

On the Application Status and Optimization Path of Energy Blockchain Technology in Carbon Neutrality in Anhui Province

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Abstract: In response to the carbon peak and carbon neutral plan proposed by the General Secretary Xi Jinping, Anhui Province actively promotes the comprehensive green transformation of economic and social development, and helps to achieve accurate, scientific energy conservation and carbon reduction by making use of the characteristics and advantages of blockchain technology, such as chained data structure, decentralized distribution, smart contracts and open source programmability. On the basis of blockchain technology, "carbon index", energy trading and other theories, this paper combines blockchain technology with the work of energy conservation and carbon reduction in Anhui Province, and realizes the systematic construction of blockchain technology in energy conservation and carbon reduction by establishing a conceptual model of energy blockchain trading.

Keywords: Energy blockchain, Carbon neutrality, Optimization path.

1. Introduction

Since the reform and opening up, China's economy has always maintained a state of rapid development, but a series of environmental pollution problems such as energy consumption and air pollution generated during the development process have also been exposed. According to the greenhouse gas emission data, China's total carbon dioxide emissions for many years continue to rank first in the world. In 2015, China officially put forward the concept of green development. As one of the important parts of the national development strategy, in order to speed up the process of green and low-carbon development and actively respond to climate change, China has formulated "the peak of carbon dioxide emissions by 2030 and the realization of carbon dioxide emissions by 2060". The long-term goal of "carbon neutrality" is not only based on the needs of the current development stage, but also an important manifestation of China's commitment to international responsibility as a major country.

In the face of increasingly serious resource and environmental problems, the energy Internet, as a product of the combination of information technology and energy, can effectively realize the marketization, efficiency and greenization of energy, and provide a feasible technical solution for the effective utilization of energy. At the same time, it empowers the realization of "new progress in the construction of ecological civilization" proposed in the outline of the national "14th Five-Year Plan". With the progress of the times, blockchain technology is rapidly developing, improving and applying, and more and more fields have its applicable space and usage, and it also plays an indispensable role in the construction of the Energy Internet, as it helps to achieve the goal of "carbon peaking and carbon neutrality", allowing people to escape from the inherent

thinking mode formulated by purely theoretical concepts. Through the review and analysis of relevant literature, it is found that how to effectively develop energy blockchain technology, organically combine blockchain technology with dual carbon goals, maximize energy efficiency, and achieve the goal of reducing carbon emissions is the most important issue in recent years. a research hotspot. However, most of the literature available for viewing at present is theoretical analysis, which is less integrated with practical applications. Based on Anhui Province, this paper will study the development status of energy blockchain technology in carbon neutrality in Anhui Province, analyze it with the actual situation, and propose an optimization path according to local conditions.

2. Literature Review

After reviewing the literature, scholars have carried out research from different perspectives around the topic of blockchain technology to help dual carbon goals. Blockchain technology helps the path of digital carbon neutrality to analyze the significance of building a credible and efficient carbon trading market combined with the characteristics of blockchain technology to achieve the dual carbon goal [1]. The Internet of Things + blockchain technology, carbon emission transparency and industrial upgrading reform proposes to use the Internet of Things + blockchain technology to obtain real carbon emission information to formulate effective industrial upgrading policies [2]. Analysis of the path of digital technology to promote the realization of carbon neutrality in China's energy industry put forward the general idea of digital technology to promote China's carbon neutrality process [3]. In the research on the incentive mechanism of renewable energy consumption based on blockchain, the blockchain energy trading platform is used as

the carrier to discuss its incentive effect on various market players in the process of renewable energy consumption, and the incentive is proposed [4]. A new business model in the future under the mechanism. Based on the design of carbon emission trading system based on blockchain smart contract technology, a carbon emission trading system platform based on Ethereum smart contract technology is built [5].

Through the above literature review, it can be seen that many scholars start from the characteristics and theory of blockchain technology to conduct research on a certain aspect, providing us with various ideas, but also ignoring the effect of blockchain technology as a whole combined with practical applications. The selected research focuses on the following points:

First, build a variety of technical models such as blockchain. We propose an optimization path of blockchain technology combined with big data and other technologies and give a specific conceptual model, which is more comprehensive and intuitive than previous research. Second, the combination of theory and practice. This study combines the theoretical research of blockchain technology and carbon neutrality with energy conservation and carbon reduction in Anhui Province to provide a path that adapts to local conditions. Third, pay attention to the role of blockchain technology in the energy market, and deeply analyze the favorable conditions of Anhui Province, so that the blockchain technology can be developed in a coordinated manner.

