Original Research Article

Study on Carbazole-like Polymer Solar Cell Materials

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ABSTRACT

With the development of modern industry, the global energy crisis and air pollution problems become increasingly prominent. Solar energy has emerged as an ideal renewable energy by many countries' attention. Solar cells are the most promising use of solar energy in the kind of concern. Compared with inorganic solar cells, polymer solar cells performance is more excellent and carbazole polymer materials with rigid fused ring structure, intramolecular electron transfer, good transport and easy to introduce a variety of multi-functional groups into the carbazole. The advantages of the ring in the field of solar cell materials show a wide range of potential applications. This paper describes the principles of polymer solar cells and several common donor materials. The precursors of carbazole polymers were designed and synthesized, and their structures were characterized.

KEYWORDS: polymer solar cell; electron donor material; carbazole polymer

Introduction

Since the Second Industrial Revolution, fossil fuels have been playing an irreplaceable role in the world's energy, as little as people travel to a country's economic development is closely related to it. However, because the fossil energy is the legacy of ancient animals and plants in the formation under the formation of thousands of years after the evolution of the use of once cannot be recycled is so extremely valuable. Uncontrolled mining close to depletion and energy crisis in the future is inevitable. Not only the energy crisis, the use of fossil fuels has also brought severe environmental problems, a large number of fossil energy consumption cause greenhouse gas emissions, the atmosphere of greenhouse gas concentrations increased and the greenhouse effect increased which lead to global warming. Furthermore, it is also caused by acid rain and haze of the culprit [1]. Therefore, people need a clean new energy to solve the current diffculties. Solar energy as an energy is not only inexhaustible but also has no pollution, easy to use, does not affect the ecological balance of the earth and other advantages. These are conventional energy cannot be compared. The development and usage of solar energy have become the focus of people's efforts. Solar cells as the development and utilization of solar energy is the most effective way, is the use of photovoltaic effects to convert it into electrical energy device [2]. Because of this, the research of solar cells by many countries' attention, monocrystalline silicon solar cells with high photoelectric conversion effciency to occupy the vast majority of the solar cell market. However, due to the high cost, it is diffcult to significantly reduce its cost [3] hence limiting its better development so people began to look for breakthroughs in new materials.

Compared with inorganic solar cells, polymer solar cells in the cost, weight, production process and the preparation of flexible devices has a prominent advantage [4]. In addition, the conjugate polymer material variety is complete, can be designed and improve the performance of solar cells by changing the nature of the material. Excellent performance of the PCBM class of electronic receptor material. Since 1995 by Wudl [5] after the invention, the electronic donor material in the field of new materials development has become active. Compared with the small molecule compounds, the conjugated polymer has many advantages: (1) a π-conjugated system with a dimensional extension that facilitates the exciton and charge carrier transfer. (2) It is easy to regulate its light through the structural design of the polymer Absorption capacity and other physical properties: solution film is better. Therefore, the majority of scientific research workers began to polymer-type electronic donor materials have great interest, the new structure and synthesis methods emerge in an endless stream of outstanding materials continue to emerge, and indeed improve the photoelectric conversion efficiency.

In the polymer solar cell donor material, carbazole compounds have a large conjugate system, containing rigid fused ring structure, strong molecular electron transfer, good transport and easy to introduce a variety of functional groups into its rigid carbazole ring and the like hence making the carbazole heterocyclic compounds in the field of solar cell materials. Research in related fields is very active and has achieved many important research results. Nevertheless, study in many areas need further in-depth.

