

Polymeric and Oligomeric OTFT Materials Containing Fused Aromatics

¹Hyeong-Sun Kim, ²Yun-Hi Kim, ¹Sung-Wook Jung, ³Mi Hye Yi, ³Seungmoon Pyo, ⁴Yong-Young No, ⁴Dong-Yu Kim, and ^{*4}Soon-Ki Kwon

¹School of Nano & Advanced Materials and ERI, ²Department of Chemistry, Gyeongsang National University, Jinju, 660-701, Republic of Korea, skwon@gnu.ac.kr, ²³Polymeric Nanomaterials Laboratory, KRICT, Daejeon, 305-610, Republic of Korea ³Department of Advanced Materials, GIST, Gwangju, 500-702, Republic of Korea

Introduction

Organic field-effect transistors (OTFTs) based on molecular and polymeric organic semiconductors are a focus of considerable current interest, motivated by their potential applications for organic integrated circuit sensors,¹ low-cost memories, smart cards, and driving circuits for large-area display device applications such as active-matrix flat-panels liquid-crystal display (AMFPDs), organic light-emitting diodes, and electronic paper displays.^{2,3}

Many of the organic semiconductors used for the fabrication of the p-channel in OTFTs have been derived from thiophene-based π -conjugated systems, oligothiophenes, carbon and/or sulfur fused rings, acenes, phthalocyanines, polythiophene, and polypyrroles. Among these, materials containing fused aromatics have been extensively studied due to the increased π -stacking and high crystallinity leading to high mobility.

In this presentation, we report the synthesis and characterization of the oligomeric and polymeric materials containing fused aromatics such as anthracene, naphthalene, and thienothiophene.

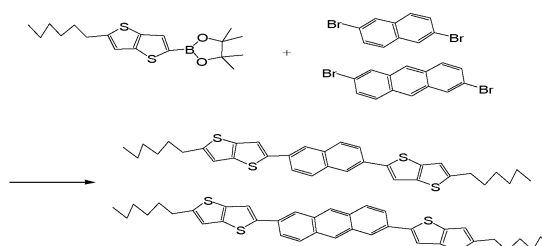
Experimental

Measurements. A Genesis II FT-IR spectrometer was used to record IR spectra. ¹H-NMR and ¹³C-NMR spectra were recorded with the use of Avance 300 and DRX 300 MHz Bruker spectrometers, and chemical shifts are reported in ppm units with tetramethylsilane as internal standard. Thermogravimetric analysis (TGA) was performed under nitrogen on a TA instrument 2050 thermogravimetric analyzer. The sample was heated using a 10 °C/min heating rate from 50 °C to 800 °C. Differential scanning calorimeter (DSC) was conducted under nitrogen on a TA instrument 2100 differential scanning calorimeter. The sample was heated with the 10 °C/min from 30 °C to 300 °C. Mass spectrum was measured by Jeol JMS-700 mass spectrometer. UV-vis absorption spectra and photoluminescence (PL) spectra were measured by Perkin Elmer LAMBDA-900 UV/VIS/NIR spectrophotometer and LS-50B luminescence spectrophotometer, respectively. Cyclic voltammograms of the oligomers were recorded on a epsilon E3 at a room temperature in a 0.1 M solution of tetrabutylammonium perchlorate (Bu₄NClO₄) in acetonitrile under nitrogen gas protection at a scan rate of 50 mV/s. A Pt wire was used as the counter electrode and a Ag/AgNO₃ electrode as the reference electrode.

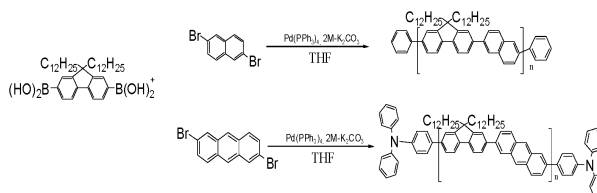
Device fabrication. A thin film organic semiconducting layer (about 50 nm measured by a quartz-crystal thickness monitor) was deposited on a SiO₂ (300 nm, 10 nF/cm²) surface on a heavily doped silicon wafer, as the gate electrode. The SiO₂ surface were pre-treated with 1,1,1,3,3,3-hexamethyldisilazane (HMDS). After evaporation, the OTFTs were completed by evaporating gold through a shadow mask to form source and drain electrodes on the semiconducting thin films as a top contact geometry. This device has a channel length and width of 20 μ m and 5 mm, respectively. The FETs characteristics were measured with a KEITHLEY 4200 semiconductor characterization system at an air atmosphere

Results and discussion

Scheme 1 and 2 illustrates the synthetic route of oligomeric and polymeric materials containing fused aromatics. The desired compounds in each steps were obtained in high yield and were confirmed by various spectroscopic methods. The oligomeric and polymeric OTFT materials were obtained by palladium-catalyzed Suzuki cross-coupling reaction.



Scheme 1. Synthetic Scheme for BHTTNA and BHTTAN



Scheme 2. Synthetic Scheme for PFN and PAN

The obtained PFN and PAN showed good solubility and high thermal stability. The weight average molecular weight of PFN and PAN was 32000 with PDI of 1.6 and 52000 with PDI of 1.7, respectively. In the measurement of optical properties such as UV-vis, PL and polarized light microscope, the obtained polymers showed liquid crystalline properties and high intermolecular interaction in the solid state.

The obtained oligomeric BHTTNA and BHTTAN are found to be stable up to about 400 °C and have 346 and 349 °C of T_m in DSC measurement, respectively. The orientation of the thin film was investigated by means of X-ray diffraction (XRD) and AFM at various substrate temperature.

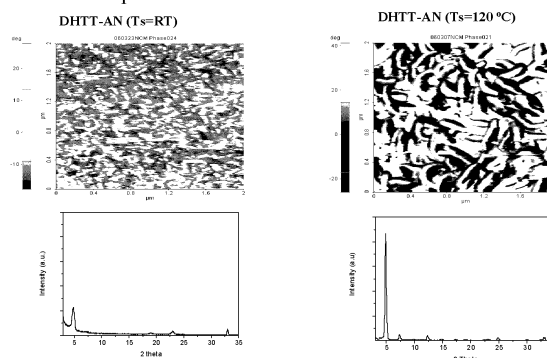


Figure. The X-ray and ARM images of evaporated thin films of BHTTAN at room temp. and 120 °C

As the temperature of substrate increase to 120 °C from room temperature, crystallinity and grain size increase. The mobility and on/off ratio of BHTTAN reach to 0.14 cm²/Vs and 10⁶, respectively and a good threshold voltage of -14 V.

Acknowledgments

This research was supported by the 21st Century Frontier R&D Program funded by Ministry of Science

References

- [1] Crone, B.; Dodabalapur, A.; Gelperin, A.; Torsi, L.; Katz, H.E. Lovinger, A.Z.; Bao, Z. *Appl. Phys. Lett.* **2001**, *78*, 2229.
- [2] Wisniew, R. *Nature* **1998**, *394*, 225.
- [3] Dimitrakopoulos, C.D.; Malenfant, P.R.L. *Adv. Mater.* **2002**, *14*, 99.
- [4] Videtot, C.; Ackermann, J.; Blanchard, P.; Raimundo, J.M.; Frere, P.; Allain, M.; Bettignies, R.; Levillain, E.; Roncali, J. *Adv. Mater.* **2003**, *15*, 306.
- [5] Mohapatra, S.; Holmes, B.T.; Newman, C.R.; Prendergast, C.F.; Frisbie, C.D.; Ward, M.D. *Adv. Funct. Mater.*, **2004**, *14*, 605.