3. Status Quo of Digital Carbon Neutral Development in Anhui Province

3.1. Ecological and Environmental Protection and Carbon Reduction Governance Process

Anhui Province currently accounts for about 70% of the total carbon emissions in the industrial sector. Promoting the green and low-carbon development of the industry is the top priority to achieve the "dual carbon" goal. The Provincial Bureau of Statistics stated that it will give full play to the basic role of statistical monitoring in energy management and energy conservation and carbon reduction, provide enterprises with more abundant and personalized energy conservation and carbon reduction information services, and guide enterprises to take carbon emission reduction as the starting point, strive to improve production efficiency, expand market space, and accelerate the establishment of an energy-saving and low-carbon green production system.

3.2. Status Quo of Blockchain Development

Anhui Provincial Department of Economics and Information recently revealed in its reply that the "goal" of blockchain development in Anhui-striving for the rapid growth of the province's blockchain industry by 2025, the obvious improvement of industrial competitiveness, and the need to overcome a number of blockchain [Stuck neck]technology, create a group of demonstration application scenarios, develop a group of innovation-leading enterprises, cultivate a group of compound leading talents, further open up the innovation chain, application chain, and value chain, and initially form resource enrichment, active innovation, and efficient collaboration, Safe and reliable blockchain industry ecology.

3.3. Carbon Emission Control Plan

Anhui has accurately grasped the internal logic of "dual carbon", and accelerated the formation of industrial structures, production methods, lifestyles, and spatial patterns that save resources and protect the environment. Anhui Province has accurately grasped the essential requirements of "double carbon", strengthened the construction of ecological civilization in the whole province, the whole process, and all-round, and the quality of the ecological environment has been greatly improved. In August 2021, Anhui's "Carbon Index" service was launched on the enterprise networking direct reporting platform of the province's statistics department. This nationally pioneered "Carbon Index" service provides online "diagnosis" of energy conservation and carbon reduction for industrial enterprises above designated size. Anhui accurately grasps the practical significance of "double carbon", promotes green transformation in economic development, and achieves greater development in green transformation, and double carbon work highlights frequently. Anhui firmly grasps the opportunity of the new round of scientific and technological revolution and industrial transformation, promotes the deep integration of emerging technologies such as the Internet, big data, and artificial intelligence with green and low-carbon industries, and accelerates low-carbon process innovation and digital transformation in the industrial field. Actively participate in the relevant work of the national carbon emission trading market, explore the establishment of an ecological protection compensation mechanism that can reflect the value of carbon sinks, build a "one picture" of carbon emissions in the province, enrich multi-scenario applications, and promote a better government and effective market combine.

4. Analysis of Favorable Conditions for Technology Empowerment of Energy Conservation and Carbon Reduction Actions in Anhui Province

4.1. Planning on Ecological Environmental Protection

Made by General Secretary Xi Jinping on Anhui and ecological environmental protection work, and closely linked the "14th Five-Year" ecological environmental protection plan, Anhui Province's "14th Five-Year" national economic and social development plan outline and relevant provincial-level special projects. On the basis of in-depth investigation and research and extensive listening to the opinions and suggestions of all parties, based on the actual situation of Anhui Province, the "Planning" was compiled and formed. According to the Plan, by 2025, on the basis of building a moderately prosperous society in an all-round way and intensifying the battle of pollution prevention and control, the quality of the ecological environment will be continuously improved, the ecological environment governance system and governance capacity will be significantly improved, the living environment will be more harmonious, and the "planning" will be gradually formed. "Green, shared, efficient, low-consumption" production and lifestyle is the overall goal. At the same time, looking forward to 2035, carbon emissions will stabilize with some decline after peaking, the quality of the ecological environment will fundamentally improve, the service function of the ecosystem will be significantly

improved, the ecological security will be effectively guaranteed, the modernization of the ecological environment governance system and governance capacity will be fully realized, and the goal of building a beautiful Anhui province in which man and nature coexist in harmony has been basically realized. The ultimate goal of this paper is consistent with the overall goal of ecological environmental protection during the "14th Five-Year Plan" period in Anhui Province.

