

Article ID: 1007-8827(2012)06-0469-07

Synthesis and characterization of condensed poly-nuclear aromatic resin using heavy distillate from ethylene tar

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Abstract: Heat-resistant condensed poly-nuclear aromatic resin (COPNAR) was prepared using heavy distillate (>250 °C, named DO) from distilled ethylene tar (ET). The basic properties of ET, DO and COPNAR were investigated by FT-IR, ¹H-NMR, TGA and elemental analysis. The structural parameters of DO and ET were obtained by the improved Brown - Ladner method and the formation mechanism of the COPNAR from DO was deduced. Results show that a superior heat-resistant COPNAR can be obtained from DO. The distillation of ET increases the heat resistance of the COPNAR, and the reaction mechanism is confirmed to be an acid-catalyzed positive ion-type polymerization.

Keywords: Condensed poly-nuclear aromatic resin; Ethylene tar; Heavy distillate; Synthesis mechanism; Heat resistance

CLC number: TQ 326.8+2

Document code: A

1 Introduction

As a kind of novel heat-resistant material, condensed poly-nuclear aromatic resin (COPNAR) has received considerable interests. In 1986, Otani reported the first successful synthesis of COPNAR with various advantages, such as high thermal stability, beneficial affinity, lubricity, good mechanical properties and mouldability^[1]. By far a number of raw materials such as coal and petroleum derivatives have been successfully employed to prepare COPNAR^[2-13].

Ethylene tar (ET), as a sort of byproduct in the production of ethylene, was normally used as fuel oil for boilers or furnaces, yet has not been developed for other high-value-added applications. It is known that ET has a high content of aromatics and a low content of branched hydrocarbon chains, which make it an ideal candidate material for COPNAR preparation. However, the reactivity of ET is presumably restricted by the large portion of inactive molecules. It is be-

lieved that the removal of those inactive molecules in ET could possibly increase its overall reactivity.

In this work, ET and its heavy distillate (>250 °C, named as DO) were used as starting materials to prepare COPNAR. After distillation under normal pressure, volatile molecules were removed when ET was heated to 250 °C. COPNAR was synthesized using trioxane as a cross-linking agent and p-toluene sulfonic acid (PTS) as a catalyst. The properties of the raw materials and as-obtained resins were systematically characterized. Finally, synthesis mechanism of COPNAR from DO was proposed.

2 Experimental

2.1 Raw materials

ET was provided by Taide Petrochemical Company, China. Trioxane and PTS were purchased from Sinopharm Chemical Reagent Company, China. Toluene was supplied by Tianjin Chemical Reagent Com-

Received date: 2012-07-08; **Revised date:** 2012-12-05

Foundation item: Program for New Century Excellent Talents in University China Ministry of Education in 2009 (No. NCET-10-0768), the National Natural Science Foundation of China (Nos. 20876176, 51172285), the Key Project of Chinese Ministry of Education (No. 109100), the Fundamental Research Funds for the Central Universities (09CX04037A) and the Natural Science Foundation of Shandong Province (ZR2011EL031, ZR2011EL030).

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English edition available online ScienceDirect (<http://www.sciencedirect.com/science/journal/18725805>).

DOI: 10.1016/S1872-5805(12)60027-4

pany and quinoline from Tingxin Chemical Reagent Company.

2.2 Distillation of ET

About 300 g of ET was put into a three-neck flask. The distillation was carried out under normal pressure to remove the volatile molecules below 250 °C. The left heavy distillate (DO) around 80% of ET was used to prepare COPNAR.

2.3 Preparation of COPNAR

50.21 g of DO, 7.51 g of trioxane and 2.52 g of PTS were thoroughly mixed and then heated with a heating profile as followed until a solidified mixture was visualized under a nitrogen flow of 30 mL/min. The heating profile included a heating at 5 °C/min from room temperature to 130 °C, a holding at 130 °C for 1 h, a second heating at 1 °C/min from 130 °C to 140 °C and a second holding at 140 °C until the mixture was solidified

It was observed that the viscosity of the mixture steadily increased, indicative of a gradual increase of the polymerization degree. At the end of reaction, a highly viscous black melt COPNAR was obtained. As a comparison, COPNAR from ET was also synthesized, using the same synthetic route and conditions as those from DO.

