

Clean Utilization of Organic Solid Waste Based on Pyrolysis Technology

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Abstract: Pyrolysis technology can convert organic solid waste into gas, liquid and solid three-state products, providing a variety of high-value utilization methods. High oxygen content and component complexity limit the high-value utilization of organic solid waste pyrolysis oil, and conventional catalysts will be deactivated due to carbon deposition during the catalytic upgrading of pyrolysis oil. The good fluidity and heat and mass transfer properties of the alkali metal molten salt can increase the effective contact area between the alkali metal cation and the reactant, and improve the reaction rate. At the same time, the alkali metal cation has a catalytic effect and can alleviate carbon deposition. The purpose of this paper is to analyze the potential of organic solid waste energy and clean utilization based on pyrolysis technology. In the experiment, salt catalytic heat treatment technology is used to convert organic solid waste pyrolysis oil model compound molten salt heat. The experimental results show that the introduction of molten salt reduces gas production and realizes clean energy.

1. Introduction

With the growth of my country's economy and the acceleration of urbanization, the output of organic solid waste is also increasing sharply. As an efficient way to treat organic solid waste, pyrolysis is receiving more and more attention and research [1]. However, the sources of organic solid waste are complex, and polluting gases will be generated during the pyrolysis process, which affects the clean utilization of subsequent products.

In the context of the dual era of "dual carbon" goals and green improvement, the governance of solid waste, especially industrial organic solid waste, concerns the sustainable improvement of society and people's health and safety. Murthy K studied the need to find alternative fuel sources due to the increasing consumption of traditional fuels such as gasoline, diesel and natural gas. Renewable energy can be considered as an alternative energy source, but the overall efficiency is very low due to the high cost and difficulty of extracting energy. In recent years, more and more attention has been focused on the production of energy from waste. Pyrolysis of waste plastics is the latest technology as an alternative source of energy for production. In this paper, various parameters affecting the pyrolysis process are deeply studied, and the liquid oil obtained in the process is analyzed. The effect of operating temperature, reaction time, biomass addition and catalyst on fuel yield has been extensively reviewed and discussed. Most plastic-produced oils have reasonable calorific values compared to conventional fuels. The blending of biomass materials such as paper and wood shows higher yield and higher calorific value [2]. Agar D A studied sludge from municipal wastewater treatment plants and organic fines from mechanical sorting of municipal solid waste, two common, widely distributed waste streams that are becoming increasingly difficult to utilize. Changing perceptions of the risks of food production limit the attractiveness of sludge on agricultural lands, while access to landfills is rapidly decreasing. Pyrolysis produces three output products: solid carbon, liquid oil, and gas. The potential of pyrolysis to convert wastewater sludge and MSW organic fines into combustion gases and carbon-rich chars has been investigated [3]. Organic solid wastes are complex and diverse in composition. Traditional biochemical and other disposal methods generally have problems such as high cost, long cycle or easy to cause secondary pollution.

This paper studies the current situation of organic solid waste, and analyzes the thermal treatment technology of organic solid waste and the utilization of clean energy and clean energy. In the experiment, the thermal conversion of molten salt of organic solid waste pyrolysis oil model compound was analyzed and studied by using molten salt catalytic heat treatment technology.

2. Research on Clean Utilization of Organic Solid Waste Energy Based on Pyrolysis Technology

2.1. Status of Organic Solid Waste

Solid waste (referred to as solid waste) is an inevitable by-product accompanying economic improvement and daily production and life. The total amount of solid waste in my country is huge and various, and can be divided into organic solid waste and inorganic solid waste according to the characteristics of components [4]. China's annual solid waste generation is about 12 billion tons, of which organic solid waste is about 6 billion tons [5]. Reduction, harmlessness and resource utilization are the three major policies of solid waste treatment and disposal in my country at present. Organic solid waste is a misplaced resource. Recycling it can, on the one hand, reduce the pressure of urban solid waste disposal and ease the situation of garbage siege; on the other hand, it can realize the reuse of resources and promote sustainable improvement. In addition, some organic wastes contain toxic and harmful components, which can easily cause environmental pollution if improperly disposed of [6-7]. Organic solid waste can be divided into three categories: agricultural sources, living sources and other sources according to their sources. Agricultural and forestry waste is a typical organic solid waste of agricultural origin, and its output is about 1 billion tons per year. Agricultural and forestry wastes (such as straw, rice husks, etc.) are often used for resource utilization by composting, direct return to fields, feed, fermentation, etc. Although compost disposal can better realize the resource utilization of organic solid

waste, compost products can also be used to improve soil and promote crop growth. However, composting takes a long time as a whole, requires a certain area, and causes odor pollution. Moreover, the quality of compost products is easily affected by weather, ambient temperature, etc. If it is not completely decomposed, it is easy to cause burning roots of crops. Kitchen waste is a type of typical organic solid waste based on domestic sources [8-9].

