



2014 춘계학술대회 연구논문 초록집
PROCEEDINGS
The Polymer Society of Korea

2014. 4. 9 [Wed] - 11 [Fri] 대전컨벤션센터
Annual Spring Meeting



한국고분자학회
The Polymer Society of Korea



대전광역시
DAEJEON METROPOLITAN CITY

DIM 대전마케팅공사

due to the high hole mobility in thin film transistors (TFTs) and high power conversion efficiency in polymer solar cells (PSCs) made of solution processing technology. These copolymers containing the strong symmetric DPP acceptor and π -extended donor endow the high crystallinity, planarity, and intermolecular interaction. In this study, we have synthesized a series of DPP-based copolymers bearing more π -extended donating units for high-performance organic TFTs and PSCs. Also, we systematically studied the effect of various donor units and donor length in these copolymers on the optical properties, film morphology, and device properties.

3PS-271 조보은

Discontinuous pn-Heterojunction for OTFTs

조보은, 유성훈¹, 김민우¹, 이무현, 이주희, 공석환, 양지혜, 송영재, 조정호, 김문성² 숭실대학교; ¹성균관대학교

Utilization of discontinuous pn-pragmatic heterojunction is introduced as a versatile method to improve charge transport in organic thin film transistors (OTFTs). The method is demonstrated by depositing n-type dioctyl perylene tetracarboxylic diimide (PTCDI-C8) discontinuously onto base p-type pentacene OTFTs. A more pronounced impact of the discontinuous upper layer is obtained on the transistor performances when thinner base layers are employed; a >100 -folds enhancement in hole mobility and a >20 V shift in threshold voltage are achieved after applying PTCDI-C8 discontinuously onto 2 nm thick pentacene thin films. Local surface potential measurements (Kelvin-probe force microscopy) and temperature-dependent transport measurements (77–300 K) reveal that the interfacial dipole formed at the pn-heterostructures effectively dopes the base pentacene films p-type and leads to a reduction in transport activation energy.

3PS-272 조세빈

Brush painted V_2O_5 as hole transport layer for high performance polymer based optoelectronic devices

조세빈, 김석순^{1,2} 전북대학교; ¹군산대학교

Due to their potential such as low-cost, low temperature, and easy solution processability, polymer based light emitting diodes and solar cells have attracted attention as next flexible and portable optoelectronic and electronic applications. In general device architecture, poly(3,4-ethylenedioxythiophene);poly(styrenesulfonate) (PEDOT:PSS) is widely adopted as interfacial buffer layer for efficient hole transporting and collecting. However, hygroscopic and acidic property of PEDOT:PSS leads to poor long-term stability and reliability of performance. Therefore, as an alternative material, we studied V_2O_5 fabricated by simple brush painting, which is very compatible with roll-to-roll process on a various substrates. Structural, electrical, optical properties of brush painted V_2O_5 were characterized their effect on performance and stability of polymer based devices will be discussed.

3PS-273 조양진

1,2-Dinaphthyl-ortho-Carborane에서 일어나는 Multiple Photoluminescence

조양진, 김소연, 강성욱¹ 고려대학교

Decarborane과 Naphthyl기가 치환된 acetylene의 합성을 통해 ortho-carborane의 탄소위치에 1, 2번 위치의 Naphthyl기가 치환된 화합물을 합성하였다. 합성된 화합물을 여기시켰을 경우 Naphthyl기가 고유의 발광(380 nm) 및 인접한 Naphthyl기에 의한 excimer 발광(420 nm), Naphthyl기와 ortho-carborane 분자내 전하이동에 의한 발광(510 nm, CT emission)이 섞인 multiple photoluminescence가 관측 되었다. DFT 계산결과를 토대로 ortho-carborane에서 보이는 특징적인 CT emission은 Naphthyl기의 π -orbital과 ortho-carborane의 σ^* -orbital의 중첩에 의해 이러한 상호작용에 의해 photoluminescence가 발생함을 확인 하였다. 또한 Naphthyl기의 2번 위치가 치환된 화합물의 경우, 치환체의 운동이 구조적으로 제한되어 orbital의 중첩이 1번 위치가 치환된 화합물보다 더 큰 것을 알 수 있었다.