2.4 Characterization

The raw materials and obtained COPNAR were systematically analyzed by TGA, FT-IR, and ¹H-NMR. For TGA measurements, 10 mg sample was placed in a platinum crucible in a Shimadzu DTG-60 thermo-gravimetric analyzer, and heated to 900 °C at 10 °C/min under a nitrogen flow of 50 mL/min. FT-IR spectra of ET, DO and the COPNAR were recorded on a Shimadzu 8400S FT-IR spectrometer in a transmittance mode. The scan frequency of each spec-

trum was 15 times per second. Bruker AV500 ¹H-NMR analyzer was used to characterize the state of hydrogen in ET, DO and the COPNAR. The solvent used was chloroform, the interior label was trimethylchlorosilane. The sweep length was 10 000 Hz, and the resonance frequency 500 MHz.

Elemental analysis was performed by Element Vario EL organic element analyzer. Analysis of CHN of raw materials was conducted in accordance to NEQ JPI-5S-22-83. The levels of ash, toluene insoluble (TI) and quinoline insoluble (QI) were determined according to international standards ISO 6245-1982, ISO 6376-96 and ISO 6791-81, respectively. The softening point of the COPNAR was measured in accordance with ASTM D36-66.

3 Results and discussion

3.1 Properties of ET and DO

Table 1 and 2 summary the basic properties of ET and DO. The level of saturate in ET is as low as 1.79%, whereas the aromatic content is up to 54.51%. TI and QI values of ET are as low as 0.25% and 0.12%, respectively. DO has obviously a higher asphaltene content (78.44%) than that of ET (31.55%) and a lower aromatic content (17.26%) than that of ET (54.51%). Likewise, TI and QI values of DO are both larger than those of ET. The TI-QI value, a critical parameter that determines the binding performance of the CONPNAR, increases from 0.13% for ET to 0.18% for DO. As the distillation yield is high (80%), the obvious composition differences between ET and DO suggest that condensation reaction indeed occur in distillation of ET.

Table 1 Properties of ET, DO, and as-prepared COPNAR

Samples	<i>M</i>	$\rho/\text{g}\cdot\text{cm}^{-3}$	<i>A</i> / %	CR / %	<i>W</i> / %	TI / %	QI / %	TI-QI / %
ET	342	1.003	0.15	19.75	4.49	0.25	0.12	0.13
DO			0.11	26.94	0	0.41	0.23	0.18
COPNAR			0.13	40.25	0	21.87	3.97	17.90

Note: *M*-average molecular weight; ρ -density; *A*-ash content; CR-carbon residue ratio; *W*-water content; TI-toluene insoluble; QI-quinoline insoluble

Table 2 gives the composition analyses of ET and DO. Compared with 91.5% of C and 6.2% of H for ET, the C and H of DO are 91.6% and 7.3%, respectively. It is noted that more H exists in DO than in ET, which will be discussed later. The aromatization degrees of ET and DO, characterized by f_A , are 0.8 and 0.7, respectively, which are both adequately high to prepare COPNAR.

3.2 Properties of COPNAR

3.2.1 Basic properties of COPNAR

Tables 1 and 2 give basic properties and compositions of COPNAR. After the COPNAR was heated for 2 h at 500 °C, the carbon residue (CR) yield is as high as 40.25%, as opposed to 26.94 and 19.75% for DO and ET, respectively. TI, TI-QI and QI values of the COPNAR remarkably increase as compared with to those of ET and DO.

Table 2 Compositions of ET, DO and as-prepared COPNAR

Samples	Four components %				Elemental components %				f_A
	Saturates	Aromatics	Resins	Asphaltenes	C	H	N	Others	
ET	1.79	54.51	12.15	31.55	91.5	6.2	0.1	2.2	0.8
DO	3.30	17.26	1.00	78.44	91.6	7.3	0.2	0.9	0.7
COPNAR					89.2	7.2	0.1	3.5	-

Note: f_A denoted as carbon aromaticity index of ET

3.2.2 FT-IR analysis

FT-IR spectra of (a) ET, (b) DO and (c) COPNAR are shown in Fig. 1. As to ET, the peak at $3\,049.5\text{ cm}^{-1}$ is attributed to aromatic C—H stretching vibration^[14-15]. The pronounced peak at $1\,097.5\text{ cm}^{-1}$ is thought to be resulted from C—O stretching vibration. The relatively weak peaks at 750.6 cm^{-1} , 810.4 cm^{-1} and 860.9 cm^{-1} are likely generated by the out-of-plane bending vibrations of 2, 3, 4 aromatic C—H. Likewise, the peak at 700.1 cm^{-1} is ascribed to out-of-plane bending vibration of 5 aromatic C—H.