4.2. Taking the Lead in Launching the "Carbon Index" Service in The Country

From September, Anhui Province will conduct online "diagnosis" of energy conservation and carbon reduction for industrial enterprises above designated size, and timely warn and remind enterprises of problems in energy conservation and emission reduction. The first "carbon index" service in the country creates a "clear account" of carbon emissions for the daily production and operation of enterprises, and promotes the implementation of the "dual carbon" strategy to the whole process of production and operation of enterprises. The "Carbon Index" system calculates the carbon emission index through the four dimensions of the energy consumption of coal, electricity, oil and gas, and displays the carbon emission level of various energy consumption of the enterprise with the "Carbon Index Ring", and displays the monthly energy consumption of the enterprise with a bar chart and carbon index trends. It provides favorable conditions for the quantification of carbon emissions for this project to successfully promote blockchain technology and energy conservation and carbon reduction actions.

4.3. Piloting the First "Blockchain + 5G" Demand Response System

The system was developed by State Grid Zhejiang Electric Power. By using "blockchain + 5G" technology, it builds a trust chain of load aggregators, users, and power supply companies to achieve credible sharing of demand response data. A load aggregator is a new service enterprise due to demand response. It mainly provides users with professional demand response technology and consulting services, and obtains benefits by aggregating demand response resources and acting as an agent to participate in demand response capacity. Compared with the power supply company directly connecting with a large number of small and medium-sized enterprises to carry out unified demand response, the load aggregator has played the role of "intermediary" and "agent", collecting scattered users as adjustable loads, and deeply understand each user's needs and requirements. To respond to potentials, customize personalized demand response strategies, which not only realizes the improvement of energy efficiency management of users, but also reduces the pressure of peak regulation for power supply companies and power generation enterprises, and effectively reduces carbon emissions. The pilot application work in Yiwu, Zhejiang is convenient for Anhui Province to apply blockchain for reference in practical work, and provides a basis for this paper to successfully promote the conceptual model of combining blockchain technology with energy-saving and carbon-reducing actions.

5. Blockchain Technology Realizes the Incentive of Energy Market and Low-carbon Behavior

The future energy trading market based on the three characteristics of "multi-agent, multi-mode and multi-rule" puts forward the requirements and challenges for the transparency, real-time and data security in the transaction [6]. Facing the energy trading market with service requirements of "intelligent mutual trust, subject equivalence, information sharing, and transaction transparency", combined with the four major technical characteristics of blockchain, "decentralization, non-tampering, information traceability, transparency and security". It can be used as a specific means of implementation for the realization of China's carbon neutrality goal, thereby forming a new distributed energy trading market.

5.1. Blockchain Technology Contributes to The Innovation of The Distributed Energy Market

(1) The blockchain realizes safe and reliable transactions and efficient settlement in the energy trading market. Use blockchain technology to build a distributed energy ledger, connect front-end transaction data, marketing data, and user consumption data in the energy market to achieve distributed accounting and storage; use the immutable record storage method of blockchain to simplify data input and storage, process to avoid human error and malicious tampering. Through smart contracts, transactions, clearing and other businesses are automated to achieve transactions and settlements, reducing errors and obstacles in the clearing process [7].

(2) The blockchain realizes business automation in the energy trading market. Through smart contracts, the transaction process of energy services such as the energy market is automatically executed, real-time energy prices are generated according to the real-time supply and demand relationship of energy, and energy transmission and control are automatically triggered. The transaction is completed, so as to achieve the balance of energy dispatching in the whole network.

(3) The blockchain realizes the optimal allocation of resources in the energy trading market. Determine energy trading and scheduling rules through on-chain code and smart contracts, coordinate trading market stakeholders, aggregate different types of distributed power supply terminals, and achieve overall coordination and optimization; through personalized energy prices and comprehensive energy optimization scheduling, improve clean energy Proportion of consumption in market transactions to promote rational energy consumption [8].

5.2. Blockchain Technology Optimizes the Energy Market Structure and Transaction Process

(1) Blockchain technology optimizes the basic system architecture of the distributed energy market. The energy market based on blockchain can realize the interconnection and intercommunication of heterogeneous equipment and transaction information in the process of distributed energy transaction, so that different subjects, hardware devices and transaction systems can interact efficiently. The overall

architecture is divided into four layers: base layer, engine layer, business layer and application layer. Among them, the base layer provides the infrastructure support of the trading platform, encapsulates the underlying data blocks, as well as data encryption and time stamping technologies, to realize off-chain data storage [9]. The engine layer encapsulates the consensus algorithm of network nodes, supports the construction of smart contracts, realizes energy trading contracts, energy pricing contracts and energy scheduling contracts, and supports the business needs of the blockchain-based distributed energy market. The business layer realizes the energy market business through smart contracts. The application layer encapsulates various scenarios and cases.