1. Polymer solar cell structure and the basic principles

1.1. Structure of polymer solar cells

In general, the positive and negative electrodes and the organic polymer photosensitive active layer form a major part of the polymer solar cell. The photoactive active layer can be divided into single layer structure, double heterojunction structure and bulk heterojunction structure. The following five steps briefly summarize the process of photoelectric conversion of solar cells: absorption of incident light generation exciton - exciton diffusion - charge separation - charge transport - charge collection. Excitations are mostly inefficient (less than 0.1%) due to recombination in monolayer structures. Compared with the single-layer structure device, the donor material in the absorption of sunlight generated exciton by the donor and acceptor two materials constitute the two-layer active layer structure, the exciton into the diffusion range but encountered To the acceptor material, resulting in excitons because the two materials of the front- line molecular orbital can be separated from the poor, making the performance of the device greatly improved. The exciton has a diffusion length of several nanometers to several tens of nanometers and the exciton can only be effectively separated when the donor and the receptors are separated by a few nanometers to several tens of nanometers. Therefore, in the two-layer heterojunction if the layer is too thick, the performance of the device will be reduced. However, the active layer has only a thickness close to the diffusion length of the exciton and is not able to effectively absorb the sunlight which greatly improves the performance of the device. The donor and acceptor blends form the bulk heterojunction solar cell active layer, which can disperse the donor receptors of these devices very well. Therefore, the problem of short diffusion length in the polymer material can be effectively solved, so that the efficiency of exciton separation is also greatly improved.
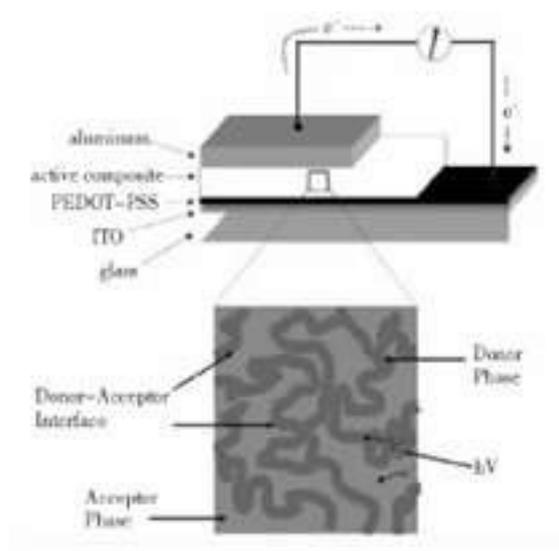

Figure 1. Polymer solar cell structure

1.2. The basic working principle of polymer solar cells

Organic photovoltaic devices as the most important part of the polymer solar cells, the battery performance is good or bad by the energy conversion efficiency of the direct decision. The organic photovoltaic device is a kind of donor and acceptor heterojunction device composed of a photosensitive active layer sandwiched between ITO transparent anode and cathode. The donor / acceptor bilayer device and the donor. The bulk heterojunction device is the most representative. When the sensitive layer is irradiated through the ITO electrode so that the photons on the light have the appropriate energy, the donor or acceptor material on the photosensitive active layer absorbs and excites the excitons, and the excitons diffuse to the donor / Receptor interface, where charge separation occurs, holes are generated on the donor, electrons are generated on the receptor, and then the anode collects the holes that pass along the donor to the anode, and the electrons that pass along the receptor to the cathode are collected by the cathode , So that light and light voltage generated. It is clear that the performance of organic photovoltaic devices depends to a large extent on the charge transport properties (the hole mobility of the donor and the electron mobility of the acceptor), the absorbance of the donor and acceptor materials (absorbance

wavelength and absorption coefficient), including the position of the highest occupancy (HOMO) and the lowest empty orbit (LUMO) level (which determines the charge separation performance of the exciton at the donor / acceptor interface). In order to achieve charge separation, it is ensured that the electrons at the LUMO level of the excitons in the donor can spontaneously transfer from the donor / acceptor interface to the LUMO level of the receptor, and the excitons in the receptor can spontaneously HOMO level is transferred to the HOMO level of the donor, so the LUMO and HOMO levels for the donor material should be higher for the electron energy level, and the LUMO and HOMO levels of the acceptor material should be Lower.

It is necessary to increase the absorption of light in the active area of the polymer solar cell as much as possible; (2) the absorption of light in the active region of the polymer solar cell; (2) the absorption of the organic energy, (3) In order to obtain a larger photoelectric conversion efficiency, the resulting carriers have less loss when they reach the external circuit.

2. Experimental part

2.1. Major instruments and reagents

2.1.1 The main instrument of the experiment

Dewar bottle.

DF-101S-type heating constant temperature heating magnetic stirrer, Zhengzhou City Brocade Instruments Equipment Co., Ltd.

RE-2000A Rotary Evaporator, Shanghai Yarong Biochemical Instrument Factory.

SHZ-D (III) type circulating water type vacuum pump, Gongyi City to China Instrument Co., Ltd.

DHG-90114 electric thermostat oven, Shanghai Jinghong Experimental Equipment Co., Ltd., Taicang Jinghong Equipment Co., Ltd.

LT102 electronic balance (NO: 0021190, e = 10 d, d = 0.01 g), Changshu City days instrument limited liability company.

Infrared spectroscopy: Instrument Bruker Tensor 27, KBr tablet method with potassium bromide tablet, detection range of 400 cm-1 ~ 4000 cm^{-1}.

1H-NMR NMR analysis: German-made Bruker Ultra Sheild Plus 400 MHz nuclear magnetic resonance spectrometer 1H-NMR spectra, tetramethylsilane as internal standard, the solvent used is deuterated chloroform.

2.1.2 Experimental reagents

The specifications of the reagents required for this experiment and their manufacturers are shown in Table 1.

