

Can black phosphorus be used for energy storage?

Black phosphorus is a potential candidate material for next-generation energy storage devices and has attracted tremendous interest because of its advantageous structural and electrochemical properties, including its large theoretical capacity, high carrier mobility, and low redox potential.

What are the applications of black phosphorus?

This review specifically highlights the very recent progress in the synthesis and applications of black phosphorus in the energy process, including secondary battery system, supercapacitor device, and catalysis reaction.

Could black phosphorus open a new chapter for energy materials?

All in all, with persistent attempts by researchers around the world, it is out of question that black phosphorus would not only open a new chapter for a new generation of energy materials but also provide a remarkable market potential in the foreseeable future. There are no conflicts to declare.

Is black phosphorus a multifunctional candidate for energy storage and conversion?

The present critical issues, challenges, and perspectives in terms of well-harnessed scalability, quality, and stability are comprehensively covered. An in-depth understanding of these aspects is of great importance for the design of black phosphorus as a multifunctional candidate in future energy storage and conversion.

1. Introduction

What is black phosphorus (BP) rediscovered as a 2D layered material?

His current research focuses on design and synthesis of nanostructured materials for electrochemical energy storage and conversion including batteries, supercapacitors, and fuel cells. Abstract Black phosphorus (BP) is rediscovered as a 2D layered material.

How does black phosphorous work?

In fact, recent X-ray diffraction experiments have proposed that black phosphorous operates through an alloy-dealloy mechanism with K ions and the final product of electrochemical transformation is a KP (not K₃P) alloy, which makes good cycling stability for the electrodes in PIBs [13].

Two-dimensional (2D) black phosphorus (BP) has attracted great attention in recent years in fundamental research as well as optoelectronics applications. The controllable synthesis of high-quality BP is vital to the investigation of its intrinsic physical properties and versatile applications. Originally, BP was mostly synthesized under high temperatures and ...

In addition, the electrochemical properties and storage mechanism of phosphorene-based electrodes for

rechargeable batteries and supercapacitors are discussed. Finally, the challenges and opportunities of phosphorene nanosheets in terms of exfoliation and energy storage applications are addressed.

The facile low-temperature synthesis of BP by the ethylene diamine-assisted liquid phase process will facilitate the extended application of BP in energy storage and conversion field. As a thermodynamically stable semiconductor material, black phosphorus (BP) has potential application in field of energy storage and conversion. The preparation of black phosphorus is ...

Black phosphorus (BP) is rediscovered as a 2D layered material. Since its first isolation in 2014, 2D BP has triggered tremendous interest in the fields of condensed matter physics, chemistry, and materials science. ... Nevertheless, 2D BP is considered an electrochemically active material for the energy storage mechanism (Figure 15), ranging ...

In the field of energy storage, supercapacitors are another important energy-storage device with attractive advantages, such as high-power density, ultrafast charging/discharging rate and longer cycle life as compared to other conventional energy-storage systems [3, 4]. According to ...

The mechanism and application of BP in Li-/ Na-ion battery anodes, oxygen evolution reaction/hydrogen evolution reaction catalysis, photocatalytic hydrogen production, and selective sensors are sum-

The mechanism and application of BP in Li-/Na-ion battery anodes, oxygen evolution reaction/hydrogen evolution reaction catalysis, photocatalytic hydrogen production, and selective sensors are summarized. As a new type of 2D semiconductor, black phosphorus (BP) possesses high charge-carrier mobility and theoretical capacity, thickness-dependent ...

Recent preparation of black phosphorene and subsequent discovery of its excellent optical and electronic properties have attracted great attention, and renewed interest to phosphorus. Recent researches have indicated that phosphorus structures are promising anodes for lithium-ion and sodium-ion batteries. A high theoretical capacity of 2,596 mAh^{·}g⁻¹ was ...

In recent years, two-dimensional (2D) materials such as graphene, MXene, MOF, and black phosphorus have been widely used in various fields such as energy storage, biosensing, and biomedicine due to their significant specific surface area and rich void structure. In recent years, the number of literatures on the application of 2D materials in electrochemistry ...

Black phosphorus (BP) emerges as a highly promising electrode material for next generation of energy-storage systems. Yet, its full potential is hindered by the instability of the solid ...

Black phosphorus with a long history of ~100 years has recently attracted extraordinary attention and has become a promising candidate for energy storage and conversion owing to its unique layered structure,

impressive carrier mobility, remarkable in-plane anisotropic properties, and tunable bandgap from 0.3 eV in the bulk to 2.0 eV in the monolayer.

Recent advances on black phosphorus for energy storage, catalysis, and sensor applications. ... Growth mechanism of black phosphorus synthesized by different ball milling techniques. *J. Alloys Compd.*, 784 (2019), pp. 339-346. View PDF View article View in Scopus Google Scholar [24]

A crystallization mechanism from red to black phosphorus based on the FTIR, XPS and DFT calculation is proposed. ... which are not only crucial for in-depth understanding of electrochemical energy ...

Besides, the reaction mechanisms of red and black phosphorus in energy storage field are discussed in detail, respectively. On account of their respective advantages and disadvantages, the targeted designs of phosphorus-carbon hybrids are summarized to improve the performance of the two kinds of phosphorus.

Black phosphorus (BP) is a thermodynamically stable two-dimensional semiconductor material, and its applications in the fields of optoelectronic devices [1], biomedicine [2], catalysis [3] and energy storage [4], [5], [6] have attracted more and more attention. Three phase structures of BP have been found: cubic, orthorhombic, rhombohedral.