(2) Blockchain technology improves the transaction process in the energy market. First, the source user (seller) publishes power supply information, and the platform pricing contract is priced according to the source user and power supply situation and uploaded to the chain. Subsequently, the consumer user (buyer) publishes the demand information and the platform matches it, or the user queries the source-side power supply information for direct transaction, and the transaction triggers the platform transaction contract. After checking the qualifications of both parties to the transaction and the conditions permit, the transaction contract is triggered, and the contract freezes the buyer's account amount. The contract is verified in the background of the system and notifies the user when it fails. The verified contract will be stored in the blockchain system and triggered by the scheduling contract to start energy scheduling and transmission [10]. At all stages of trading, governments can participate in developing carbon-neutral policies that affect the functioning of trading markets. In the whole transaction process, in addition to the source end and the consumer end, it also involves power grid transmission, government and other energy transmission and supervision participants.

5.3. Blockchain Technology Realizes Carbon Neutrality and Low-carbon Behavior Incentives

By using blockchain tokens or smart contracts, realizing the token economy of the energy market or prioritizing energy scheduling can not only enhance the additional economic benefits of low-carbon behaviors, but also stimulate low-carbon behaviors. Specific measures include: First, energy-

saving power dispatching. Abandon the principle of average dispatch, reduce the cost of excessive use of renewable and non-renewable energy sources, and distribute energy from suppliers with higher energy efficiency and lower pollutant emissions, or prioritize these energy sources. Second, low-carbon incentives on the demand side of electricity consumption. Reduce overall consumer energy demand by incentivizing and controlling peak-to-valley transitions. carbon neutrality is achieved by incentivizing consumers to use more efficient, energy-intensive appliances. Third, low-carbon token trading. Similar to emissions trading, it encourages low-carbon behaviors through market mechanisms to address the environmental externality of carbon emissions [11].

6. Path Optimization Analysis of Energy Blockchain and Digital Carbon Neutrality

6.1. The Development Plan and Stage Goals of Anhui Energy Blockchain

In 2018, the Ministry of Industry and Information Technology released the "2018 China Blockchain Industry White Paper", proposing that the blockchain can become an important tool for effectively integrating the energy industry. Considering the application characteristics of blockchain in the energy industry and in Anhui Province, this paper proposes a three-stage framework for the development of energy blockchain in Anhui Province.

The first stage of energy blockchain development takes technology integration as the primary goal, and will gradually implement tests from small-scale projects in 2022. The first thing is to use blockchain technology to solve the trust problem of multi-unit collaboration. The second phase, which starts in 2023, takes optimization as the main goal, gradually increases the scale of the project, and meets a certain degree of performance upgrade requirements. The final stage uses three years of independent development as the main goal. By absorbing the experience of the first and second stages, it develops the underlying technology of the blockchain that is exclusive to the energy industry, and becomes a reliable "adaptive core system" in the energy Internet. It can be quickly deployed on a large number of similar energy networks in my country.

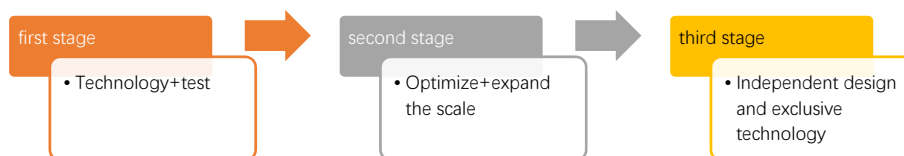


Figure 1. Three stages of energy blockchain development

6.2. Application Scenarios and Implementation Approaches of Energy Blockchain To Help Anhui Industrial Enterprises Save Energy and Reduce Carbon Emissions