In contrast to FT-IR peaks of ET in Fig. 1a, the peaks of DO in Fig. 1b change remarkably. There is a new peak at $1\,705.7\text{ cm}^{-1}$ caused by C=O stretching vibration. Meanwhile, the peak at 860.9 cm^{-1} in Fig. 1a disappears in Fig. 1b. The peak at $1\,022.5\text{ cm}^{-1}$ is likely generated by C—O stretching vibration, and there is a big decrease in intensity compared to ET. Similarly, there are noticeable changes in peaks of out-of-plane bending vibrations of C—H in aromatic (811.3 cm^{-1} and 740.4 cm^{-1}). These changes indicated that chemical reactions took place in ET when it is distilled, and those changes discussed later are found to be beneficial to the heat resistance of COPNAR. These FT-IR spectra clearly confirm the availability of active sites in different positions of DO aromatic ring for possible aromatic substitution reactions.

In contrast to the peaks of DO in Fig. 1b, the peaks between 900 cm^{-1} and 650 cm^{-1} of the COPNAR in Fig. 1c are found to be changed remarkably. This change is ascribed to out-of-plane bending vibrations of C—H in aromatic ring and indicates that the cross-linking reactions alter the types of aromatics. These results reveal the occurrence of the cross-linking reactions between trioxane and DO.

3.2.3 $^1\text{H-NMR}$ analysis

The $^1\text{H-NMR}$ data of ET, DO, and COPNAR are shown in Table 3, where H_A refers to the atom content of H in aromatic ring. H_α denotes the atom content of H in groups of $\alpha\text{-CH}_3$, $\alpha\text{-CH}_2$ and $\alpha\text{-CH}$ that connected with aromatic ring. Similarly, H_β refers to atom content of H in $\beta\text{-CH}_2$, $\beta\text{-CH}$, and H_γ in $\gamma\text{-CH}_3$ that connected with aromatic ring^[16]. The ob-

served levels of changes in H_α , H_β , H_γ and H_A reflect the degree of actual substitution reaction on different positions of ET and DO molecules. The data given in Table 3 reveals a change in H forms in the order of $H_A > H_\alpha > H_\beta > H_\gamma$.

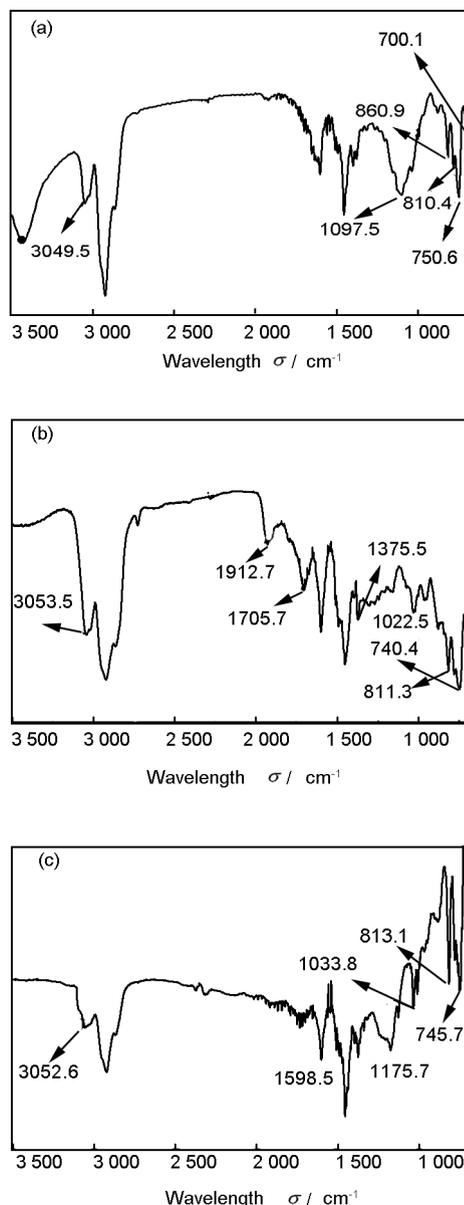


Fig. 1 FT-IR Spectra of (a) ET, (b) DO and (c) COPNAR

Table 3 Atom percentage of different H in ET, DO and COPNAR

H	ET /at. %	DO /at. %	COPNAR /at. %
H _γ	1.98	1.92	2.07
H _β	15.94	17.82	14.52
H _α	31.35	32.66	37.22
H _A	49.61	46.34	44.07

