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Energimyndighetens titel på projektet – engelska Ecological organic solar cells based on cellulose substrates	
Universitet/högskola/företag Linköpings Universitet	Avdelning/institution Institutionen för fysik, kemi och biologi (IFM)
Adress Linköpings universitet, 58183, Linköping	
Namn på projektledare Fengling Zhang	
Namn på ev övriga projektdeltagare Sven Englund and Nannan Yao	
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Förord

Detta projekt finansierat av Energimyndigheten.

Innehållsförteckning

Box 310 • 631 04 Eskilstuna
Telefon 016-544 20 00 • Telefax 016-544 20 99
registrator@energimyndigheten.se
www.energimyndigheten.se
Org.nr 202100-5000

Sammanfattning

Projektet syftar till att utveckla nya ekologiska organiska solceller (e-OSC) som använder cellulosa som substrat för att minska miljöpåverkan. Lösningsbearbetade OSC tillverkas vanligtvis på polymersubstrat, såsom polyetylentereftalat (PET). Det är dock välkänt att plast orsakar föroreningar. Att byta från plast till cellulosa som substrat skulle därför göra OSC till en långsiktigt hållbar teknik för att skörda solljus till el.

Med projektet har vi intensivt undersökt och optimerat prestandan hos e-OSC tillverkade på två sorters cellulosa. Vi uppnådde en effektkonverteringseffektivitet (PCE) på 11,5 % i e-OSC på kommersiell cellulosa med silvernanotråd (AgNW) som elektrod genom samarbete med Prof. Yinhua Zhou vid Huazhong University of Science and Technology, Kina. PCE på 11,5 % är högre än vårt ursprungliga mål (10 %). Vi erhöll en PCE på 2 % i e-OSC med ledande polymer poly(3,4-etylendioxitiofen) polystyrensulfonat (PEDOT:PSS) som elektrod på syntetiserad cellulosa extraherad från trä och majs tillhandahållen av Prof. Min Wu vid Technical Institute of Fysik och kemi, kinesiska vetenskapsakademin.Resultaten av projektet kommer att spridas genom att presenteras på internationella konferenser och publiceras i peer-reviewed tidskrifter för att främja användningen av ekologiska substrat i OSCs och möjliggöra den organiska solcellstekniken en grön industri för ett hållbart energisystem.

Vi arbetar just nu med organiska solcellsmoduler. Vi kommer att trycka prototyper avsedda att installeras på böjda, flexibla ytor, som paraplyer och persienner. De kan ställas ut vid vissa offentliga evenemang för att öka allmänhetens medvetenhet om denna framväxande teknik som en potentiell hållbar energikälla i framtiden.

Summary

The project aims to develop novel ecological organic solar cells (e-OSC) that use cellulose as a substrate to reduce environmental impact. Solution-processed OSCs are typically fabricated on polymer substrates, such as polyethylene terephthalate (PET). However, it is well known that plastics causes pollution. Switching from plastics to cellulose as a substrate would therefore make OSC a long-term sustainable technology for harvesting sunlight into electricity.

With the project, we intensively investigated and optimized the performance of e-OSCs made on two kinds of cellulose. We achieved a power conversion efficiency (PCE) of 11.5% in e-OSC on commercial cellulose with silver nanowire (AgNW) as electrode by collaboration with Prof. Yinhua Zhou at Huazhong University of Science and Technology, China. The PCE of 11.5% is higher than our original target (10%). We obtained a PCE of 2% in the e-OSC employing conductive polymer poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) as electrode on synthesized cellulose extracted from woods and corns by Prof. Min

Wu at Technical Institute of Physics and Chemistry, Chinese Academy of Sciences.

The results of the project will be disseminated by being presented at international conferences and published in peer-reviewed journals to promote the use of ecological substrates in OSCs and enable the organic solar cell technology a green industry for a sustainable energy system.

We are currently working with organic solar modules. We will print prototypes intended to be installed on curved, flexible surfaces, such as umbrellas and blinds. They may be exhibited at certain public events to raise public awareness of this emerging technology as a potential sustainable energy source in the future.

Inledning/Bakgrund

Converting the sunlight into electricity by PV technology is the best option as sustainable energy systems. Commercial PV panels are dominated by Si. Organic solar cells (OSCs), an emerging PV technology, possess unique advantages, such as printable, colorful, lightweight, robust, flexible, and semi-transparent. Complementally to Si PV panels, OSCs can be installed on windows, walls, curved surfaces, and soft substrates (textiles) as mobile powers[1-4]. By smart design, OSCs can provide both electricity and decoration. In addition, from a psychological perspective, colorful OSCs may alleviate people's anxiety during the long, dark winter months.

