Scholar Publishing Group
Academic Journal of Energy
https://doi.org/10.38007/RE.2021.020204
ISSN 2790-2714 Vol. 2, Issue 2: 29-37

Clean Energy Conversion Efficiency Based on Nanocomposite Photothermal Mode

Paweł Domogała*

Tech Univ Cluj Napoca, Cluj Napoca 400114, Romania

**corresponding author*

Keywords: Nanocomposites, Clean Energy, Fuel Cells, Energy Conversion Efficiency

Abstract: Due to the energy crisis and the intensification of environmental pollution, people have been paying close attention to the harvesting and transformation of clean and sustainable energy. In recent years, composite nanomaterials composed of semiconductor materials and the like have been recognized as high-efficiency light energy conversion materials in the fields of optoelectronic and biomedical research. The purpose of this paper is to verify and analyze the conversion efficiency of clean energy based on nanocomposite photothermal mode. In the experiment, boron-doped graphene materials are used. The experimental results show that the new boron-doped graphene nanoribbons can be used as ORR catalysts in fuel cells. It has a good prospect in practical application.

1. Introduction

The relationship between human beings and nature continues to evolve with the improvement of human history [1]. Human's attitude towards nature has gone through the process of revering nature, conquering and transforming nature, rationally utilizing and protecting nature. If the assumption of "rational man" in economic theory is also applicable to human beings as a whole, then human beings should have the tendency to rationally utilize limited resources and pursue long-term benefit maximization, that is, "intertemporal equilibrium", while human beings should have an attitude of rational use and protection of nature That is to reflect this equilibrium [2].

At present, climate change has gradually become the biggest challenge facing human society, and it is related to the fate of human life and death. The rise in global temperature caused by greenhouse gases and emissions is a sword hanging over human heads [3].Backer SN demonstrates a simple, efficient and cost-effective process for producing clean water that can be implemented in local cold springs. CaCl₂ was used as a stand-alone device to purify surface water, and nanocomposite plates were synthesized for artificial heating. Black anatase TiO ₂ ions Mn ²⁺ ions to enhance oxygen lifetime (V _O) as fillers and poly(partial)idene fluoride ethylene) dual polymer matrix. The upgraded E-PNS exhibits a patented optimum absorption rate of 98.5% across the entire solar spectrum (250-2500 nm) and features interconnected micropores that help to efficiently and maximize solar heat transfer. Therefore, the reported pure water power generation process achieves a high solar heat conversion efficiency of 90% under electric power (solar simulator, density 1.13 kWm⁻²), which is 2.2 times that of the process [4]. Cho KT believes that perovskite solar cells are an alternative to clean energy due to their high energy conversion capability and low material and operating costs. However, their poor business stability still limits their applications. Here, an innovative approach aims to control the surface evolution of small-scale perovskite layers on 3D perovskite films. This leads to structured perovskite displays, in which low-density perovskites with unique dimensions are created on top of 3D thin films. The composition and optical properties of the composites were studied, and the solar cells were verified [5]. Researchers in various countries have put a lot of energy into improving clean energy for sustainable applications.

In this paper, nanocomposite materials, fuel cells in clean energy and the research situation of clean energy at home and abroad are studied. In the experiment, the adsorption of reaction intermediates on boron-doped graphene-like materials was analyzed and several boron-doped graphene-like materials were compared. The results show that the increase of boron doping concentration not only provides more catalytically active sites but also significantly improves the catalytic performance of BGNRs.

2. Research on Nanocomposite Photothermal Mode and Clean Energy

2.1. Nanocomposites

There are many kinds of composite materials. When one or more materials in its components belong to the nanometer level (1-100 nanometers), it is called a nanocomposite material. Since this concept was proposed, it has experienced considerable improvement [6-7]. Compared with ordinary composite materials, the biggest feature of nanocomposites lies in the particularity of their nano-components—nanoparticles have nano-effects on the microscopic scale, which makes them have special physical properties. Traditional composite materials often fail to combine the advantages of two or more materials. For example, plastics and rubbers cannot be toughened and strengthened at the same time, while nanomaterials can improve the defects of materials while retaining the original properties of materials due to their quantum effects. Advantageous properties [8-9]. In addition, because nanomaterials are dispersed phase, and the physical and chemical properties are relatively stable. Therefore, the synthesis method of nanocomposite materials has become more simplified. Usually, it is only necessary to directly add nanomaterials to the continuous phase materials that have been modified by functional groups. Through the combination of intermolecular forces, the energy conversion ability that the material does not have can be efficiently given to the material. , improve its chemical stability, improve material life and stability, etc.

