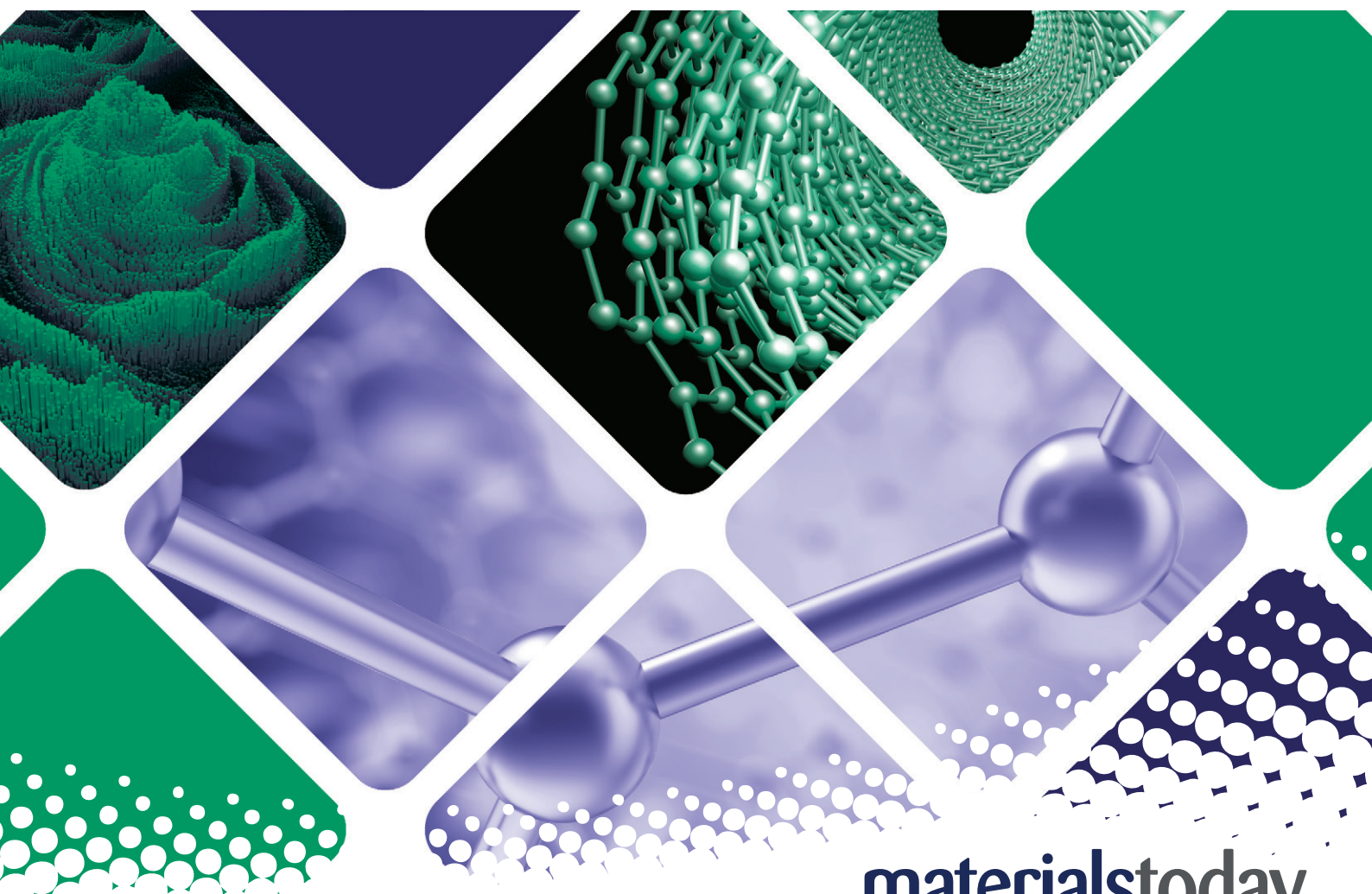


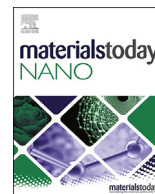
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Editorial

Presenting *Materials Today Nano* to the nanotechnology community!