Layered black phosphorus (BP) exhibits several attractive features for high-rate, high-capacity Li storage. Through a three-electron alloying reaction with Li⁺, BP can theoretically deliver a gravimetric capacity of 2596 mA·h/g (7, 8), which is only bettered by Si (4200 mA·h/g) and Li metal (3860 mA·h/g). The large capacity of BP helps offset its ...

In the proposed mechanism, Sn₂₄P_{19.3}I₈ is the active site for the growth of black phosphorus, and the black phosphorus crystals are formed with the assistance of SnI₂, following a polymerization-like process. In addition, we suggest that all Sn-I assisted synthesis of black phosphorus should share the same reaction mechanism despite the ...

Sodium-ion batteries (SIBs) have been considered as promising candidates for large-scale energy storage. ... the as-synthesized MoS₂/black phosphorus heterostructure shows a high reversible capacity of 435.5 mA h g⁻¹ at 1.0 A g⁻¹ over 150 cycles and a good ... the sodium storage mechanism can be unraveled. When coupled with the high ...

Hybridization with other smaller lateral-size two-dimensional (2D) materials has been demonstrated to be effective for MXene materials in other types of energy storage devices. For instance, black phosphorus (BP) is an emerging 2D material that has been doped with MXenes for use in supercapacitors, Li-ion storage, K-ion capacitors, and Na-ion ...

The successful isolation of phosphorene (atomic layer thick black phosphorus) in 2014 has currently aroused

the interest of 2D material researchers. In this review, first, the fundamentals of phosphorus allotropes, phosphorene, and black phosphorus, are briefly introduced, along with their structures, properties, and synthesis methods.

Black phosphorus has been applied for potassium ion storage due to its high electronic conductivity (10^2 S m^{-1}) and very stable thermodynamics due to its layered crystal structure.[21, 22] For instance, Sultana et al. firstly used black phosphorus in KIBs in 2017 with inferior electrochemical performance.[23]

Elemental black phosphorus (BP) is an attractive anode material for lithium-ion batteries (LIBs) as like other known alloying materials such as Ge, Si, Sn, Pb, As and Sb, BP offers much higher volumetric and gravimetric energy densities than traditional graphite. This is because BP charge storage benefits from the intercalation of alkali ions and their alloying with ...

Two-dimensional black phosphorus (2D BP), well known as phosphorene, has triggered tremendous attention since the first discovery in 2014. The unique puckered monolayer structure endows 2D BP intriguing properties, which facilitate its potential applications in various fields, such as catalyst, energy storage, sensor, etc. Owing to the large surface area, good ...

Thanks to the scientists' hard work, hundreds of papers focusing on BP with various applications have been published in the past few years. Among of them, there are existing some review articles about preparation and applications of BP flakes and black phosphorus quantum dots (BPQDs) [45], [46], [47], but few concentrates on their energy applications fully ...

Abstract Black phosphorus (BP), an emerging 2D material semiconductor material, exhibits unique properties and promising application prospects for photo/electrocatalysis. ... which are in favor of excellent applications in solar energy storage, ... These mechanisms correspond to the aforementioned advantageous properties of BP, reflecting its ...

Both the high specific capacity and ion mobility of phosphorus may lead to a breakthrough in energy storage materials. Black phosphorus, an allotrope of phosphorus, has a sheet-like structure ...

Black phosphorus with a long history of ~100 years has recently attracted extraordinary attention and has become a promising candidate for energy storage and conversion owing to its unique ...

Applications of Phosphorene and Black Phosphorus in Energy Conversion and Storage Devices. December 2017; ... Sodiation/desodiation mechanism in black phosphorus and the electrochemical ...

Two-dimensional (2D) crystals have emerged as a class of materials that can impact future electronics (Li et al., 2014), with excellent electrochemical properties and a high specific surface area, which are important for sensing, catalysis, and energy storage applications (Coleman et al., 2011).As a 2D material, graphene has

many potential applications in ...

Phase-Changing Microcapsules Incorporated with Black Phosphorus for Efficient Solar Energy Storage. Hao Huang, Hao Huang. Shenzhen Engineering Center for the Fabrication of Two-Dimensional Atomic Crystals, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen, 518055 P. R. China ... Solar energy storage ...

Considering different charge storage mechanisms, SCs can be classified into two types, such as (i) EDLCs and (ii) pseudocapacitors. In EDLCs, energy is stored through electrostatic charge ...

To further improve the electrochemical performance of phosphorus, Qian et al. prepared an amorphous phosphorus/carbon nanocomposite (a-P/C) through ball-milling red phosphorus with conductive carbon black powders and found that the amorphous phosphorus can fully store reversible 3-Li storage capacity (2355 mA h/g) with stable cyclability (2119. ...

DOI: 10.1016/J.JALLCOM.2019.01.023 Corpus ID: 140050874; Growth mechanism of black phosphorus synthesized by different ball milling techniques @article{Zhou2019GrowthMO, title={Growth mechanism of black phosphorus synthesized by different ball milling techniques}, author={Fengchen Zhou and Liuzhang Ouyang and Meiqin Zeng and Jiangwen Liu and Hui ...

The preparation and electrochemical properties of black phosphorus, recent advances, potential challenges, and relevant perspectives in electrochemical energy storage, and the potential of ...

In this study, first-principles calculations based on density functional theory (DFT) were undertaken to examine the K ion adsorption, diffusion, embedding, and alloying ...

In the most common electrolyte of 1 M LiPF₆ in ethylene carbonate/diethyl carbonate (EC/DEC, v/v = 1/1), the dissolution behavior of black phosphorus (Supplementary Section 1.1, "Preparation of black phosphorus") was studied by assembling a visual cell for direct observation. When it was discharged for the first cycle, the solution became inconspicuous ...

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