Table 1. Reagents, specifications and their manufacturers

Name	Structure	Manufacturer
Carbazole	97%	Shanghai Jiuding Chemical Technology Co. Ltd
Ethanol	Pure	Nanjing Chemical Reagent Co. Ltd
Potassium hydroxide	Pure	Shanghai Ling Feng Chemical Reagent Co., Ltd.
DMSO	Pure	Nanjing Chemical Reagent Co., Ltd.
2 - ethylhexyl bromide	98%	Shanghai Jiuding Chemical Technology Co., Ltd
Petroleum ether	Pure	Nanjing Chemical Reagent Co., Ltd
Dichloromethane	Pure	Nanjing Chemical Reagent Co., Ltd.
Ethyl acetate	Pure	Nanjing Chemical Reagent Co., Ltd.
N - bromosuccinimide	98%	Shanghai Jiuding Chemical Technology Co., Ltd
Anhydrous sodium sulfate	Pure	Nanjing Chemical Reagent Co., Ltd.
DMF	Pure	Nanjing Chemical Reagent Co., Ltd.
4,4 '- dibromobiphenyl	99%	Nanjing Weiao Chemical Co., Ltd.
glacial acetic acid	Pure	Shanghai four - dimensional Chemical Co., Ltd
Concentrated nitric acid	Pure	Zhongcheng Chemical Co., Ltd.
Triethyl phosphite	Chemically pure	Shanghai Ling Feng Chemical Reagent Co., Ltd.
2,7-dibromocarbazole analysis was pure	>98%	Tokyo Chemical Industry Co., Ltd

2.2.   Experimental steps

As the purchase of carbazole as a brown solid, so its recrystallization treatment, the specific steps are as follows; DMF, DMSO after 4 Å molecular sieve (activated) treatment; other drugs and solvents are purchased directly after use.
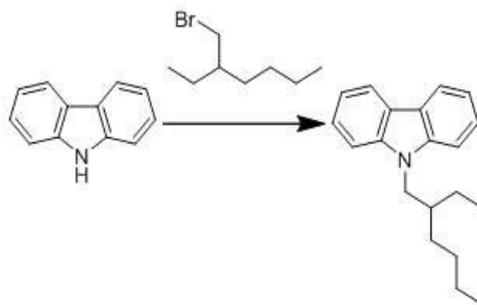
2.2.1   Preparation of 3,6-dibromo-9- (2-ethylhexyl) carbazole

Recrystallization of carbazole Experimental steps:
(1)   Select solvent: take 0.1 g carbazole in the test tube, add 1 mL of solvent to see if it is dissolved, if not dissolved, then heated to boiling, see if it is dissolved, if still not dissolved, add 1 mL of solvent in accordance with the above Method to operate. If the solvent is added with 1 to 5 mL of boiling, the carbazole can be completely dissolved, and the solvent can be used to recrystallize the carbazole. With the above operation, ethanol meets our requirements for solvents, the solvent for this experiment is defined as ethanol.

(2)   2.00 g carbazole were weighed, the amount of 20 mL of ethanol added to the 100 mL single-mouth flask to add the magnet. The temperature was set to 80 °C and heated to reflux with stirring. And then wait until the boiling point, carbazole is not completely dissolved, add 5 mL of ethanol to observe the dissolution of carbazole, if not dissolved then add 5 mL of ethanol, this cycle until the carbazole completely dissolved, using 65 mL of ethanol. The end of the heating, hot pumping filter, take the mother liquor transferred to 100 mL beaker, cooled to room temperature, a large number of white crystal precipitation, again pumping, take the crystal, transferred to the evaporative dish, put 50 °C oven drying, Crystallized carbazole 1.86 g, yield 93.0%.
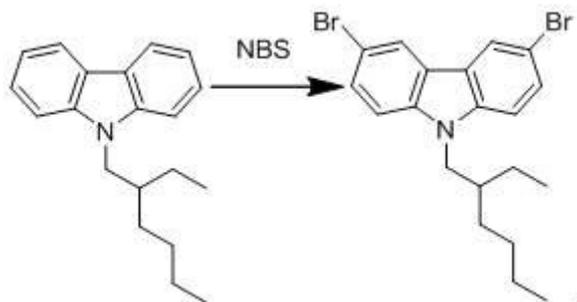
The alkylation of carbazole Reaction equation:

Experimental steps:

(1)   Calculated: Carbazole, potassium hydroxide and 2-ethylhexyl bromide molar equivalence ratio of 1: 1.5: 1.2. Weighing 1.77 g of carbazole about 11.0 mmol, then the need for potassium hydroxide 16.5 mmol about 0.92 g, 2-ethylhexyl bromide 13.2 mmol about 2.55 g.

(2)   Take 30 mL of DMSO, mix with 1.77 g of carbazole, 0.92 g of potassium hydroxide and 2.79 g of anhydrous sodium sulfate into a 50 mL three-necked flask. The mixture was heated to reflux for 30 min and the temperature was set at 80 ° C.