2.2. Thermal Treatment Technology Of organic Solid Waste

Organic solid waste heat treatment technology mainly includes incineration technology and pyrolysis technology. Incineration is an organic solid waste heat treatment technology that burns organic solid waste directly as fuel in the boiler or is mixed with coal/biomass and then sent to the boiler for combustion, so that the combustible components in the organic solid waste undergo rapid oxidation reaction and release energy [10-11]. Although incineration technology can quickly reduce and recycle domestic waste, the inorganic components in organic solid waste are converted into incineration bottom slag and fly ash after incineration, forming environmentally hazardous waste. Disposal of incineration bottom slag and fly ash is a key problem restricting the improvement of incineration technology [11-12]. Pyrolysis is a complex and continuous chemical reaction process, which includes chemical changes such as the breaking of chemical bonds and the secondary reaction of products. By changing the process parameters of pyrolysis, the proportion of pyrolysis tri-state products can be regulated to a certain extent. Pyrolysis products have flexible high-value utilization methods, pyrolysis coke is mainly used as fuel and activated carbon, pyrolysis oil is mainly used as chemical raw material and liquid fuel, pyrolysis gas can be used for ammonia production process and as gas fuel, while high heat Value gas can also be used for methanol and hydrocarbon production. However, the deep utilization of pyrolysis oil is limited by its own characteristics [13-14].

2.3. Clean Energy and Clean Energy Utilization

According to the definition of the International Energy Agency, clean energy refers to energy that is environmentally friendly and does not produce carbon emissions in its production and use. Low emissions and low pollution are the basic characteristics of clean energy [15-16].

On the one hand, the utilization of clean energy includes the part of renewable energy such as solar energy; The utilization of clean energy should include three basic characteristics: (1) The utilization of clean energy refers to the entire system that runs through the beginning and end [17-18]. The real definition of clean energy utilization does not refer to energy sources or terminals, and clean energy utilization essentially includes clean energy technology systems rather than just a simple classification. (2) Emphasis on economy. For the utilization of clean energy, the essence of its realization is the possibility of application, so economic rationality is a basic condition. A series of clean energy technologies represented by biogas digesters have entered the stage of marketization, mainly because the cost of such technologies can be controlled. On the contrary, due to the high application cost, it is difficult to encourage the promotion of hydrogen energy in the market [19-20]. (3) Clean energy is different from other energy sources in that it is clean. Cleanliness requires energy to produce as little pollution as possible in all links, and its production and processing processes also need to be controlled within the range of emission standards, which can promote environmental sustainability.

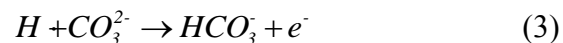
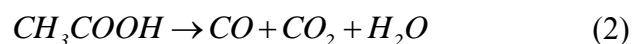
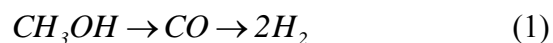
3. Investigation and Research on Clean Utilization of Organic Solid Waste Energy Based on Pyrolysis Technology

3.1. Molten Salt Catalytic Heat Treatment Technology

As a catalyst and heat carrier, molten salt has the characteristics of low viscosity, good dispersibility and fluidity, high specific heat capacity and thermal conductivity, and strong thermal stability, which can alleviate the problem of carbon deposition in the process of pyrolysis oil upgrading. We propose a process route for thermal conversion and upgrading of pyrolysis oil by using molten salt. This route mainly uses the catalytic action of molten salt to achieve the upgrading of pyrolysis oil, and takes advantage of the high fluidity and high dispersibility of molten salt to reduce the accumulation of The generation of carbon, avoiding the contact between molten salt and ash, and preventing the integration of ash to bring uncertainty to the reaction path of pyrolysis oil. Existing research on the thermal conversion of pyrolysis oil molten salt mainly focuses on the gas and liquid yields after molten salt upgrading, and evaluates the catalytic effect of molten salt on pyrolysis oil. However, there are few reports on the reaction paths of typical components in pyrolysis oil and the interaction mechanism between molten salt and pyrolysis oil in molten salt environment. Therefore, this paper mainly explores the thermal conversion and upgrading mechanism of molten salt of organic solid waste pyrolysis oil.