¹H-NMR spectra of (a) ET, (b) DO, and (c) COPNAR are shown in Fig. 2. The large peaks between δ7.0 and δ9.0 are from absorption resonance of hydrogen in aromatic ring. α-H absorption resonance peaks between δ2.0 and δ4.0, β-H absorption resonance peaks between δ1.0 and δ2.0, as well as γ-H absorption resonance peaks between δ0.5 and δ1.0 are also illustrated in Fig. 2. These differences in hydrogen atom content can be used to analyze the hydrogen change during the preparation of COPNAR, which is useful to explain the formation mechanism of COPNAR. The data of DO and COPNAR given in Table 3 indicates that the condensation reduces the values of H_A and H_β, and increases the values of H_α

and H_γ. It is noteworthy that a sizeable absorption resonance peak of methylene-hydrogen is shown at 2.0 of δ, which is supposedly owing to the chemical displacement of methyl proton with diaryl methane structure. This peak unambiguously confirms the occurrence of the cross-linking reaction between DO and trioxane, as well as the formation of the aromatics connected with CH₂ group of trioxane.

3.2.4 Synthesis mechanism of COPNAR

The average structural parameters including C_T, H_T, f_A, H_{AU}/C_A, σ, R_T, R_A, R_N, C_R of DO can be obtained by the improved Brown-Ladner method based on the results of ¹H-NMR, element analysis and average molecular weight^[17-18].

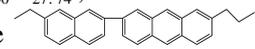
Element analysis given in Table 2 suggests that the S, O and N levels are negligible. Keep this in mind, the obtained average structure parameters of DO were calculated by the improved Brown-Ladner method and listed in Table 4. The calculated average molecular formula is C_{29.00}H_{27.74}, the most reasonable structure of DO should be 

Table 4 Average molecular structural parameters calculated for ET and DO

	C _T	H _T	f _A	H _{AU} /C _A	σ	R _T	R _A	R _N	C _R
ET	26.08	21.20	0.80	0.66	0.24	6.05	4.71	1.33	26.19
DO	29.01	27.74	0.75	0.80	0.26	5.33	4.91	0.42	23.30

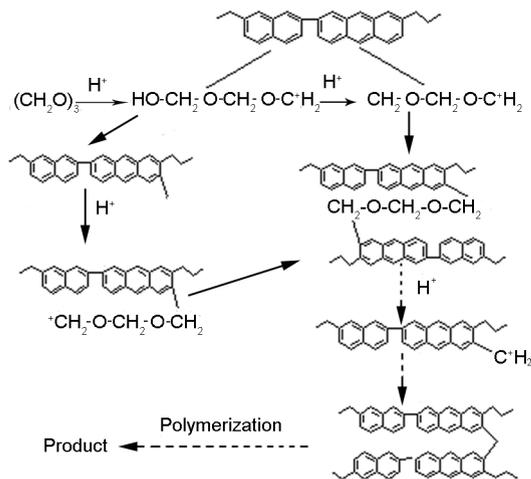
Note: C_T-Total carbon number of average molecular; H_T-Total hydrogen number of average molecular; H_{AU}/C_A- Condensation degree parameter of average molecular; σ- Hydrogen replaced rate surrounding aromatic rings of average molecular; R_T- Total rings per average molecular; R_A-Aromatic rings per average molecular; R_N-Naphthenic rings per average molecular; C_R-Carbon number on the rings of average molecular

Consistently, the FT-IR and ¹H-NMR both support the occurrence of the above synthetic reaction in the formation of COPNAR from DO. In conformity to previous findings described elsewhere^[19], those results reveal an acid-catalyzed positive ion-typed cross-linking reaction. Specifically, reaction mechanism is as follows:

3.3 Heat resistance analysis

The heat resistances of (a) ET, (b) DO, and COPNAR from (c) ET and (d) DO are shown in Fig. 3. It is clearly shown that ET has a significant weight loss at around 110 °C, whereas the onset degradation temperature of DO is above 200 °C and its weight loss rate is obviously slower than that of ET. As a result, the carbon residue yield of DO is much higher than that of ET. COPNAR from ET and DO have a remarkably lower weight loss than ET and DO. At 250 °C, the weight losses for ET, DO, COPNAR from ET and COPNAR from DO are 37.64, 13.84, 10.53 and 7.75%, respectively.