2.2. Fuel Cell

With the improvement of the economy and the advancement of science and technology, the rapid growth of global energy consumption and the increasingly prominent problems of environmental pollution pose serious challenges to human health, energy security and environmental protection [10-11]. People are gradually realizing the importance of improving next-generation renewable energy and sustainable energy conversion technologies. Therefore, it has become an inevitable trend to replace traditional fossil fuels with sustainable clean energy. In recent years, some new clean energy represented by fuel cells and solar cells have shown very broad application and improvement prospects [12-13]. For the improvement of clean energy, in addition to new energy conversion technologies, the harm to human beings caused by the polluting gases produced in the process of research and improvement of new energy materials cannot be ignored. With the improvement of the times, people's safety awareness has become stronger, and the requirements for the living environment are also increasing. The detection and control of some toxic and harmful gases around us are becoming more and more important, which also provides a strong impetus for the improvement of various new gas sensing technologies [14].

2.3. Research Situation

(1) Overview of domestic clean energy research

Clean energy is not an absolute concept, the so-called clean energy is compared with traditional energy [15]. In terms of the definition of clean energy, clean energy in a narrow sense means that in the process of energy improvement, transportation, use and waste disposal (discharge), it does not cause any degree of pollution to the ecological environment. According to this definition, wind energy, water Potential energy, solar energy, tides, etc. The broad scope is much larger, that is, the energy from improvement to disposal has less pollution to the environment and ecology, or compared with traditional fossil energy, the energy that threatens the environment is greatly reduced. In addition to the definition, it also includes natural gas, geothermal, coal gas, and biomass energy. In the research of clean energy industry, there is no clear logical system [16].

(2) Overview of foreign clean energy research

Clean Energy In terms of clean energy technology transfer, the study provides strong evidence that large-scale market failures and barriers prevent U.S. consumers from accessing energy services at the lowest cost. The study evaluates a variety of energy policies and programs. Through literature review and case analysis, he concluded that the industrial policy of clean energy improvement in the United States was ineffective at that time, and proposed the concept of "energy efficiency tipping point" or "energy efficiency gap" to evaluate the improvement of clean energy industry [17]. Through interviews and surveys, the data of private equity funds are collected, and it is found that investors' investment decisions and risk management behaviors are closely related to the national clean energy policy. Investors believe that clean energy or climate-related policies provide investors with positive effects, but investors are not inclined to invest in a company that is completely controlled by the policy. Investors believe that the potential biggest factor affecting the clean energy market is high Capital expenditures. In terms of policy choices, investors tend to favor clean energy technology-driven policies rather than market-driven policies [18].

3. Investigation and Research on the Conversion Efficiency of Clean Energy Conversion Efficiency Based on Nanocomposite Photothermal Mode

3.1. Theoretical Research

As an energy conversion device for sustainable power generation, the fuel cell can directly convert the chemical energy in the fuel and oxidant into electrical energy. Since the battery does not go through the combustion process during operation, it will not be limited by the Carnot cycle. The advantages of high energy conversion efficiency and low pollution make fuel cells attract more and more attention of researchers. The synthesis of a novel boron-doped graphene nanoribbon (BGNR) was investigated. The unique structural feature of BGNR (two para-boron atoms located at the center of BGNR) not only provides a large number of active sites for oxygen reduction, And it is advantageous for the rapid transport of oxygen and reduction products. We systematically explored the oxygen reduction reaction mechanism and potential applications on the surface of BGNR. The rational reaction mechanism and possible reaction process were determined, and BGNR exhibited excellent catalytic performance. We therefore consider this newly synthesized BGNR to be a promising ORR catalyst.

3.2. Calculation Method

Based on the experimental structural analysis, we constructed the initial crystal structure of BGNR. We performed a layout analysis of the optimized structure using Mulliken charges. where E_{BGNR} and E_{mol} are the energies of the BGNR substrate and the adsorbed small molecules, respectively, and $E_{BGNR/mol}$ is the total energy of the small molecules adsorbed on the BGNR substrate. According to our definition, if the value of is positive, it is an exothermic adsorption process, indicating that small molecules tend to adsorb on the BGNR substrate. Transition state (TS) search adopts the method of LST/QST. The activation energy barrier (E_a) is defined as the energy difference (E_{TS}) between the transition structure (E_{IS}) and the initial structure (E_{ads}), and the adsorption energy ( ) of the adsorbate on the BGNR surface is defined as:

$$E_{ads} = \left(E_{BGNR} + E_{mol} - E_{BGNR/mol}\right) \tag{1}$$

$$E_a = \left(E_{TS} - E_{IS}\right) \tag{2}$$

4. Analysis and Research on Conversion Efficiency Verification of Clean Energy Based on Nanocomposite Photothermal Models