(3)   Weigh 2.55 g of 2-ethylhexyl bromide, add to a three-necked flask, perform a TLC test every 30 min, monitor the degree of reaction and calculate the Rf value.

(4)   Ingredients: Rf = 0.283;

(5)   Crude product: Rf1 = 0.80, Rf2 = 0.286 (raw material).

(6)   TLC test showed that the reaction point disappeared, the reaction was complete, the product poured into 300 mL of water, extracted with ethyl acetate transferred to the conical flask, add anhydrous sodium sulfate to dry.

(7)   Suction filter, take the filtrate, steaming dry solvent to get brown oil.

(8)   For column chromatography, the developing agent for the petroleum ether, with a conical flask to collect the separated products, steamed dry solvent to obtain carbazole alkylation of pure products. Finally, the product was 2.41 g, the yield was 78.5%.

Preparation of 3,6-dibromo-9- (2-ethylhexyl) carbazole by NBS method
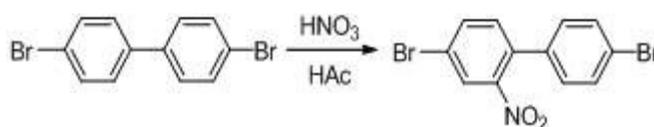
Reaction equation:

Experimental steps:

(1) The mole equivalent ratio of the carbazole alkylation product to NBS was 1: 2.1. The carbazole alkylation product was 2.41 g, about 8.63 mmol, requiring NBS 18.12 mM of about 3.22 g.

(2) preparation of ice water mixture in the Dewar bottle, weighed NBS 3.22 g, with 10 mL of DMF were dissolved carbazole alkylation products and NBS, carbazole alkylation product solution was added to 50 mL three-necked flask, The DMF solution was added to the dropping funnel. Insert the drying tube into the ice water mixture in the 0 °C under the conditions of stirring, until the solution began to drop NBS solution drop, the speed should not be too fast, about 1 to 2 seconds a drop, drop after the withdrawal of the dropping funnel and plug Good stopper. A TLC test was performed every 30 min during the reaction, the degree of reaction was measured and the Rf value was calculated.

(3) Ingredients: Rf = 0.667;

(4) Crude product: $Rf_1 = 0.516$, $Rf_2 = 0.677$ (raw material).

(5) TLC test showed that the reaction point disappeared and the reaction was complete. The product was poured into 200 mL of water, extracted with ethyl acetate into a conical flask, and dried over anhydrous sodium sulfate.

(6) Filter, take the filtrate, steaming, steaming dry solvent, to light yellow oil.

(7) Then it was subjected to column chromatography, and the developing solvent was petroleum ether. The separated product was collected by a conical flask and eluted with distilled water to obtain 3,6-dibromo-9- (2-ethylhexyl) carbazole Pure product. The product was 2.84 g, the yield was 75.3%.

4.2.2 Preparation of 2,7-dibromo-9- (2-ethylhexyl) carbazole

Preparation of 2,7-dibromocarbazole

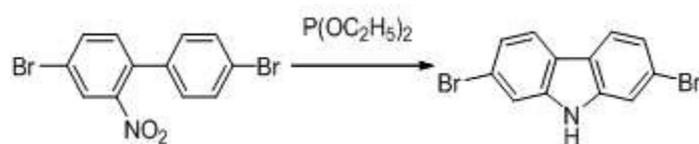1)   4,4 '- nitration of dibromobiphenyl Reaction equation:

Experimental steps:

(1) Weighing 1.56 g 4,4 '-dibromobiphenyl, measuring 20 mL of glacial acetic acid, adding to a four-necked flask, the temperature was set at 100 °C, heated and stirred, and the temperature was raised to 100 °C, If 4,4 '- dibromobiphenyl is not completely dissolved, add 1 mL of glacial acetic acid, observe the dissolution, if not dissolved, then continue to drop 1 mL of glacial acetic acid, so the cycle until 4,4' - dibromo Biphenyl completely dissolved, common glacial acetic acid 23 mL (dissolved before the best 4,4 '- dibromide biphenyl grinding, reducing the dissolution time).

(2) The amount of 20 mL of concentrated nitric acid, adding dropping funnel, the slow drop, the speed of about 1 to 2 drops per second, after the drop of a large number of white floc, continue to drip concentrated nitric acid, floc White to pale yellow, and finally completely dissolved, the solution was pale yellow. Avoid the addition of nitric acid too fast, otherwise the floc will not be dissolved. A TLC test was performed every 30 min during the reaction, the degree of reaction was measured and the Rf value was calculated.

Raw material: Rf = 0.767;

Crude product: Rf1 = 0.267, Rf2 = 0.800 (raw material).