3PS-274 조우섬

Solution Processed Red Phosphorescent Organic Light-emitting Diodes with CzPAF-OXD as Host

조우섬, 이재욱¹, 재강영준², 진성호³ 부산대학교; ¹동아대학교; ²경일대학교

The extensively used bipolar host CzPAF-OXD as for red phosphorescent organic light emitting diodes (OLEDs) were fabricated by solution process. The OLEDs that we prepared utilizes phosphorescent dopant materials, bis-(1-phenylisoquinoline)(acetylacetonate) iridium(III) (Ir(piq)₂(acac)), exhibit a Commission Internationale de l'Eclairage (CIE) coordinates of (0.68, 0.31). We have fabricated solution processed red OLEDs with a configuration of ITO/PEDOT:PSS/CzPAF-OXD:mCP:Ir(piq)₂(acac)/TmPyPB/LiF/Al. The optimized interlayer OLEDs showed excellent performance such as maximum luminance efficiency of 4.16 cd/A, a maximum power efficiency of 2.18 lm/W and a maximum external quantum efficiency of 6.96 % and the driving voltage of 4.1 V.

3PS-275 조창현

Highly sensitive photoconductor using polymer blends

조창현, 정대성¹, 권순기¹, 김윤희¹, 강 일² 중앙대학교; ¹경성대학교

Here we demonstrate a smart photoconductor device where photoconductive gain is generated by one-step phase separation of polymer blends. The designed photo-active layer consists of high mobility DPP-derivative and various insulating amorphous polymers. Under the optimized processing solvent, DPP-derivative formed very uniform layer at the air-interface while the amorphous polymer was positioned between DPP-derivative and the substrate. By optimizing the thickness and functional group of amorphous polymer, we could show exceptionally high photoconductive gain as well as photo-responsivity. The physics behind the designed polymer photoconductor is fully discussed in conjunction with various characterization tools

3PS-276 조현수

실버-나노와이어 투명전극을 적용한 유연 유기태양전지

조현수, 박상혁¹ 공주대학교

유기태양전지는 무기태양전지에 비해 효율을 다소 낮지만, 저비용으로 제작할 수 있는 태양전지이다. 유기태양전지는 다양한 분자를 이용하여 다이아스를 만들 수 있으며, 또한 유기물을 사용함으로써 높은 출광 계수와 유연성을 보장받을 수 있다. 따라서 우리는 유기태양전지의 유연성에 초점을 맞추고 현재 유기태양전지의 유연성을 저해하는 ITO전극을 유연투명전극 중에 하나인 실버-나노와이어 투명전극을 활용하여 유기태양전지의 소자를 제작하고 그 물성을 확인해보았다.

3PS-277 지찬혁

Applications of Ytterbium in Inverted Organic Photovoltaic Cells as High-performance and Stable Electron Transport

지찬혁, 김규민, 오세용¹ 서강대학교

The electron transport (ETL) layer improves power conversion efficiency (PCE) in organic photovoltaic cells (OPVs) by helping form ohmic contact between the active layer and the cathode metal. Here, we introduce ytterbium (Yb) as an electron transport layer in inverted OPVs where Yb is directly evaporated on indium tin oxide (ITO). The PCE of the inverted OPVs composed of ITO/Yb/P3HT:PCBM/MoO₃/Ag reaches up to 4.3%, recording 71% of the fill factor (FF) in one sun irradiation. Over 80% of its original PCE is retained over 30 days. The results indicate that Yb in inverted OPVs is vastly superior to other ETLs as it improves the majority of the parameters including short circuit current, FF and PCE. In this report, we will discuss how Yb functions physically and optically in inverted OPVs, making it a promising candidate for achieving high PCE and good air stability simultaneously.