Nanotechnology has been bringing tremendous innovations and pushing the boundaries of our knowledge. The newest technological advancements will allow a much broader and deeper study of the materials structures/functions at the nanoscale. For example, electron microscopy in very different chemical, temperature, and mechanical force environments resulted in ground-breaking understanding on the chemistry, physics, and engineering of materials at the nanoscale in a way which was not possible before. It is at the nanoscale that we can deepen our understanding of the relationship between the unmapped physical and chemical properties and the material structures.

Nanoscience is also an unparalleled example of an interdisciplinary field, underpinned by the study of structure–function relationships. *Materials Today Nano* presents a new platform to serve a very wide range of authors and readers across the nano fields. The journal will focus on the most important aspects of nanoscience, including new high-impact advances, techniques, and their application.

It is my great personal honor to serve as the Editor-in-Chief of *Materials Today Nano*, in collaboration with Elsevier and supported by my alma mater Zhejiang University. I am delighted to take on this new role leading Elsevier's first broad scope nanoscience

journal. Our ambition is to provide researchers a transparent, fast peer review process which delivers exciting content and gives authors the opportunity to share their research data alongside with their articles.

Materials Today Nano aims to publish high-quality new perspectives of significant interest across the field. We seek to capture the latest advances and breakthroughs, as well as innovative concepts in nanoscience and the development of existing techniques to be applied beyond their traditional applications. *Materials Today Nano* welcomes full-length original research articles, short communications, and reviews. We invite you to submit your pioneering research to *Materials Today Nano*.

Finally, I would like to thank our editorial board members and the Elsevier publishing staff for joining me in this exciting journey.

Ze Zhang

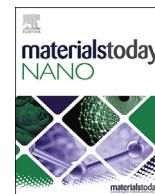
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Available online 24 March 2018



Contents lists available at ScienceDirect

Materials Today Nano

journal homepage: <https://www.elsevier.com/profile/#/MTNANO/login>

Review Article

Novel behaviors/properties of nanometals induced by surface effects

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ARTICLE INFO

Article history:

Available online 14 April 2018

Keywords:

Surface effect
Nanometals
Novel properties
Electron microscopy
In situ characterization

ABSTRACT

Surface effect is believed as one of the most important origins from which the novel properties of nanomaterials derive. Although this effect has been investigated for decades, the understanding of the essential correlations between materials' structures and their unique properties still has a long way to go. Recently, the innovation of aberration-correction techniques in electron microscopy, as well as the fast-developing *in situ* techniques, has made a big step toward unveiling the mysterious mechanisms underlying the unusual behaviors. In this review, we summarize the surface effect-induced extraordinary phenomena of nanometals that were uncovered recently, including peculiar mechanical behaviors, unusual thermal instabilities, remarkable electromigrations, unconventional structure evolution, and phase separations. All these findings apparently give an in-depth understanding of the novelties that appeared only in nanometals, such as the rubber-like or liquid-like deformation behaviors in mechanics, the size-dependent melting and wetting behaviors in thermodynamics and surface science, the atomic-scale welding and mass conveying in electrics, and the size- or composition-dependent phase segregations in kinetics and metallography. Such abundant knowledge not only extends the classical theories established on bulk materials but also can provide valuable instructions for future applications of nanometals such as the design of versatile functional nanodevices like sensors and actuators. By using the state-of-the-art characterization techniques, tremendous progress has been made toward approaching the truth on what factors essentially govern the discrepancies between nanometals and their bulk counterparts. Moreover, this review also opens up a discussion on several surface effect-related controversies that have been retained for a long period. Finally, a brief perspective is presented on the basis of upcoming new techniques in electron microscopy, giving an imagination of viewing and measuring the surface structures and properties directly.