(3) TLC test showed that the reaction point disappeared, the reaction was complete, the product into 300 mL of water to stir, and washed twice, with a yellow solid precipitation. Filtration, collection of yellow solid and drying.

(4) For column chromatography, the developing agent for the petroleum ether: dichloromethane = 3: 1, with a conical flask to collect the separated products, steamed dry solvent, to be 4,4 '- dibromide The product was finally 1.13 g in a yield of 63.3%.

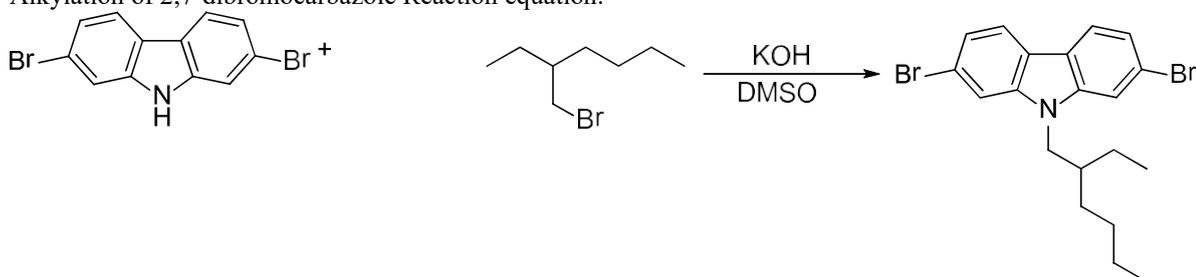2)   reduction of nitro groups Reaction equation:

Experimental steps:

(1) 20 mL of triethyl phosphite, with 1.13 g of 4,4 '- dibromobiphenyl nitrated product was added to a three-necked flask, the internal air was aspirated and protected by nitrogen. The temperature was set at 156 °C. Triethyl phosphite has an odor and requires reaction under ventilating conditions. TLC is performed at about 1 h to detect the degree of reaction and calculate the Rf value.

Raw material: Rf = 0.597;

Crude product: Rf1 = 0.145, Rf2 = 0.597 (raw material).

(2) TLC detection showed that the reaction point disappeared, the reaction was complete, vacuum distillation, set the temperature reduced to 100 °C, steamed dry solvent to obtain a yellow solid.

(3) For the column chromatography, the first with the developing agent for the petroleum ether: dichloromethane = 3: 1 will be the front product separation, and then with the development of petroleum ether: dichloromethane = 1: 1 the latter product separation, The product was collected from a conical flask and the solvent was distilled off to give pure product of 2,7-dibromocarbazole. Finally, 0.39 g of the product was obtained in a yield of 37.9% (due to the explosion of the solution at the time of vacuum distillation, resulting in the loss of some of the product).

Alkylation of 2,7-dibromocarbazole Reaction equation:

Experimental steps:

(1) Calculate: The molar equivalent ratio of 2,7-dibromocarbazole, potassium hydroxide and 2-ethylhexyl bromide is 1: 1.5: 1.2. Weigh 0.35 g carbazole about 1.08 mmol, then need to potassium potassium 1.62 mmol about 0.10 g, 2-ethylhexyl bromide 1.29 mmol about 0.25 g.

(2) Take 40 mL of DMSO, mix with 0.35 g of carbazole, 0.10 g of potassium hydroxide and 2.79 g of anhydrous sodium sulfate into a 50 mL three-necked flask. The mixture was heated to reflux for 30 min and the temperature was set at 80 ° C.

(3) 0.25 g of 2-ethylhexyl bromide was weighed and added to a three-necked flask. TLC was performed every 30 min. The degree of reaction was monitored and the Rf value was calculated.
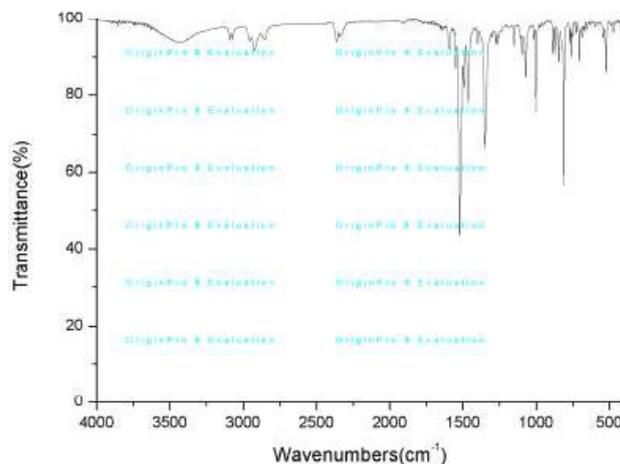Raw material: Rf = 0.167;

Crude product: Rf1 = 0.833, Rf2 = 0.167 (raw material).