It should be noted that the obvious onset degradation temperature for COPNAR from DO is higher than that from ET, which indicates a significantly superior heat resistance of COPNAR from DO to that from ET. It is believed that the distillation significantly increase the heat resistance of COPNAR. This observation highlights the importance of the distillation in the preparation of resin. More importantly, it also suggests that the heat resistance of the COPNAR from DO can be finely tuned by adjusting the distillation



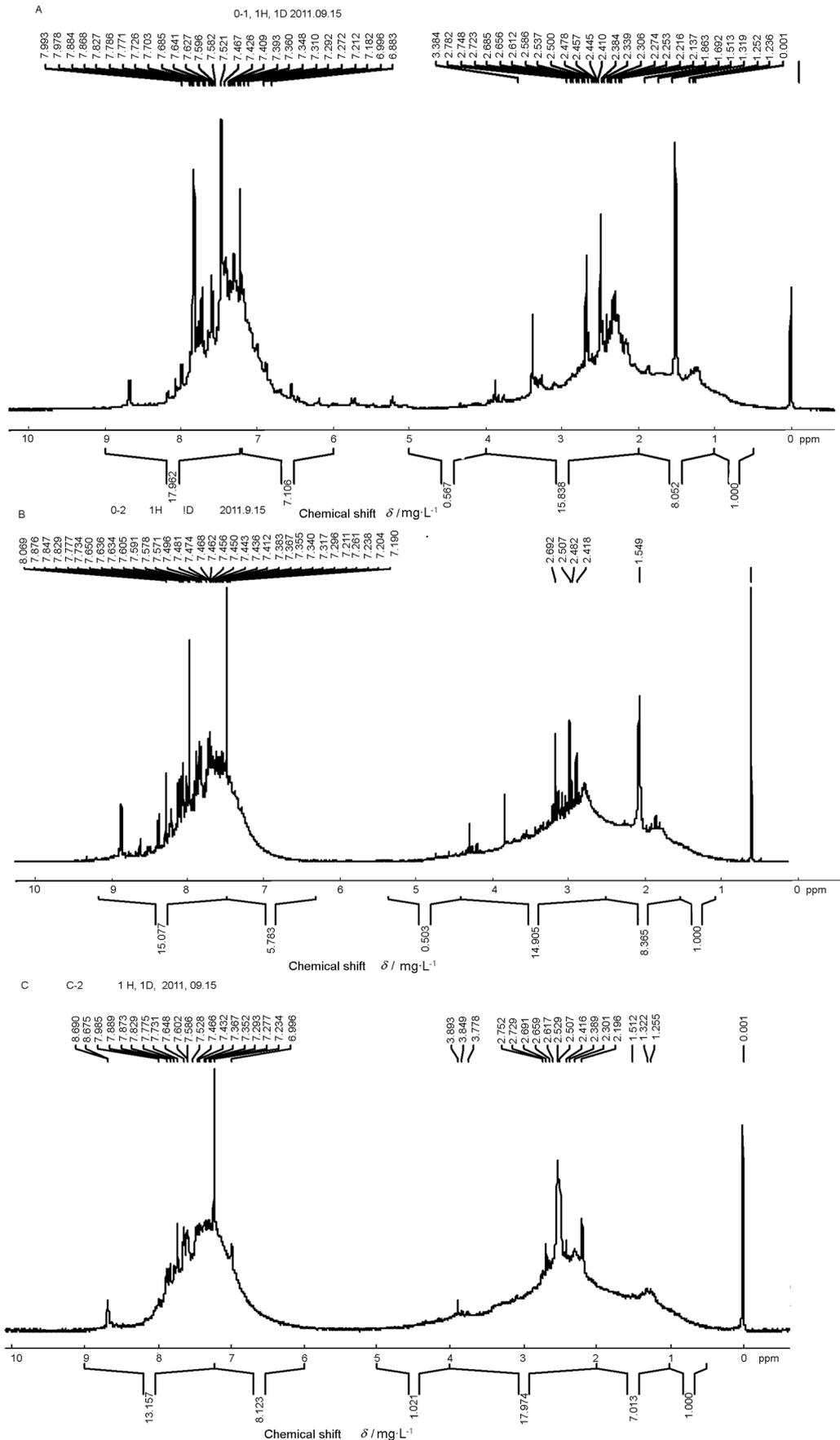


Fig. 2 ¹H-NMR spectra of (a) ET, (b) DO and (c) COPNAR

and heating parameters for suitable potential applications.