3PS-278 차충정

Development of Bulk Heterojunction Morphology by the Difference of Inter-molecular Interaction Behaviors

차충정, 안태규, 백장열¹, 김슬옹¹, 김윤희¹, 권순기¹, 박찬원¹ POSTECH; ¹경상대학교

The study of bulk heterojunction morphology can be controlled by adding a processing additive in order to improve the power conversion efficiency (PCE) in photovoltaic devices. Here, the phase-separated morphology of an amorphous polymer or a highly ordered crystalline polymer blends with the fullerene derivatives is systematically examined with various processing additives, which possess the different alkyl lengths or the different electro-negativity of end-groups. Intermolecular interaction between the polymer and the processing additive, and the fullerene and the processing additive controls the morphology and efficiency of photovoltaic devices.

3PS-279 천광희

Space Charge Limited Current of High Mobility DPP-based Polymer

천광희, 정대성¹, 조장환, 권순기¹, 김윤희¹, 강 일² 중앙대학교; ¹경성대학교

Here we studied the charge transport characteristics of widely studied diketopyrrolopyrrole (DPP)-based polymers by using space charge limited current theory. From electric field and temperature dependences of charge transport characteristics in hole-only-device geometry of one of highly conductive DPP-derivative, we could show that the density of state (DOS) for charge carrier is significantly narrow in the bulk of semiconductors. We argue that the intrinsically narrow DOS in the bulk of PDDPTSE resulted in significantly superior charge transport behavior, which was not visible in the case of other low mobility organic semiconductors containing intrinsically high density of trap states in their bulk.

3PS-280 최수민

용액공정이 가능한 SiO 수분차단 박막 제조

최수민, 조해명, 김성희, 황조은, 이준영¹ 성균관대학교

고분자 필름에 여러 방법으로 수분을 차단할 수 있는 박막을 코팅하는 연구들이 수행되어 왔지만, 단면적화, 신뢰성, 가격 등 여러 문제들이 있다. 따라서, 본 연구의 목적은 이러한 기존 기술의 단점들을 보완하면서 용액공정을 통해 대면적 코팅이 가능하며 우수한 수분차단 능력을 가진 플렉서블한 SiO 수분차단박막을 개발하는 것이다. 실리카는 대표적인 하이브리드 복합재료의 무기성분으로서, 본 연구에서는 전구체로 TEOS(Tetraethyl orthosilicate)를 사용하였으며, Sol-gel법을 이용하여 코팅용액을 제조하였다. 제조된 용액을 PEN film위에 Wire bar를 이용하여 코팅하였다. 박막의 특성을 관찰하기 위하여 광투과도, 표면특성 등을 각각 UV-VIS spectrometer, SEM을 통해 분석하였다. 또한 코팅된 하이브리드 박막의 수분차단 특성을 확인하기 위해 상대습도 85%, 온도 85℃의 항온항습기에서, Ca-test를 통해 Water Vapor Transmission Rate (WVTR) 값을 구하였다.

3PS-281 최윤석

Thieno[3,4-c]pyrrole-4,6-dione Based Small Molecules for High V_{oc} Organic Photovoltaics

최윤석, 조원호¹ 서울대학교 재료공학부

The optoelectronic properties of organic semiconductors are primarily governed by the type of conjugated unit in the molecular backbone. Especially, in utilization of the push-pull concept for designing low bandgap organic materials, selection of electron deficient unit requires special attention because the frontier orbital energy level, planarity and dipole moment in organic molecules may be determined by the properties of the unit. Herein we report the synthesis and characterization of new organic small molecule (SM) composed of thienopyrroledione (TPD) as electron-deficient unit and dithienosilole as electron-rich unit. Since TPD has strong electron-accepting properties, it is expected for TPD to lower the HOMO energy level of the SM, resulting in high V_{oc} of OPV cell. The SM exhibits a deep HOMO level of -5.50 as measured by cyclic voltammetry. As a result, the solar cell device fabricated from the new donor material shows a PCE of 5.5% with a high V_{oc} of 0.93 V.