(4) TLC test showed that the reaction point disappeared, the reaction was complete, the product poured into 400 mL of water, extracted with ethyl acetate transferred to the conical flask, add anhydrous sodium sulfate drying.

(5) Filter, take the filtrate, steamed dry solvent, white solid.

(6) For column chromatography, the developing agent for the petroleum ether, with a conical flask to collect the separated products, steamed dry solvent to obtain carbazole alkylation of pure products. Finally, the product was 0.38 g, yield 81.0%.

3. Product characterization and analysis

3.1. Infrared spectra

Analysis of Nitration Products of 4,4 '- Dibromobiphenyl by Infrared Spectroscopy

The absorption peak at 1550 cm^{-1} is the stretching vibration absorption peak of -NO$_2$. 1591 cm^{-1}, 1494 cm^{-1} and 1464 cm^{-1} are the skeletal vibration peaks of the benzene ring, and 811 cm^{-1} is the outward bending vibration peak of two adjacent hydrogen atoms on the benzene ring, indicating that the benzene For the di-substituted benzene, and 886 cm^{-1} and 885 cm^{-1} showed that 1,3,4-trisubstituted on the benzene ring, 542 cm^{-1} is the absorption peak of -Br, indicating that the benzene ring is attached and a benzene Ring-to-bit connection -Br, another benzene ring is not only connected to -Br, the remaining position connected to -NO$_2$.

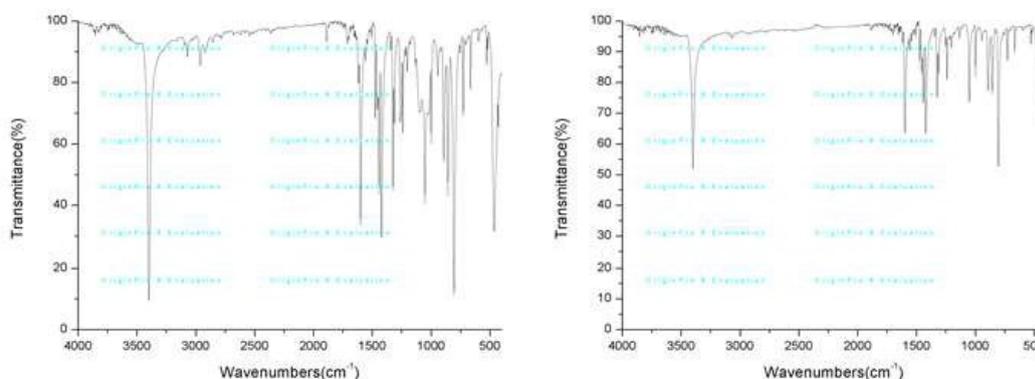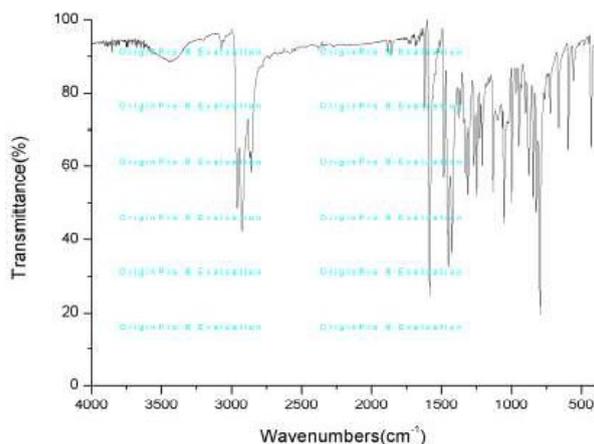### 3.1.1 Preparation of 2,7-dibromocarbazole and standard 2,7-dibromocarbazole by infrared spectroscopy

Figure 2. The left side shows the infrared spectra of the prepared 2,7-dibromocarbazole; the right is the infrared spectrum of the standard 2,7-dibromocarbazole