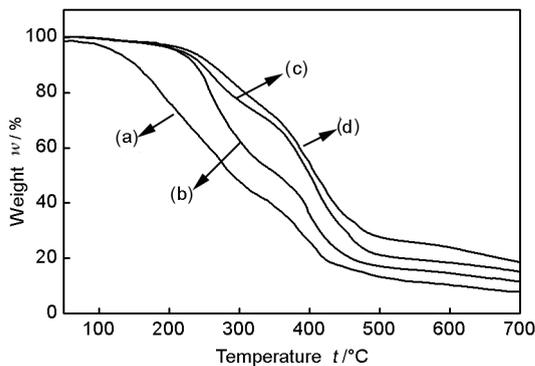


Fig.3 TGA curves of (a) ET, (b) DO, COPNAR derived from (c) ET and (d) DO

4 Conclusions

ET as an industrial byproduct, is readily available at low cost, yet has barely been developed towards any economically and technically rewarding applications. In this work, heavy distillate of ET can be successfully used to synthesize COPNAR with trioxane as a cross-linking agent and PTS as a catalyst. DO with high asphaltene content is proved to be an advantageous for the synthesis of COPNAR with a superior thermal stability. To achieve a definitive insight into the reaction mechanism, the critical characteristics of DO and ET, including average molecular structure, relative hydrogen contents at specific molecular locations were thoroughly explored and deduced, and the mechanism of which has been proved to be a positive ion-typed condensation polymerization catalyzed by acid. Heat resistance of COPNAR from DO, a key factor determining its quality and application, is found to be higher than that from ET. The COPNAR from DO shows promising applications, such as binder materials, precursors of carbon fiber and composite matrix materials.

