curve of PDPFDE.



**Figure S6.** DSC curve of PDPFDE in  $\text{N}_2$  atmosphere.



**Figure S7.** The SEM image of the char residue of PDPFDE under nitrogen at 700°C in muffle furnace for 30 min.

The Figure S7 represents the SEM image of the char residue of PDPFDE under nitrogen at 700°C in muffle furnace for 30 min. Based on the SEM image, we can clearly see the many nanowires existing in the char residue. However, the investigation of the detailed component and structure of the nanowires needs further study in the future.