The application direction of energy blockchain needs to start from the four major elements of the energy industry,

namely energy asset management, energy trading, green certification and security monitoring, combined with the "carbon index" service launched by industrial enterprises in Anhui Province, this project combines blockchain technology with the four major energy sources of coal, electricity, oil and gas for industrial enterprises in Anhui Province. In the initial stage, individual cities with good development momentum will be selected to establish experimental sites, and the

application model of blockchain will be continuously improve the blockchain application model while expanding the number of provincial industrial enterprises to apply this

technology. The implementation methods are described below according to different application scenarios:

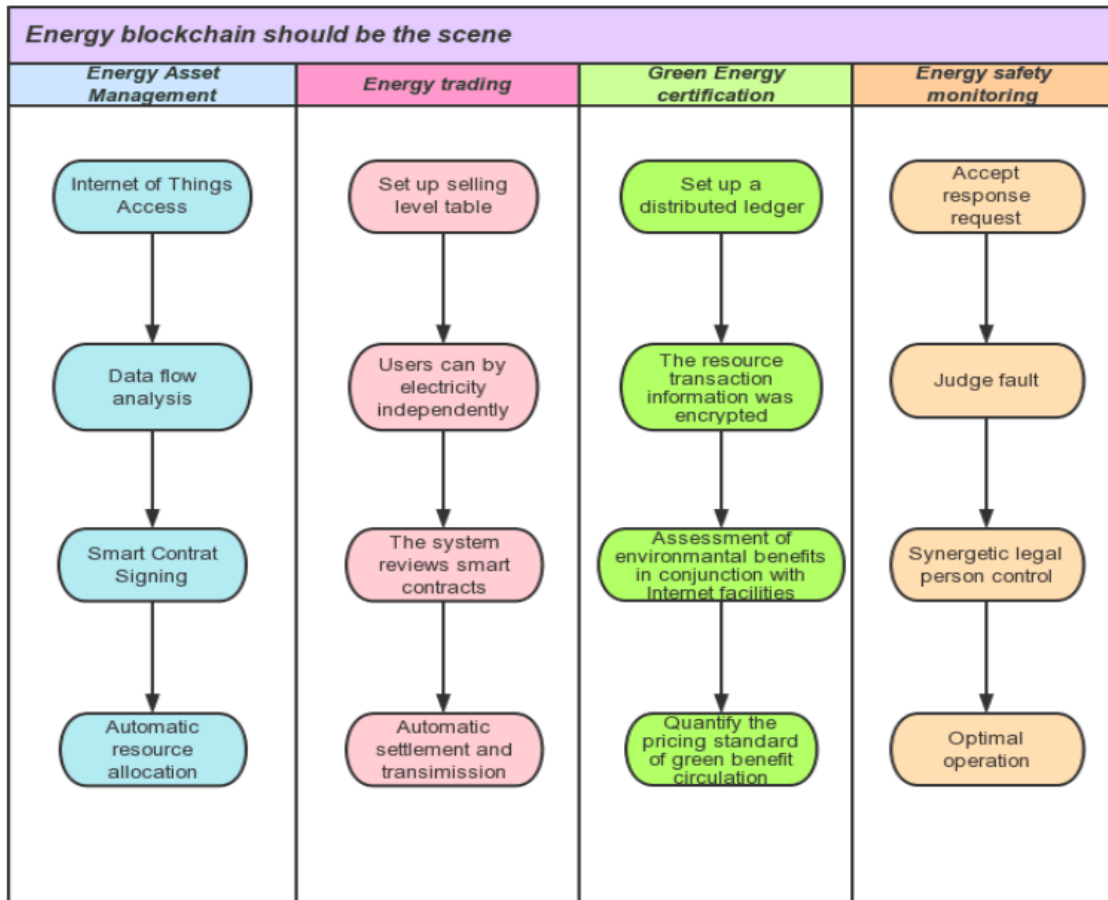


Figure 2. Energy blockchain application scenario diagram

(1) Energy asset management. In the management of energy assets using the energy blockchain, the core is the access to the Internet of Things, the analysis and management of the data flow on the chain by smart contracts, and ultimately the automatic allocation of energy resources according to user needs.

(2) Energy trading. Producers can use the developer tools provided by the blockchain to establish a power sales platform. Users can purchase power from nearby producers according to their needs. The system will check the legality through smart contracts, and automatically settle and perform power transmission operations after verification. Based on some smart terminals with on-chain, small and scattered customer needs are selected as the entry point to provide a simple transaction and settlement model for both supply and demand [12].