3.2. Experimental Samples and Methods

In the experiment, the ternary carbonate system was selected as the reaction bed material for the pyrolysis oil molten salt upgrading. Ternary molten salt system is a molten salt bed material widely used in coal, biomass and organic solid waste heat conversion, with high specific heat capacity, low melting point, low viscosity and other characteristics. The Li_2CO_3 , Na_2CO_3 , K_2CO_3 analytically pure powders were weighed according to the mass ratios of 33.2%, 34.3% and 32.5%, and the three kinds of alkali metal carbonate powders that were weighed were fully stirred, and then the evenly mixed alkali metal carbonate mixture was placed in the corundum In the crucible, the temperature was programmed to 850°C in a muffle furnace and held for 5 hours to obtain a uniform molten eutectic. After the high-temperature sintering of the ternary alkali metal carbonate, it was naturally cooled to room temperature, and the molten salt eutectic was taken out and ground for subsequent experiments. The reaction equation is as follows:



4. Research on Potential Analysis of Clean Utilization of Organic Solid Waste Energy Based on Pyrolysis Technology

With the increase of temperature, the gas yield of pyrolysis oil model compound thermal cracking

increased, the liquid yield decreased, and the carbon deposition increased, indicating that the increase of temperature has a promoting effect on the process of pyrolysis oil model compound thermal cracking to generate gas. However, in the process of heating up, the tendency of the macromolecular components of pyrolysis oil to polymerize to form carbon deposits is also enhanced, which leads to the increase of carbon deposits. drop in liquid product. The distribution of three-state products of conventional cracking and molten salt cracking of pyrolysis oil model compounds is shown in Table 1 and Figure 1:

Table 1. Distribution of three-state products of conventional lysis and molten salt lysis of pyrolysis oil model compounds

Temperature (°C)	Traditional cracking (wt.%)			Melt salt cracking (wt.%)		
	gas	Liquid	Solid body	gas	Liquid	Solid body
700	3.14	79.54	25.49	3.35	85.14	21.69
800	9.47	63.51	41.36	4.61	78.13	32.54
900	19.14	40.47	53.67	7.83	57.61	52.13

The results show that after introducing molten salt as the reaction bed material, it can be found that the yield of gaseous products decreases at each temperature compared with the traditional cracking. At the same time, at the same temperature, the carbon deposition phenomenon in the thermal conversion process of the pyrolysis oil model compound was also alleviated to a certain extent, and the carbon deposition production decreased at each temperature. In contrast, the yield of the liquid product was improved to a certain extent, indicating that in the molten salt environment, the pyrolysis oil model compound retained more substances and energy in the liquid product during the thermal conversion process.