4.1. Adsorption of Reaction Intermediates on Boron-doped Graphene-like Materials

According to existing reports, it can be found that the distribution of charge and spin density plays a very important role in identifying the catalytically active sites of ORR. As the initial step of ORR, the adsorption of carbon dioxide molecules on the surface of BGNR is very important in the whole ORR process. Therefore, we investigated the adsorption of carbon dioxide molecules on the surface of BGNRs. Several possible adsorption sites were considered, including the six-membered ring center, the top position of the boron atom, the bridge position of the B-C and C-C bonds, and the corresponding adsorption energies and bond length information are shown in Table 1 and Figure 1:

Table 1. Adsorption energy and bond length information of different adsorption sites on BGNR

Sites	E	Distance (A)
A	0.94	1.53
B	0.81	1.71
C	0.73	1.43

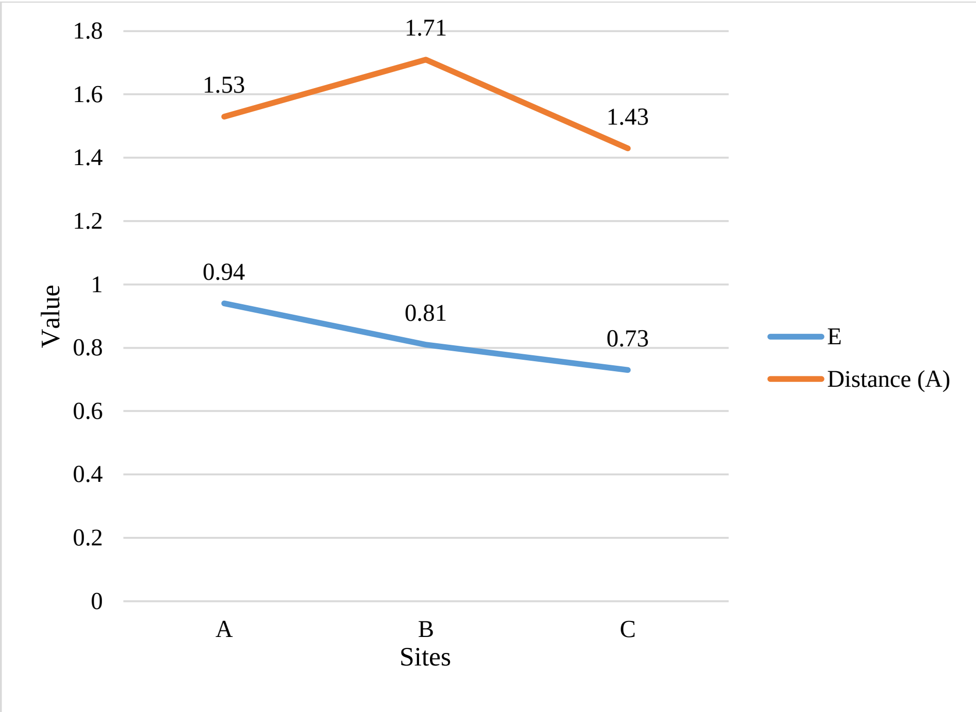

Figure 1. Comparison of the adsorption energy of carbon dioxide molecules at different adsorption sites on the BGNR

Next, we constructed different adsorption models of ORR reaction intermediates on the surface of BGNR, and after structural optimization, the optimal adsorption configuration was determined by comparing the adsorption energy. The most stable adsorption configurations of 00H, 0, H, OH groups and H_2O molecule on BGNR are given, and the corresponding adsorption energy values are shown in Table 2 and Figure 2:

Table 2. Adsorption energy of carbon dioxide molecules, reaction intermediates and carbon monoxide molecules on the surfaces of BGNR, S-BGNR, D-BG and S-BG

	BGNR	S-BGNR	D-BG	S-BG
Oxygen	0.96	0.69	0.78	0.59
Peroxide hydroxide ion	2.24	2.12	2.24	1.93
Oxygen elements	4.98	4.95	4.98	4.83
Hydrogen	3.43	3.44	3.34	3.22
Oxygen root ion	3.45	3.40	3.48	3.28
Water	0.36	0.34	0.34	0.32
Carbon monoxide	0.23	0.23	0.25	0.23