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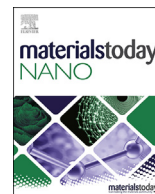
1. Introduction

It has been widely known that nanometals usually have unique structures and extraordinary properties compared to their bulk counterparts [1,2]. Size effect and surface effect are believed as the two main origins from which the extraordinary properties derive. As benefited from the well-developed bottom-up synthesis and top-down manufacturing techniques, the size effect has been extensively investigated by systematically varying the metal sample dimension. Size-dependent novel properties have been uncovered abundantly, with various remarkable behaviors in mechanics [3–5], thermodynamics [6–10], kinetics [11–13], optics [14,15], transport [16], magnetism [17,18], etc. Although several

controversies remain, the great progress that has been made in recent years undoubtedly promotes the understanding of the size dependence on nanometal structures and properties. In contrast to the well-revealed size effect, the understanding of the surface effect is still somewhat limited to the concept of increasing the surface-to-volume ratio. This is generally correct for large metal samples as the large free surfaces indeed provide more chances for structure instability. However, when the metal dimension decreases to nanoscale, the surface effects are usually combined with the size effect. In fact, it is imaginable that the surface effect should be beyond the increase of surface atoms. Several events possibly contribute to this effect including the variable atomic diffusion; migration and plating of the outermost crystal layers; the interaction, vibration, scattering, and relaxation of the outer few layers; the distributions of electron clouds; electrostatic fields; and polarizations. Unfortunately, current characterization techniques are still incapable to visualize all these effects directly. Moreover, the

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Short Communication

Solid-state synthesis of silver nanowires using biopolymer thin films

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ARTICLE INFO

Article history:

Available online 14 April 2018

Keywords:

Chitin
Chitosan
Silver nanowire
Chemical sensor
Thin film
Polysaccharide

ABSTRACT

In this paper, we describe a novel method of silver nanowire (AgNW) synthesis. Silver nanoparticles (AgNPs) were synthesized under ambient conditions by a chitosan/chitin-based method. These crystalline AgNPs then served as seeds for the solid-state formation of AgNWs within a drop-cast chitosan/chitin thin film. To the best of our knowledge, this is the first report of AgNW growth on a bio-polymer thin film. Chemical analysis demonstrated that AgNPs and AgNWs produced by this synthetic process have distinct interactions with polysaccharide polymers, and unlike AgNWs produced by other methods, the AgNWs formed in the chitin/chitosan matrix display an irregular twisted morphology. The flexible AgNW/chitosan nanocomposite material is conductive, and we incorporate this new material into a peroxide sensor to demonstrate of its potential applications in chemical sensing devices.

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1. Introduction

Metallic nanoparticles have enhanced and often unique catalytic [1–3] and physical properties [4,5]. Silver and other noble metal nanomaterials are of particular interest and importance because of their unique electronic, optical, and biological activities [6–9]. Silver nanomaterials are synthesized by various methods including photochemical approaches that utilize the light-sensitive aspects of precursor materials, standard chemical approaches using citrate or borate reducing agents, and “green” approaches that use a biological material in at least one step of the synthesis process [10–12]. Nanoparticle synthetic processes involve several steps that include the reduction of a metal ion in solution into an insoluble precipitate; the formation of a nucleation site either from individual precipitated nanoparticles or by the aggregation of these particles; and the stabilization of the nascent particle, which is followed by the nanoparticle growth [10,11,13,14]. Control of each step enables the control over the size, crystallinity, and morphology of the nanomaterial products from specific synthetic reactions [9–11,14,15].