(3) Green energy certification. The energy blockchain can encrypt and store resource scheduling and transaction information on the distributed ledger, and can solve the environmental benefit assessment problem of green certification with the cooperation of related internet of things facilities, especially for the circulation of trace and distributed green benefits. Pricing provides quantitative criteria.

(4) Energy security monitoring. Different response requirements, "Internet of Things + Energy Block Chain" has certain advantages in judging the space and time of failure, and quickly coordinating control and optimal scheduling between different legal persons, and plays It plays an

important role in the monitoring and security of energy security.

7. Conclusions and Suggestions

Realization of carbon peaking, carbon neutrality plan, and comprehensive green development is the focus of today's society, and the application of energy blockchain technology will help the plan to be realized. According to the development status of energy blockchain in Anhui Province in carbon neutrality, this paper proposes planning and stage goals, technology integration + testing, optimization and expansion of scale, independent design and exclusive design, progressive layer by layer, combined with reality, proposes specific Application scenarios and implementation paths are expected to provide reference for the development of Anhui Province.

In order to better apply blockchain technology to the process of carbon neutrality in Anhui Province, this paper proposes the following three policy recommendations: First, improve the transparency of information and the timeliness of official data in the use of blockchain technology for carbon emissions-related accounting, reporting and measurement, reduce data management and technical operating costs, and increase data traceability. Second, reduce the centralization of blockchain technology and prevent the blockchain technology from forming an information island in Anhui Province. Third, bring together high-quality partners and

guide multiple parties to complement each other, so that the blockchain technology in Anhui Province can develop collaboratively across borders.

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References

- [1] Zhang Yihui, Yan Shu, Wei Kai. Research on the path of blockchain technology to help digital carbon neutrality [J]. Information and Communication Technology and Policy, 2022(01):81-83.
- [2] Zeng Jianguang, Zou Yuhua, You Lantao. Internet of Things + Blockchain Technology, Carbon Emission Transparency and Industrial Upgrading Reform [J]. China Development, 2021, 21(S1): 83-88.
- [3] Chen Xiaohong, Hu Dongbin, Cao Wenzhi, Liang Wei, Xu Xuesong, Tang Xiangbo, Wang Yangjie. Analysis on the path of digital technology to promote the realization of carbon neutrality in China's energy industry [J]. Proceedings of the Chinese Academy of Sciences, 2021, 36(09) :1019-1029.
- [4] Zhao Guotao, Qian Guoming, Ding Quan, Huang Chao. Research on the incentive mechanism of renewable energy consumption based on blockchain [J]. Huadian Technology, 2021, 43(04): 71-77.
- [5] Zhang Ze. Design of carbon emissions trading system based on blockchain smart contract technology [D]. North China Electric Power University, 2020.
- [6] Shi Weijie, Zhang Hanzhou, Wang Hao. Application of Blockchain in Energy Internet and Suggestions for Shanghai Development [J]. Shanghai Energy Conservation, 2021(05):456-462.
- [7] Zhang Lingrong, Bloomberg, Cheng Chunqi . Research on government subsidy strategy of low-carbon supply chain based on blockchain technology [J/OL]. China Management Science: 1-13 [2022-08-13].
- [8] Ye Qiang, Gao Chaoyue, Jiang Guangxin. Design of China's future blockchain carbon market system under big data environment [J]. Management World, 2022, 38(01): 229-249.
- [9] Ji Bin, Chang Li, Chen Zhenhuan, Liu Yan, Zhu Donghai, Juliet. Design and application of electricity carbon emission trading market mechanism based on blockchain technology [J]. Automation of Electric Power Systems, 2021, 45(12): 1-10.
- [10] Zhou Li, Zhang Shengping, Hou Fangmiao, Zhang Luning. Construction of carbon trading model based on blockchain technology [J]. China Soil and Water Conservation Science, 2020, 18(03): 139-145.
- [11] Hirotaka Hazehara, Dhruva Narayana Katpady, Masashi Soeda, Yukihiro Okabe, Kazunori Era. Neutralization inhibition mechanism of lithium nitrite and its effect on the microstructure of mortar[J]. Construction and Building Materials, 2020, 264.
- [12] Jongchan Yoo ,Heeyoung Shin,Sangwoo Ji. An Eco-Friendly Neutralization Process by Carbon Mineralization for Ca-Rich Alkaline Wastewater Generated from Concrete Sludge [J]. Metals, 2017, 7 (9).