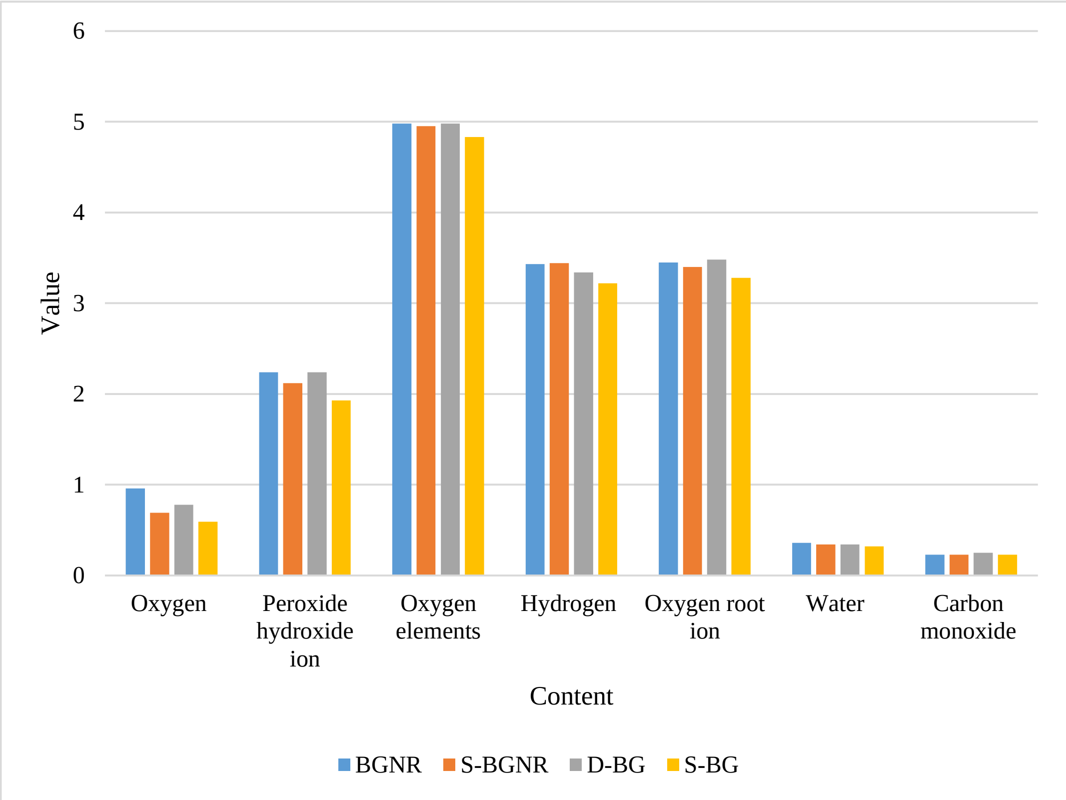

Figure 2. Comparison diagram of the adsorption energy of carbon dioxide molecules, reaction intermediates and carbon monoxide molecules on the surfaces of BGNR, S-BGNR, D-BG and S-BG

The results show that the tolerance of carbon monoxide is also an important indicator to measure the performance of an oxygen reduction catalyst. The interaction between carbon monoxide and Pt surface is very strong, and high adsorption energy can cause carbon monoxide poisoning.

4.2. Comprehensive Comparison Among Several Boron-doped Graphene-like Materials

By comparing the activation energy barrier and overpotential of the reaction, we can see that the performance of boron-doped graphene nanoribbons (BNGR) as ORR catalyst is better than that of Pt-based and N-doped graphene materials. We calculated the HOMO-LUMO energy gaps of the four structures, BGNR, S-BGNR, D-BG and S-BG, respectively. The calculation results are shown in Table 3 and Figure 3:

Table 3. The Mulliken charge layouts on the B atoms doped in BGNR, S-BG N R, D-BG, and S-B G, and the HOMO-LOMO energy gap of these four materials

	Mulliken charge	Bader charge	Hirshfeld charge	Band gap
BGNR	0.374	4.08	0.097	0.69
S-BGNR	0.341	3.48	0.035	0.84
D-BG	0.363	3.39	0.071	1.44
S-BG	0.312	3.23	0.031	1.83