Several green synthetic methods for generating silver nanoparticles (AgNPs) have also been developed, which use biomolecules such as proteins and polysaccharides to stabilize and promote nucleation [14,16]. Environmentally friendly “green” methods of

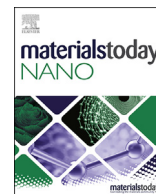
nanoparticle synthesis often take advantage of biomimetic self-assembling systems or use catalytic elements such as living cells or biopolymers [13,17,18]. A polysaccharide AgNP synthetic method uses starch as the capping agent and monomeric β -D-glucose as the reducing agent in an aqueous solution. Extracts of various plants and microorganisms have also been demonstrated to promote the formation of AgNPs by the participation of protein/peptides in the reduction, nucleation, and stabilization steps [13,17]. Recently, a chitosan photochemical synthetic method has been described that enables the formation of AgNPs of different morphologies and crystallinities in a wavelength-dependent manner [10]. Synthetic processes that produce highly anisotropically shaped particles are especially desirable in many applications because of the enhancement of specific optical properties such as surface plasmon resonance [9,12].

Silver nanowires (AgNWs) are synthesized primarily by polyol methods, which are energetically and environmentally costly [13,16,19,20]. Recently, there has been an increased interest in the identification and fabrication of novel nanocomposite materials, which consist of metallic or metal oxide nanoparticles and another nanoscale material [13,21]. By combining the properties of two nanomaterials, there is often a synergetic effect that extends, enhances, and/or increases the properties of one or more of the constituents of the nanocomposite [22–24]. However, fabrication methods of such multicomponent nanomaterials often rely on a multistep process, relying on post-fabrication mixing or the combination of individual nanoscale components, which often results in a product that is not ideal in composition and/or non-scalable

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Review Article

Palladium-based nanoelectrocatalysts for renewable energy generation and conversion



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ARTICLE INFO

Article history:

Available online 14 April 2018

Keywords:

Palladium

Electrocatalysts

Hydrogen evolution/oxidation reaction

Oxygen reduction reaction

Liquid fuels oxidation reaction

ABSTRACT

Replacing platinum (Pt) with palladium (Pd) as the electrocatalytic materials is essential to address the technical barriers of unaffordable Pt usage in numerous renewable energy technologies, such as fuel cells, metal-air batteries, and water electrolyzers. In the past decades, both theoretical and experimental progresses have been made in advancing the Pd-based nanocatalysts, leading to catalytic activity comparable to or even exceeding that of Pt. In the present review, we overview the recently important breakthroughs in the development of promising Pd-based nanoelectrocatalysts. We begin with the brief introduction of current knowledge in fundamental electrocatalytic behavior of Pd-based electrodes and some reaction mechanism, aiming to rationalize the general guidelines of structural design for more promising nanocatalysts. Then, we demonstrate the representative examples of high-performance Pd-based nanoelectrocatalysts in terms of catalytic reactions, including hydrogen evolution/oxidation reaction, oxygen reduction reaction, and liquid fuels oxidation reaction. Finally, we provide a short conclusion and personal perspective in this research field.

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1. Introduction

Energy generation and conversion represent the essential processes in renewable energy innovations based on electrochemistry, which aim to solve the global crisis of energy shortage and environmental pollution [1–3]. Lying at the heart of these processes is a phenomenon called electrocatalysis, the efficiency of which critically relies on the applied electrocatalytic nanomaterials [4,5]. Owing to its unique chemical, physical, and electronic properties, platinum (Pt) seems to be the natural choice for catalyzing a wide range of reactions that are associated with the renewable energy technologies, such as fuel cells, metal-air batteries, water electrolyzers, and so on. However, the high cost and low abundance of Pt greatly hinder the wide adoption of these technologies, which has thus stimulated considerable efforts being devoted to reducing the Pt usages in electrocatalyst or even replacing it with less expensive materials [6,7].