In the left figure, a significant absorption peak appears at 3400 cm^{-1}, which belongs to the stretching vibration absorption peak of N-H. 1600, 1558 and 1475 cm^{-1} are the skeletal vibration peaks of the benzene ring. 805 and 857 cm^{-1} indicate that 1,3,4 trisubstituted on the benzene ring, 1 is the absorption peak of -Br, which indicates that the benzene ring is attached, and that the two benzene rings are attached to the column at both ends of the benzene ring.
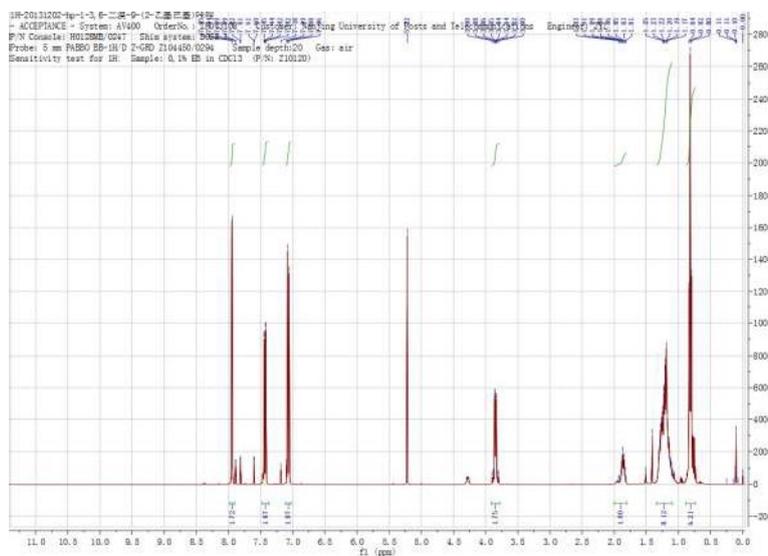
Compared with the infrared spectrum of 2,7-dibromocarbazole in the figure, there are absorption peaks at 3399 cm- 1, which are the stretching vibration absorption peaks attributed to NH, 1556, 1474 and 1558 cm^{-1}, the absorption peaks of 805 and 857 cm^{-1} indicate that the benzene ring is also 1,3,4-trisubstituted, and 525 cm^{-1} is -Br Absorption peak. The product of Figure 5, the infrared spectrum is basically the same, so we prepared the reduction product is 2,7-dibromocarbazole.

3.1.2 Analysis of 2,7-dibromo-9- (2-ethylhexyl) carbazole by infrared spectroscopy

As compared with 2,7-dibromocarbazole infrared spectroscopy, the absorption peak of about 3200 cm^{-1} disappears, indicating that there is no NH, and 2958, 2924 and 2857 cm^{-1} have three absorption peaks, indicating that there are three saturated hydrocarbon radical stretching vibration, consistent with 2-ethylhexyl. 1585, 1484 and 1585 cm^{-1} are the skeletal vibration peaks of the benzene ring. The absorption peaks at 822 and 845 cm^{-1} indicate that the benzene ring is 1,3,4 substituted, 593 cm^{-1} is the absorption peak of -Br, indicating that the benzene ring is connected, the two benzene ring at the junction of the junction are attached to-Br, benzene ring attached to the ortho position has been attached to the NH-H was 2 - Hexyl-substituted, i.e. product C is 2,7-dibromo-9- (2-ethylhexyl) carbazole.

3.2.   1H-NMR NMR spectra

3.2.1 NMR spectra of 3,6-dibromo-9- (2-ethylhexyl) carbazole

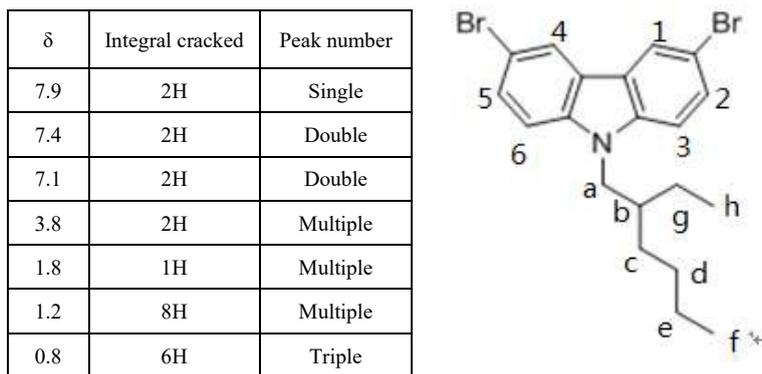| δ	Integral cracked	Peak number
7.9	2H	Single
7.4	2H	Double
7.1	2H	Double
3.8	2H	Multiple
1.8	1H	Multiple
1.2	8H	Multiple
0.8	6H	Triple

Figure 3. 3,6-Dibromo-9- (2-ethylhexyl) carbazole

In combination with Table 2 and Figure 9, the proton H on the aromatic ring is generally at low field, and the chemical shift is similar to that of n + 1, and is a single peak on the magnetic field. Therefore, the chemical shift is 1 at δ = 7.9 ppm, 4 proton peaks; 2,5 chemical shifts similar to the bimodal in the nuclear magnetic; 3,6 at the same chemical shift, in the nuclear magnetic bimodal. Since the quaternary carbon is at the low field of the proton on the proton, the chemical shift is a proton at 2,5 ppm at δ = 7.4 ppm and the chemical shift is at proton peak at 3,6 at δ = 7.1 ppm The The H on the alkyl chain is generally in the high field, δ = 1.8 ppm out of the peak is divided into 1H, and the peak is at the peak of b, then δ = 3.8 ppm where the peak integral is 2H and the peak is a Proton peak, c, d, e, g chemical shift similar, δ = 1.2 ppm out of the peak integral 8H, this peak c, d, e, g proton peak, h, f chemical shift similar, Δ = 0.8 ppm where the peak integral is 6H, the peak of h, f at the proton peak, is the triplet.