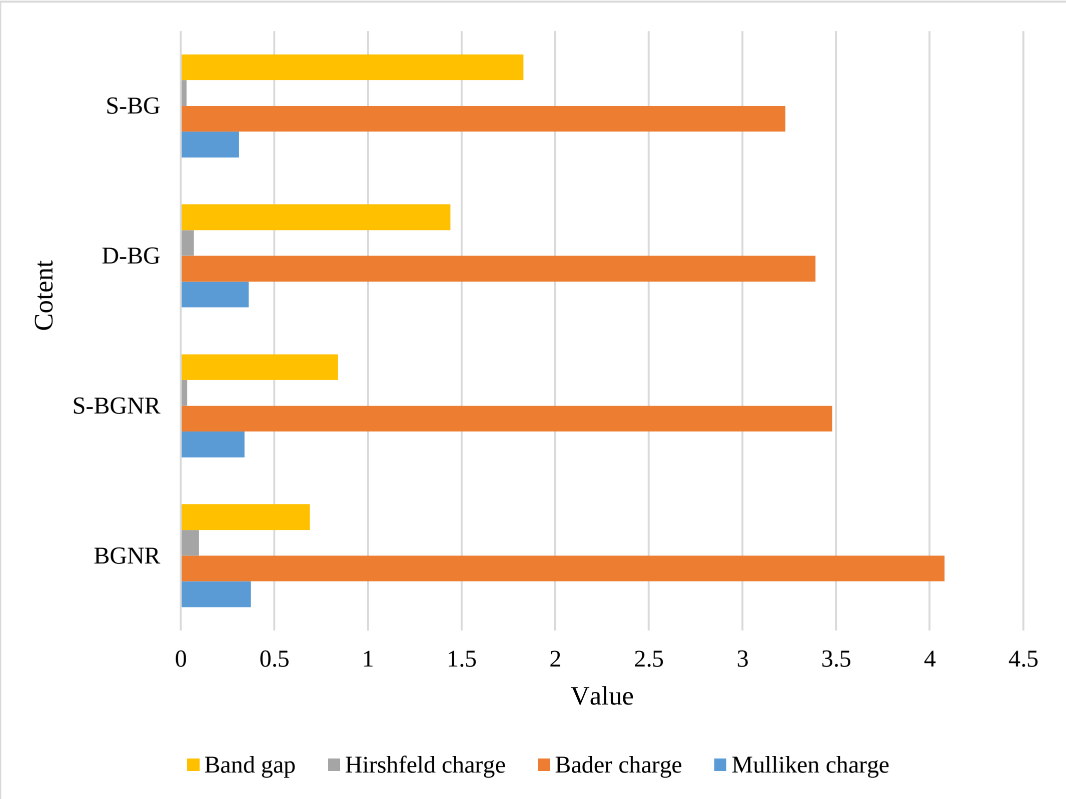

Figure 3. The Mulliken charge layout on the B atoms doped in BGNR, S-BG N R, D-BG, and S-B G, and the HOMO-LOMO energy gap of these four materials.

The results show that the energy gap value of HOMO-LUMO of BGNR is significantly smaller than that of S-BGNR, D-BG and S-BG. The small energy gap of BGNR means that its kinetic stability is lower than that of the other three materials. This makes it easier for valence band electrons to be excited to the conduction band. Therefore, we can think that the chemical reactivity of the BGNR surface is higher and the catalytic activity is better than the other three materials. Mulliken charge layouts on doped B atoms in BGNR, S-BGNR, D-BG, and S-BG, and the HOMO-LOMO energy gap of these four materials. The results show that the increase of boron doping concentration not only provides more catalytically active sites but also significantly improves the catalytic performance of BGNRs. This novel boron-doped graphene nanoribbon holds great promise as an ORR catalyst for practical applications in fuel cells.

5.Conclusion

In recent years, some new energy materials represented by fuel cells and solar cells have attracted the attention of more and more researchers. Fuel cells can convert chemical energy into electrical energy through electrochemical catalysis, and the improvement of sustainable, low-cost, and highly catalytically active electrocatalysts is crucial for the wide application of fuel cells. For the improvement of clean energy, in addition to new energy conversion technologies, the hazards of polluting gases generated in the process of research and improvement of new energy materials cannot be ignored. With the enhancement of people's safety awareness, the detection and control of toxic and harmful gases are becoming more and more important, which also provides impetus for the improvement of various new gas sensing technologies.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Singh A , Ahuja H , Bhadoria V S , et al. Control Implementation of Squirrel Cage Induction Generator based Wind Energy Conversion System. Journal of scientific and industrial research, 2020, 79(4):306-311.