**Thieno[3,4-c]pyrrole-4,6-dione Based Small Molecules
for High V_{OC} Organic Photovoltaics**

최윤석, 조원호*

서울대학교 재료공학부

The optoelectronic properties of organic semiconductors are primarily governed by the type of conjugated unit in the molecular backbone. Especially, in utilization of the push-pull concept for designing low bandgap organic materials, selection of electron deficient unit requires special attention because the frontier orbital energy level, planarity and dipole moment in organic molecules may be determined by the properties of the unit. Herein we report the synthesis and characterization of new organic small molecule (SM) composed of thienopyrroledione (TPD) as electron-deficient unit and dithienosilole as electron-rich unit. Since TPD has strong electron-accepting properties, it is expected for TPD to lower the HOMO energy level of the SM, resulting in high V_{OC} of OPV cell. The SM exhibits a deep HOMO level of -5.50 as measured by cyclic voltammetry. As a result, the solar cell device fabricated from the new donor material shows a PCE of 5.5% with a high V_{OC} of 0.95 V, which is, to the best of our knowledge, the best PCE value reported to date in TPD-based SM solar cells.



Small Molecules Based on Thieno[3,4-*c*]pyrrole-4,6-dione for High V_{OC} Photovoltaics

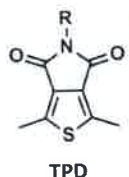


최윤석, 조원호*

서울대학교 재료공학부

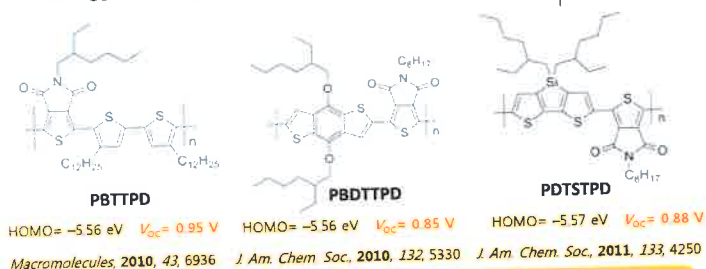
Introduction

Thienopyrroledione (TPD) as an electron deficient building block



- Features of TPD derivatives as a building block of conjugated materials
- Easy synthesis and good solubility
 - Highly planar structure, which leads to strong π - π interaction
 - Strong accepting moiety in donor-acceptor type conjugated materials

High V_{OC} of TPD-based polymers in photovoltaic cells



The TPD moiety significantly facilitates to afford low-lying HOMO energy level and concomitant high V_{OC} for photovoltaic cells.

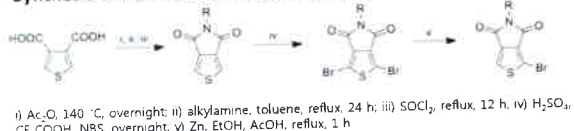
Objectives

- To synthesize two TPD-based small molecules with different alkyl chain position
- To investigate and compare the optical, electrochemical, and photovoltaic properties of these two small molecules