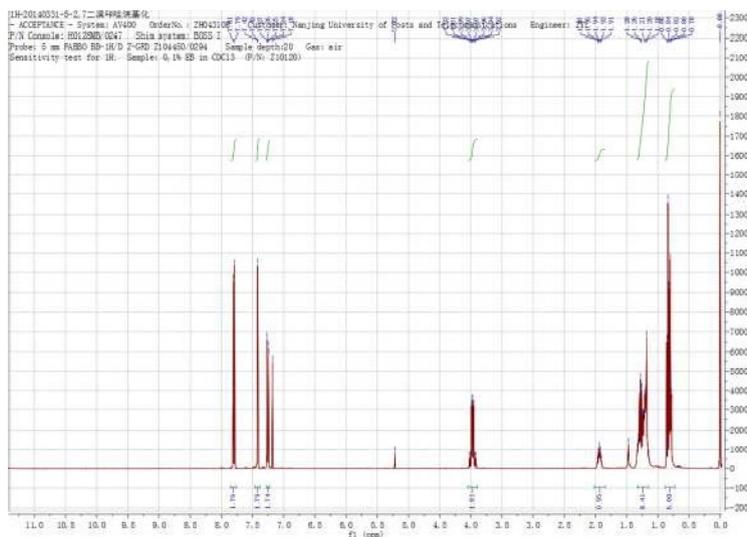### 3.3.   NMR spectrum of 1H-NMR of 2,7-dibromo-9- (2-ethylhexyl) carbazole

Figure 4. 1H-NMR NMR spectra of 2,7-dibromo-9- (2-ethylhexyl) carbazole According to the data in Fig. 10, Table 3 is plotted.

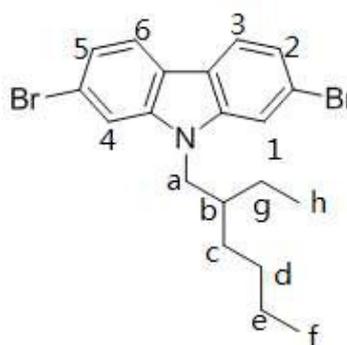| δ	Integral cracked	Peak number
7.8	2H	Double
7.4	2H	Single
7.1	2H	Double
3.9	2H	Multiple
1.8	1H	Multiple
1.2	8H	Multiple
0.8	6H	Triple

Figure 5. 2,7-Dibromo-9- (2-ethylhexyl) carbazole

In combination with Table 3 and Figure 10, the proton H on the aromatic ring is generally at low field, and the chemical shift is similar to that of n + 1, and is a single peak on the magnetic field. Therefore, the chemical shift is 1 at δ= 7.4 ppm, 4 proton peaks; 2,5 chemical shifts similar to the bimodal in the nuclear magnetic; 3,6 at the same chemical shift, in the nuclear magnetic bimodal. Since the H on the proton on the proton is at the high field, the chemical shift is a proton at 2,5 ppm at δ = 7.2 ppm and the chemical shift is at proton at 3 and 6 at δ = 7.8 ppm Out of the peak. The H chain on the alkyl chain is generally at the high field, δ = 1.8 ppm out of the peak is divided into 1H, and the peak is at the peak of b, then δ = 3.9 ppm where the peak integral is 2H and the peak is a Proton peak, c, d, e, g chemical shift similar, δ = 1.2 ppm out of the peak integral 8H, this peak c, d, e, g proton peak, h, f chemical shift similar, Δ = 0.8 ppm where the peak integral is 6H, the peak of h, f at the proton peak is the triplet.

4.   Conclusion

In this paper, the structure and basic working principle of polymer solar cells, the types and development of electron donor and electron acceptor materials of polymer solar cells are introduced, and the advantages and prospects of carbazole polymers are introduced emphatically. In this paper, the carbazole polymer precursors were prepared and the fused carbazole polymer precursors were synthesized. Finally, the IR spectra and 1H-NMR NMR spectra were characterized. Finally, the results show that the carbazole polymer precursors have a wide range of applications.

In general, carbazole and its derivatives have an unparalleled advantage over other polymers in terms of performance. With the progress of research and in depth, will promote the carbazole polymer solar cell materials industry, its R \u0026 D investment will be further strengthened to improve performance. So in the near future, it will be in the field of polymer solar energy occupy an important position.

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