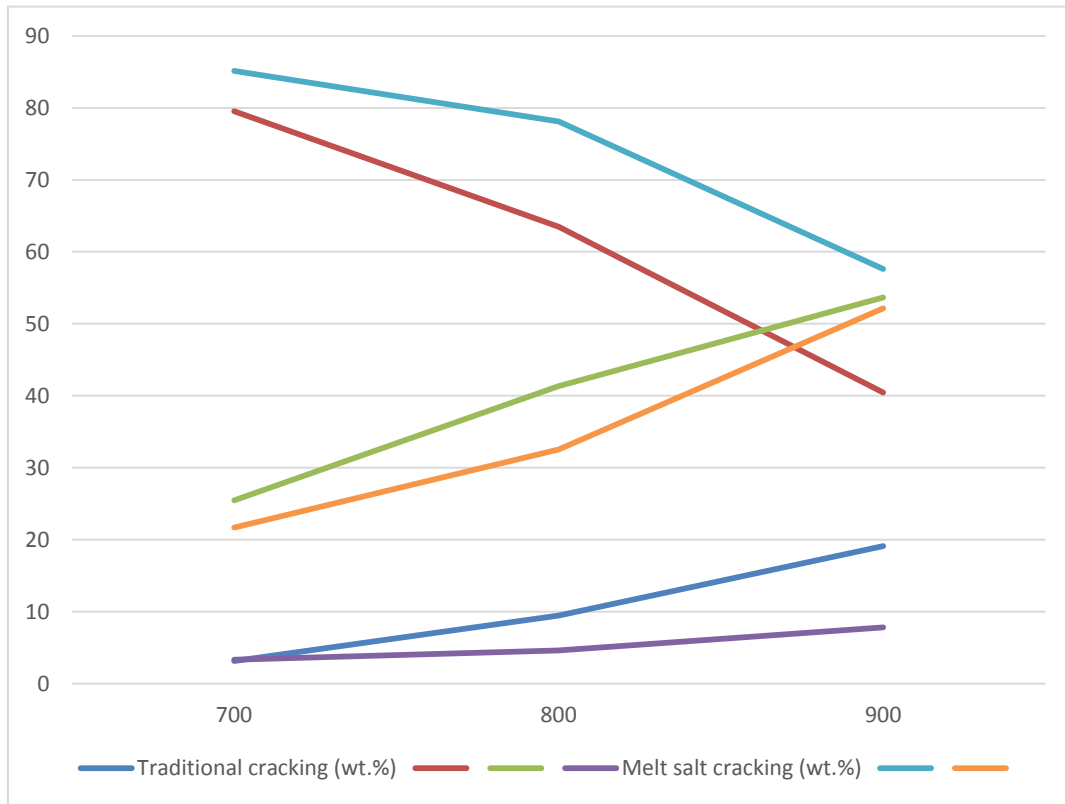


Figure 1. Comparison of the distribution of three-state products of conventional and molten salt lysis of pyrolysis oil model compounds

To study the gaseous product yield and distribution of pyrolysis oil model compounds during conventional thermal cracking and molten salt thermal cracking. The gaseous products are mainly hydrogen and carbon monoxide, with a small amount of carbon dioxide and formaldehyde. The production of major gaseous products such as hydrogen and carbon monoxide increases with increasing temperature. The gaseous product yields and distributions of the pyrolysis oil model compounds in the conventional pyrolysis process are shown in Table 2 and Figure 2:

Table 2. Production and distribution of gaseous products of pyrolysis oil model compounds during conventional pyrolysis

Temperature	Gas generation rate			
Temperature	Hydrogen	Carbon dioxide	Carbon monoxide	Formaldehyde
700	4	3	9	6
800	88	92	149	0
900	173	186	294	310