References

- [1] S Otani, H A Yu, E Ota. Carbonization behavior of condensed poly-nuclear aromatic (COPNA) resins [J]. *Tanso*, 1986, 127: 162-170.
- [2] K Tanemura, T Suzuki, Y Nishida, et al. Synthesis of the sulfonated condensed polynuclear aromatic (S-COPNA) resins as strong protonic acids [J]. *Tetrahedron*, 2011, 67: 1314-1319.
- [3] X L Cheng, Q F Zha, J T Zhong, et al. Needle coke formation derived from co-carbonization of ethylene tar pitch and polystyrene [J]. *Fuel*, 2009, 88: 2188-2192.
- [4] Q L Lin, M Z Zheng, T Qin, et al. Preparation of solid carbon spheres by pyrolysis of allyl COPNA-BMI resin [J]. *Anal Appl* Pyrolysis, 2010, 89: 112-116.
- [5] K Nawa. Development of flexible polymer blend films from advanced COPNA resin and nylon 6 [J]. *Appl Polym Sci*, 1996, 61: 1737-1746.
- [6] I Gerard, D Begin, G Furidin. Prolysis of coal tar pitch with graphite-MoCl₅ intercalation compound [J]. *Fuel*, 1998, 77: 607-611.
- [7] S Nakajima, Y Iijima, T Inoue, et al. Anomalous magnetic properties of polycondensate of fused polynuclear aromatics (COPNA) resin [J]. *Synth Met*, 1995, 71: 1817-1818.
- [8] S Otani, V Raskovic, A Oya. Some properties of a condensed polynuclear aromatic resin (COPNA) as a binder for carbon fibre composites [J]. *Journal of Materials Science*, 1986, 21: 2027-2032.
- [9] I Sekiguchi, K Kubota, Y Oyanagi, et al. Tribological properties of COPNA resin [J]. *Wear*, 1992, 158: 171-183.
- [10] K Nawa, M Ohkita. Reliability of the laminate from COPNA resin /E-glass fabrics system [J]. *IEEE T Compon Pack B*, 1997, 20: 78-86.
- [11] Y Yu, D Z Zhao, S Huang. Research on preparation of petroleum resin from ethylene Tar [J]. *Chem Adhes*, 2010, 32: 33-36.
- [12] K Kusakabe, S Gohgi, S Morooka. Carbon molecular sieving membranes derived from condensed polynuclear aromatic (COPNA) resins for gas separations [J]. *Ind Eng Chem Res*, 1998, 37: 4262-4266.
- [13] A Takagaki, M Toda, M Okamura, et al. Esterification of higher fatty acids by a novel strong solid acid [J]. *Catal Today*, 2006, 116: 157-161.
- [14] A Toms, L Toms. Oil analysis and condition monitoring [J]. *Chemistry and Technology of Lubricants*, 2010, 4: 459-495.
- [15] K Tsuchida, J P Bell. A new epoxy/episulfide resin system for coating applications; curing mechanism and properties [J]. *Int J Adhes Adhes*, 2000, 20: 449-456.
- [16] S Hiroshi, I Nobuyuki, K. Akira. Development of high-performance sliding material by multi-layer interlocked fabric-reinforced COPNA resin composite [J]. *Reports of Industrial Technology Center of Tochigi Prefecture*, 2006, 4: 77-80.
- [17] J K Brown, W R Ladner. A study of the hydrogen distribution in coal-like materials by high-resolution nuclear magnetic resonance spectroscopy II -A comparison with infrared measurement and the conversion to carbon structure [J]. *Fuel*, 1960, 39: 87-96.
- [18] L H Ali, K A Al-Ghannam, J M Al-Rawi. Chemical structure of asphaltene in heavy crude oils investigated by NMR [J]. *Fuel*, 1990, 69(4): 519-521.
- [19] S B Li, C G Song, B H Hou, et al. Study on the synthesis and composite properties of condensed polynuclear aromatics resin using coal tar pitch as monomer and trioxane as cross-linking agent [J]. *Carbon (China)*, 2008, 4: 13-17.

乙烯焦油重质馏分合成缩合多核芳香烃树脂

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摘要: 以价廉量广的乙烯焦油的重馏分油 (>250 °C) 为原料, 以三聚甲醛为交联剂合成耐热性优异的缩合多核芳香烃树脂 (COPNAR)。基于¹H-NMR 分析, 采用改进的 B-L 法对重馏分油和乙烯焦油的平均分子结构进行解析。采用 FT-IR、¹H-NMR、TGA 和元素分析等研究了所制 COPNAR 的基本性质和合成机理。结果表明, 乙烯焦油的重馏分油可用来合成具有优异耐热性的 COPNAR。对乙烯焦油进行蒸馏, 可显著提高所制树脂的耐热性。反应机理为酸催化阳离子缩聚反应。

关键词: 缩合多核芳香烃树脂; 乙烯焦油; 重馏分; 合成机理; 耐热性

基金项目: 教育部新世纪优秀人才支持计划 (NCET-10-0768), 国家自然科学基金面上项目 (20876176, 51172285), 教育部科学技术研究重点项目 (109100), 中央高校基本科研业务费专项资金 (09CX04037A) 和山东省自然科学基金 (ZR2011EL031, ZR2011EL030)。

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主要产品

- 一. 2000 目 ~ 12500 目植物炭粉, 纳米植物炭黑, 纳米植物炭浆;
- 二. 1500 目 ~ 12500 目竹炭粉, 涤纶长纤用纳米竹炭粉, 短丝用纳米竹炭粉, 纳米竹质活性炭粉;
- 三. 1500 目 ~ 12500 目木炭粉, 纳米木炭粉, 纳米木质活性炭粉;
- 四. 2000 目 ~ 12500 目脩长炭粉, 纳米脩长炭粉;
- 五. 2000 目 ~ 12500 目椰壳活性炭粉, 纳米椰壳活性炭粉;
- 六. 植物导电炭黑, 纳米植物导电炭黑;
- 七. 2000 目 ~ 12500 目橡木炭粉, 纳米橡木炭粉;
- 八. 纳米麻杆炭粉;
- 九. 绝缘植物炭粉, 纳米植物绝缘炭浆;
- 十. 超级活性炭 (BET: 2500-3200 m²/g)

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