[2] Kaushal M . Performance analysis of Clean Energy using Geothermal Earth to Air Heat Exchanger (GEAHE) in Lower Himalayan Region – Case Study Scenario. Energy and Buildings, 2021, 248(4):111166-111166. https://doi.org/10.1016/j.enbuild.2021.111166

[3] Pathak S , Saxena P , Ray A K , et al. Irradiation based clean and energy efficient thermochemical conversion of biowaste into paper. Journal of Cleaner Production, 2019, 233(1):893-902. https://doi.org/10.1016/j.jclepro.2019.06.042

[4] Backer S N , Ramachandran A M , Venugopal A A , et al. Clean Water from Air Utilizing Black TiO2-based Photothermal Nanocomposite Sheets. ACS Applied Nano Materials, 2020, 3(7):6827-6835. https://doi.org/10.1021/acsanm.0c01207

[5] Cho K T , Grancini G , Lee Y , et al. Selective growth of layered perovskites for stable and efficient photovoltaics. Energy & Environmental Science, 2018, 11(4):952-959. https://doi.org/10.1039/C7EE03513F

[6] Barbosa A , Zilliani R R , Tiritan C S , et al. Energy conversion efficiency in sugarcane cultivars as a function of production environments in Brazil. Renewable and Sustainable Energy Reviews, 2021, 150(8):111500-111500. https://doi.org/10.1016/j.rser.2021.111500

[7] Behura A K , Kumar D A , Rajak D K , et al. Towards better performances for a novel rooftop solar PV system. Solar Energy, 2021, 216(5):518-529. https://doi.org/10.1016/j.solener.2021.01.045

[8] Melle G , Altair T , Romano R , et al. Electrocatalytic Efficiency of the Oxidation of Ethylene glycol, Glycerol, and Glucose under Oscillatory Regime. Energy And Fuels, 2021, 35(7):6202-6209. https://doi.org/10.1021/acs.energyfuels.1c00203

[9] Singh S , Chen H , Shahrokhi S , et al. Hybrid Organic-Inorganic Materials and Composites for Photoelectrochemical Water Splitting. ACS Energy Letters, 2020, 5(5):1487-1497. https://doi.org/10.1021/acsenergylett.0c00327

[10] Ishaq H , Dincer I . Design and performance evaluation of a new biomass and solar based combined system with thermochemical hydrogen production. Energy Conversion & Management, 2019, 196(11):395-409.

[11] Nuth, Sirirermrux, Somrat, et al. Steam Gasification of Municipal Solid Waste in Drop Tube Fixed Bed Reactor. IOP Conference Series: Earth and Environmental Science, 2019, 265(1):12017-12017.
[12] Trimarco D B , Scott S B , Thilsted A H , et al. Enabling real-time detection of electrochemical desorption phenomena with sub-monolayer sensitivity. Electrochimica Acta, 2018, 268(1):520-530. https://doi.org/10.1016/j.electacta.2018.02.060
[13] Darmawan A , Ajiwibowo M W , Aziz M , et al. Efficient black liquor conversion to power and H2 based on process integration and exergy recovery. Energy Procedia, 2018, 152(1):1272-1277. https://doi.org/10.1016/j.egypro.2018.09.181
[14] Corona A , Parajuli R , Ambye-Jensen M , et al. Environmental screening of potential biomass for green biorefinery conversion. Journal of Cleaner Production, 2018, 189(10):344-357. https://doi.org/10.1016/j.jclepro.2018.03.316
[15] Buscheck T A , Upadhye R S . Hybrid-energy approach enabled by heat storage and oxy-combustion to generate electricity with near-zero or negative CO2 emissions. Energy Conversion and Management, 2021, 244(9):114496-114496.
[16] Mao J , Iocozzia J , et al. Graphene aerogels for efficient energy storage and conversion. Energy & Environmental Science, 2018, 11(4):772-799. https://doi.org/10.1039/C7EE03031B
[17] Mhda D , Tkg A , Nnsa B , et al. Type-II GeAs/GaSe heterostructure as suitable candidate for solar power conversion efficiency. Solar Energy, 2021, 223(1):87-99.
[18] Bauer M , Wiesmeier J , Lygeros J . A comparison of system architectures for high-voltage electric vehicle batteries in stationary applications. The Journal of Energy Storage, 2018, 19(12):15-27. https://doi.org/10.1016/j.est.2018.06.007