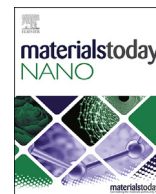
As one of the most promising replacements to Pt, palladium (Pd) has received extensive attention in the past decades [8–10]. First, Pd is located in the same group and shares similar physicochemical properties with Pt. This explains why Pd lies among the most active elements for hydrogen evolution/oxidation reaction (HER/HOR), oxygen reduction reaction (ORR), and liquid fuels oxidation reactions. Second, in comparison with other transition metals, Pd possesses relatively high oxidation potential, thus ensuring fairly good stability during the long-term electrochemical operation. Finally, the average cost of Pd in history is only 1/3 to 1/2 of Pt, which might considerably decrease the overall cost of nanoelectrocatalysts.

In spite of these attractive advantages, a gap in catalytic performance (in terms of both activity and stability) between Pd and Pt still exists. In the past decade, various strategies have been proposed to fill this gap, including alloying or doping with other cheap transition metals, controlling the morphology or architecture, tuning the crystalline phases, searching for the optimized support materials, and so on. The present review aims to summarize recent progresses on advancing Pd-based electrocatalysts based on the abovementioned strategies. We first overview the fundamental studies of electrocatalysis toward various reactions using well-

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Full Length Article

Pd–Pt nanoalloy transformation pathways at the atomic scale[☆]

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Yi Gao^{b, **}, Yong Wang^{a, *}

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ARTICLE INFO

Article history:

Available online 14 April 2018

Keywords:

Transformation pathways
Palladium–platinum core-shell
nanoparticles
In-situ STEM
Alloying

ABSTRACT

Nanoalloys have attracted considerable attention for their wide applications in materials, optics, catalysis, and biomedicine, which largely rely on their composition-, size-, and shape-dependent properties. Because these properties change dynamically with working conditions, the knowledge of the complex transformation pathway of nanoalloys is highly demanded. Herein, we combined the in-situ aberration-corrected scanning transmission electron microscopy and multiscale modeling to fully resolve the whole transformation trajectory of a bimetallic nanoalloy (Pd–Pt) at the atomic level. The transformation from core-shell to solid-solution structure is a multistep and temperature-dependent pathway, which includes monometallic-surface refaceting, bimetallic-surface refaceting, and alloy mixing, owing to the different atomic activation barriers of surface diffusion and bulk migration. The critical role of shell thickness in determining the transformation pathway was also revealed and explained. In particular, a unique partial core-shell structure with an anisotropic surface pattern was observed in the annealing process of ultrathin core-shell nanoparticles. This study offers a fundamental insight into the structure evolution of nanoalloys, which is beneficial for the development of functionalized nanoparticles with kinetic stability.

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Nanoalloys have attracted extensive attention for their potential applications in nanocatalysis, nano-engineering, and nanomedicine [1,2]. The unique properties of nanoalloys are determined not only by their morphologies and sizes, as for other nanomaterials, but also by their unique chemical compositions and atomic distributions [1–9]. For Pt-based bimetallic alloys, the solid solution structures and core-shell structures exhibit distinct properties. The Pd–Pt solid-solution alloy nanoparticles (NPs) have a higher hydrogen-storage capacity than the core-shell-type NPs [10], and their core-shell NPs have been widely employed as model catalysts for oxygen reduction reaction in fuel cells [11–15]. In particular, the core-shell Pd–Pt NPs with controlled shell thickness and morphology have attracted great interests because of their distinct catalytic properties [16–18]. Interestingly, recent in-situ

experiments have shown that both structures and compositions of nanoalloys may considerably transform during thermal treatment and under real reaction conditions [19–26]. For instance, Vara et al. recently reported that both the shape and the mixing pattern of Pd–Pt core shell NPs change at a high temperature, consequently changing their catalytic activities [27]. As a result, understanding how the structure of a controlled core-shell nanoalloy changes under a given condition is crucial for the effective tuning of properties, which requires detailed information about the complex transformation pathways.