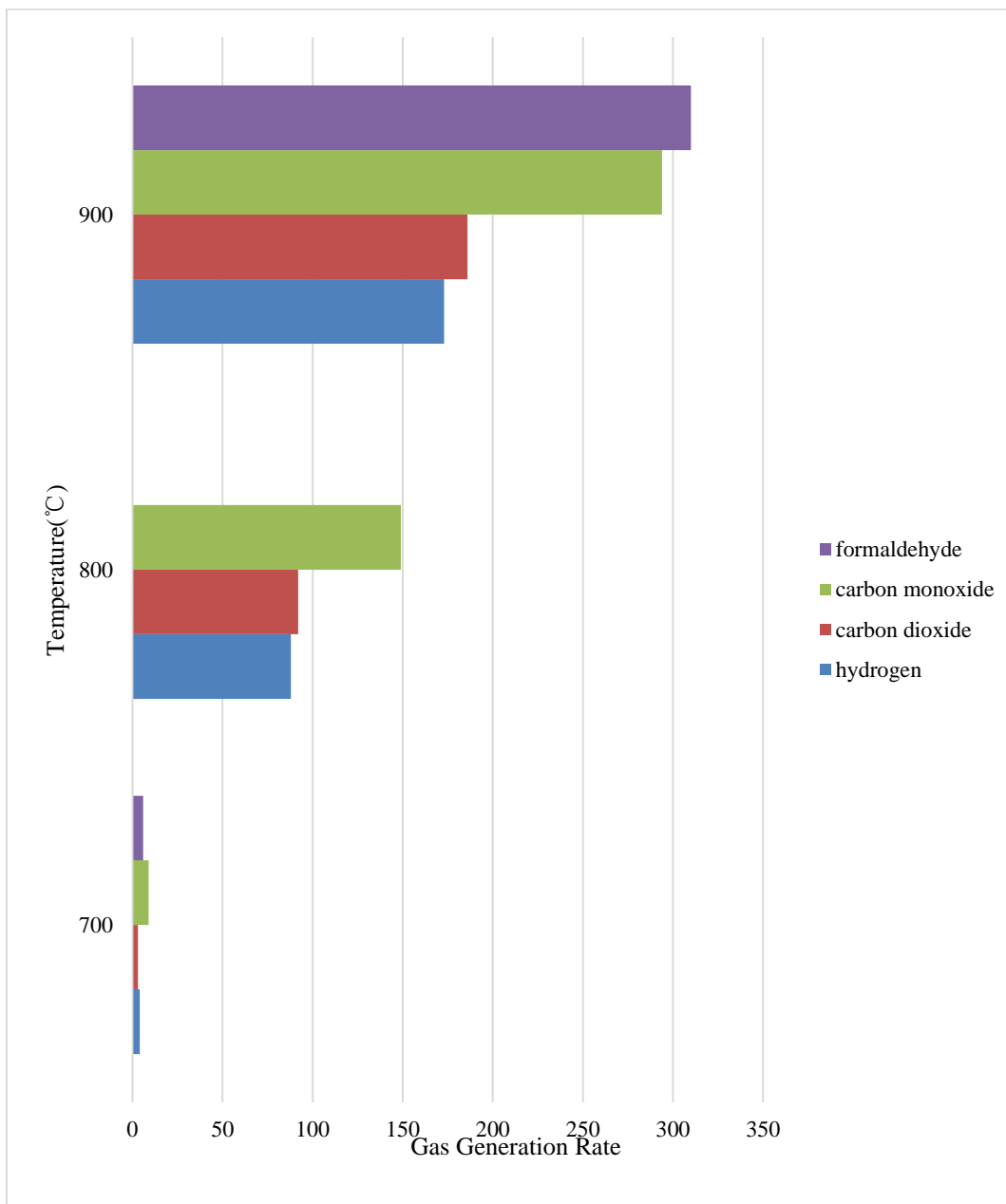


Figure 2. Comparison of gaseous product yield and distribution of pyrolysis oil model compounds during conventional pyrolysis

In the molten salt thermal cracking experiment, the production of the main gas products decreased significantly after 800°C. Compared with the same temperature, the hydrogen production in the molten salt environment decreased by 65.07% (800°C) and 68.98% (900°C), respectively, compared with the non-salt environment.), the carbon monoxide production decreased by 78.69% (800°C) and 75.13% (900°C), respectively. The gaseous product yields and distributions of the pyrolysis oil model compounds during the molten salt thermal cracking process are shown in Table 3 and Figure 3:

Table 3. Gaseous product production and distribution of oil model compounds during thermal lysis of molten salts

Temperature	Gas generation rate			
Temperature	Hydrogen	Carbon dioxide	Carbon monoxide	Formaldehyde
700	13	15	17	18
800	53	57	59	63
900	68	72	79	83