OSCs are commonly made on plastic substrates, such as polyethylene terephthalate (PET) which will pollute environment in a long-term view. Currently, organic photovoltaic (OPV) community focus on pursuing high conversation efficiency but pays little attention on potential environmental impacts of plastic substrates. To prevent plastic substrate pollution, we proposed to explore biodegradable cellulose as ecological substrates to replace plastics. It is a very challenging project because the mechanical strength, surface roughness and transmittance of the cellulose hardly compete with mature plastics.

In past 28 months, supported by Energimyndigheten and closely international collaboration, we intensively investigated and optimized the performance of e-OSCs on cellulose. Very encouraged power conversion efficiency (PCE) of 11.5% was achieved in e-OSCs fabricated on cellulose with silver nanowires (AgNW), which is higher than our original target (10%) for single OSCs. The e-OSC fabricated with highly conductive polymer poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS)[5,6] as electrode on the synthesized cellulose by Wu's group achieved a power conversion efficiency (PCE) of 2%.

We believe that the results of the project will provoke and promote the use of environmentally friendly ecological substrates in OSCs and enable the OPV technology a green industry as a sustainable energy system in the future.

Genomförande

To make e-OSCs as a long-term ecological technology for harvesting solar energy to electricity, the project was divided into 3 steps and conducted in 28 months.

Firstly, Wu's group at Technical Institute of Physics and Chemistry, CAS, China study and modify nanocellulose film according to the requirement of the substrates in OSCs.

Secondly, Zhang's group at Linköping University explored different methods to deposit highly conducting polymer PEDOT:PSS on the nanocellulose film and optimized the conductivity and transparency of PEDOT:PSS/cellulose electrodes.

Finally, Zhang's group investigated and optimized the performance of e-OSCs on different cellulose substrates, conductors and manipulated the morphology of the active layers collaborated with Zhou's group.

Resultat

In last 28 months, with financial support of Energimyndigheten and international collaboration, we achieved following results:

1) Cellulose substrates with transparency of 80% and roughness of 10 nm have been synthesized by synergizing celluloses extracted from woods and corns.
2) Polymer electrodes for e-OSCs with R_{sq}=150 Ω/□ were obtained by solution-deposit 100 nm highly conductive PEDOT:PSS (PH1000) on the top of the cellulose.
3) The e-OSCs made on PH1000 electrodes achieved power conversion efficiencies (PCEs) about 2% with short circuit current density (J_{sc}) of 14 mA/cm^2, open circuit voltage (V_{oc}) of 0.49V and fill factor (FF) of 0.30.
4) Furthermore, PCEs of 11.5% were reached in e-OSCs with Ag nanowires (AgNW) electrodes on commercial cellulose, which is higher than our original goal (10%).
5) Working on e-OSC modules is ongoing and have not been accomplished, yet.

Diskussion

Currently, organic photovoltaic (PV) community pays less attention on the negative environmental impacts of commonly used plastic substrates in OSCs. The impressed PCEs of 11.5% in e-OSCs with commercial cellulose substrates will convince the organic PV community and related industry the feasibility of e-OSCs. Therefore, the results of the project will be disseminated by presented in international conferences and published in high impact peer-reviewed journals to evoke using environment friendly ecological substrates replacing plastics in OSCs and enable the organic PV technology a green industry for a sustainable system in the future.

Based on our experience and achievements in this project, we convince that there is still large room for further improvement of the e-OSCs. In the future, to improve the performance of e-OSCs, we will take the following approaches:

1. Select appropriate commercial cellulose substrates.

2. Further modify and optimize the optical, mechanical properties and the roughness of the synthesized cellulose substrates.
3. Study alternative processing methods, such as solid film-transfer, layer lamination to avoid the short-circuit issues in the solution-processed e-OSCs.
4. Explore MXene or PEDOT:PSS/MXene and other solution processible conductors as electrodes.
5. Introduce novel interface materials to enhance the device performance.
6. Explore different device configurations and fabricate e-OSC modules for integrating with different objects for charging low electricity consume electronics.

Moreover, to show the unique advantages of organic PV technology, such as colorful, flexible, lightweight, robust, and semitransparency, in the future we will fabricate prototypes of e-OSCs, which will be installed on bent, flexible surfaces, such as umbrella, blinds, which can be exhibited in some public events for increasing society's awareness to this emerging organic PV technology as a potential sustainable energy source in the future.

Publikationslista

A manuscript is under preparation.

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Bilagor

No attachments