In the past decade, much effort has been contributed to study the complex pathways of formation [28], transformation [29–32], and dissolution [33,34] of individual nanoscale building blocks. Chi et al. identified the distinct stages of surface element rearrangements of Pt₃Co NPs under thermal treatment [35]. Very recently, Ye et al. presented a breakthrough work for mapping the short-lived intermediate state of single gold NPs [36] to provide the possibility of designing a kinetically stabilized surface. However, despite the above achievements, only limited information is available on the transformation pathways of nanoalloys because it remains a challenge to monitor the structure evolution of a single NP during the long-time annealing process at the atomic scale.

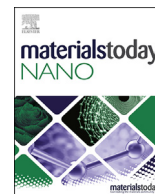
[☆] Given his role as Editor-in-Chief, Ze Zhang had no involvement in the peer-review of this article and has no access to information regarding its peer-review. Full responsibility for the editorial process for this article was delegated to Zhifeng Ren of Materials Today Physics.

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Review Article

Non-fullerene acceptors for large-open-circuit-voltage and high-efficiency organic solar cells

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ARTICLE INFO

Article history:

Available online 16 April 2018

Keywords:

Non-fullerene acceptor

Organic solar cell

Open-circuit voltage

Charge transfer

Exciton dissociation

ABSTRACT

The development of fused ring-based non-fullerene acceptors has established a great competitiveness of solution-processed organic solar cells (OSCs) beyond other emerging solar photovoltaics. In this review, we highlight the recent progresses in non-fullerene OSCs that have shown high power conversion efficiencies along with large open-circuit voltages because of the low energy loss. By tailoring the molecular structures of non-fullerene acceptors, energy-level alignments between non-fullerene acceptors and the paired donors can be optimized, together with a complementary absorption covering a broad range of solar spectrum. Nanoscale morphological structure can be tuned by thermal annealing and solvent additive treatments to improve exciton dissociation and charge extraction. All these appealing features lead to a better photovoltaic performance of non-fullerene OSCs than that of fullerene counterparts, which is critically important for potential applications in economically efficient building-integrated photovoltaics.

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1. Introduction

The flexible, light-weight, solution-processed organic solar cells (OSCs) have been intensively investigated for several decades toward next-generation low-cost and high-efficiency thin-film photovoltaics [1–3]. The OSCs are based on a pair of an electron donor and an acceptor that have electronic energy levels required for an efficient photoinduced charge transfer between the two components of the donor-acceptor blend film [2,4]. Different from band-like transport in crystalline inorganic semiconductors [5], the photogenerated charges move by a hopping transport mechanism in organic semiconducting molecules that have weak intermolecular interaction forces and a low dielectric constant ($k \sim 3$) [6–8], leading to low charge mobilities [9] and a strong binding energy of excitons [10], which typically have a short diffusion length of around 20 nm [1]. To split the strongly bound excitons into free charges, the energy level offset between the donor and acceptor

should be larger than the exciton binding energy to drive efficient charge transfer [11], which is subsequently followed by the formation of relatively weakly bound ‘charge transfer excitons’ (CTEs), owing to the weak coulombic force between electrons in the acceptor and holes in the donor after the photoinduced charge transfer process [10,12,13]. The CTEs can be separated by the internal electric field to create free carriers [10], which are collected along the donor and acceptor network paths to respective electrodes. Fig. 1a and b shows a typical device structure and working mechanism of OSCs, respectively [14].

The steady progresses in the fundamental understanding of the operating principle in OSCs have advanced the device performance [15]. The initial OSCs were based on the Schottky-junction structure [16], in which a layer of organic semiconductor was sandwiched between two layers of metal electrodes with different work functions [17,18]. However, because of the relatively weak internal electric fields formed in the Schottky-junction structure, the strongly bound excitons more likely recombine rather than contributing to the generation of photocurrent, leading to poor power conversion efficiencies (PCEs) [19]. C. Tang developed a successful bilayer heterojunction OSC [20], where the photo-generated excitons can dissociate at the donor-acceptor interfaces,

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