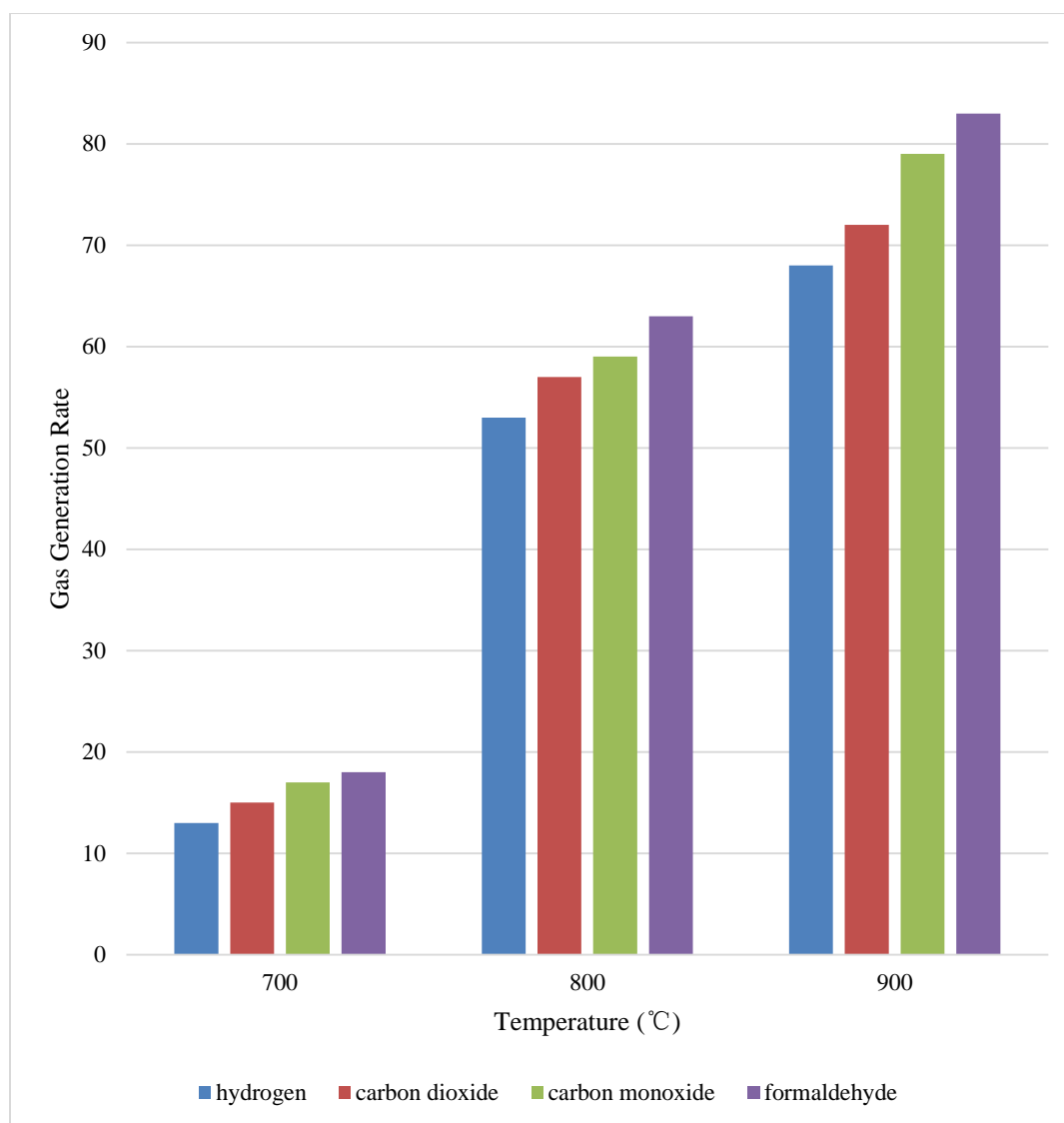


Figure 3. Comparison of gaseous product yield and distribution of oil model compounds during thermal lysis of molten salt

The components of the pyrolysis oil model compounds are toluene, phenol, methanol, furfural,

naphthalene and acetic acid. During the thermal conversion of these substances, there is a process of thermal cracking to produce gas. Among them, the decomposition process of methanol and acetic acid is more likely to occur. In the process of decomposing methanol and acetic acid, the amount of hydrogen produced is significantly higher than that of carbon monoxide and carbon dioxide, which is consistent with the higher yield of hydrogen in the gas composition distribution than carbon monoxide and carbon dioxide in the experimental results. In addition, other macromolecular compounds, such as toluene, phenol, furfural, and naphthalene, also undergo thermal cracking or polymerization at high temperatures to generate a certain amount of hydrogen, carbon monoxide, carbon dioxide and formaldehyde. The high-temperature decomposition process of organic macromolecules is affected by the reaction system. The promotion of hydrogen radicals and the introduction of molten salts may cause H radicals to be consumed. The introduction of molten salt slowed down the continuation of the above reaction, resulting in a decrease in gas production.

5. Conclusion

Organic solid waste pyrolysis technology is a clean and efficient technology to realize the resource utilization of organic solid waste. The organic solid waste is converted into pyrolysis gas, pyrolysis oil and pyrolysis carbon after pyrolysis treatment, which can be further utilized. However, organic solid waste pyrolysis oil has high oxygen content and complex components, which limits its high-value utilization. In order to realize the high-value utilization of organic solid waste pyrolysis oil, it is necessary to upgrade the pyrolysis oil. Molten salt has large specific heat capacity and thermal conductivity, and is a good heat transfer medium, which can alleviate the carbon deposition problem in the catalytic upgrading of pyrolysis oil. In addition, alkali metal ions in alkali metal carbonates have a catalytic effect on the conversion of carbonaceous compounds. Under my country's energy distribution pattern of more coal, lack of oil, and lack of gas, the clean utilization of organic solid waste energy has very important practical significance, and has economic, environmental protection, green and other benefits.

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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.

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