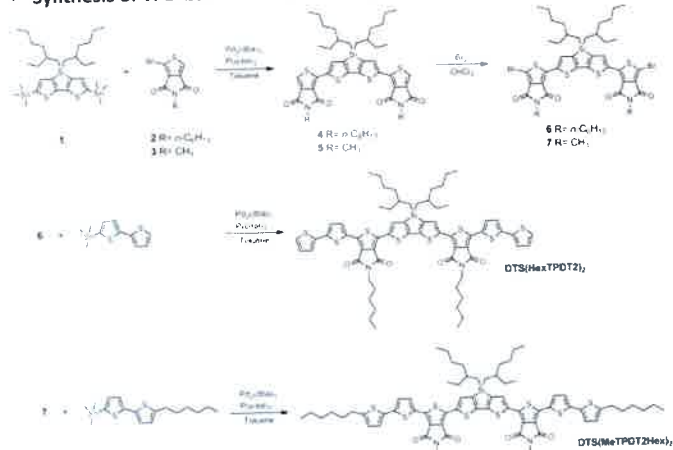
Results

Synthetic scheme of small molecules

Synthesis of mono-brominated TPD unit

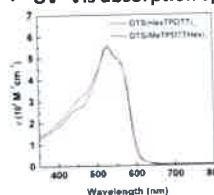


Synthesis of TPD-based small molecules

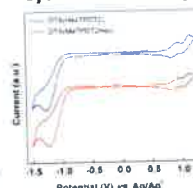


Optical and electrochemical properties of small molecules

UV-Vis absorption spectra



Cyclic voltammetry

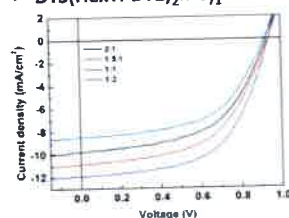


	E_g^{opt} (eV)	E_g^{el} (eV)	HOMO (eV)	LUMO (eV)
DTS(HexTPDT2) ₂	1.86	1.72	-5.50	-3.78
DTS(MeTPDT2Hex) ₂	1.85	1.67	-5.50	-3.83

- TPD-based small molecules represent deep HOMO energy level.
- Two small molecules with different alkyl chain position exhibit similar optical and electrochemical properties.

Photovoltaic properties

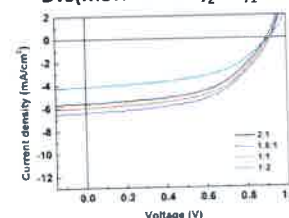
DTS(HexTPDT2)₂:PC₇₁BM



Blend ratio ^{a)} (w/w)	V_{OC} (V)	J_{SC} (mA cm ⁻²)	FF	PCE (%)
2:1	0.93	9.7	0.54	4.9
1.5:1	0.94	11.8	0.54	6.0
1:1	0.94	10.8	0.54	5.5
1:2	0.92	8.5	0.53	4.3

^{a)} 0.5 vol% DIO is added to chloroform solution.
 Device configuration: ITO/PEDOT:PSS/SM:PC₇₁BM/Ca/Al

DTS(MeTPDT2Hex)₂:PC₇₁BM

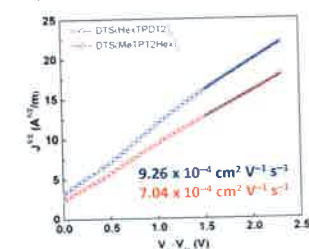


Blend ratio ^{a)} (w/w)	V_{OC} (V)	J_{SC} (mA cm ⁻²)	FF	PCE (%)
2:1	0.91	5.6	0.52	2.7
1.5:1	0.93	6.4	0.52	3.1
1:1	0.92	6.0	0.52	2.9
1:2	0.92	4.1	0.50	1.9

^{a)} 0.5 vol% DIO is added to o-dichlorobenzene solution.
 Device configuration: ITO/PEDOT:PSS/SM:PC₇₁BM/Ca/Al

- Two small molecules with low-lying HOMO energy level exhibit high V_{OC} in the range of 0.91–0.94 eV.
- DTS(HexTPDT2)₂ showed a higher PCE and J_{SC} as compared to DTS(MeTPDT2Hex)₂.

SCLC mobilities



TEM images



Conclusions

- Two TPD-based small molecules were successfully synthesized and represent low-lying HOMO energy levels of -5.50 eV, and concomitant high V_{OC} s (0.91–0.94 V) of OSCs.
- DTS(HexTPDT2)₂ shows a higher SCLC hole mobility and distinctive phase separation, leading to high PCE of 6.0% with a J_{SC} of 11.8 mA cm⁻², a V_{OC} of 0.94 V and a FF of 0.54.