Reorganization Reaction Characteristics between Different Volatile Content and Waste Pyrolysis

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Received 15 June 2022; Revised 9 July 2022; Accepted 12 July 2022; Published 21 September 2022

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In order to obtain the ideal high-value product and recognize the contribution of various waste components to the final product, each typical single component of domestic waste was pyrolyzed separately, the volatile was reformed with half coke at 600°C, and the yield and components of the reforming gas and liquid were analyzed. The investigation was followed by the results: after reforming, the yield of the gas is the highest, reaching 66.40 wt.% of plastic air-dry weight, 119.74% higher than before reforming, the highest yield, 37.22 wt.% of kitchen waste air-dry weight, only 2.21% lower than before reforming. At the same time, after plastic pyrolysis volatile reforming, H₂ production is the highest, 13.14 mol/kg of air-dry-based plastic, and the largest molar fraction in the reforming gas, 37.33 mol%. Compared with the results of single-component pyrolysis-reforming and multi-component waste copyrolysis-reforming results, the multicomponent copyrolysis-reforming process promotes hydrolysis de-oxidation, electrolyte-water vapor reforming and cracking reaction, chain hydrocarbon looping and aromatic dehydrogenation reaction, hydrogenation gasification reaction and methylation reaction, copyrolysis-reforming H₂, CO₂ production, and less oxygen content in the liquid.

1. Introduction

The diversity of waste pyrolysis products and the difficulty of direct use of oil and carbon, and the unfixed market of products are important reasons that hinder the separate commercialization of the waste pyrolysis process. If simple and effective technologies can be used to improve the quality of oil and gas and use the half coke, the pyrolysis process itself can become an independent waste treatment technology, which will greatly improve the environmental protection and economy of waste disposal. However, the use of hydrolysis and semi-coke is not clear at present. Although there are many reports on hydrolysis, especially the utilization of semi-coke, the overall economical and feasible high-value transformation technology of pyrolysis products is still very lacking. In view of such demand and the current situation, more and more people pay attention to the quality improvement method of pyrolysis products.

The author before the References [1, 2] of the pyrolytic half coke reforming volatile method, already after reforming products, the city waste volatile by homologous waste pyrolytic half coke reforming conditions are selected, but different sources of volatile and half coke reforming products in the process of specific reaction mode and mechanism are not clear [3, 4].

Household waste, as a mixture, its various typical single components due to their own physical and chemical characteristics; the volatiles produced vary widely; it reacts differently between reforming section and half focus at high temperature; and the volatilization produced by different components and the semifocal reaction process will interact, the restructuring process is very complicated.

In this article, based on previous studies, select the appropriate reforming temperature, semi-coke/volatile ratio, and volume airspeed, to study the volatilization produced by the pyrolysis of the typical components of different municipal solid waste, after the reforming reactor, changes
in the reforming product distribution and components, in order to understand the product characteristics of different waste pyrolysis and study the specific reforming effect of waste pyrolysis on different sources as a regulation means to control the final product [5].

In addition, from the previous research, the pyrolysis in the reforming to produce a large amount of gas, the amount of gas can be reduced, and the thick cyclic aromatic hydrocarbons can be removed. In order to understand the difficulty of the lysis and removal of different components in the hydrothermal solution, the thermal electrolyte section was divided into oil and water phases to observe the characteristics of the reaction products [6]. Typical single components of urban garbage include components, including plastic, cotton, kitchen waste, paper, and sorting residue, to conduct the experiment [7].

2. Materials and Methods

Elemental analysis, industrial analysis, and calorific value results of each typical single component of MSW are shown in Table 1.

According to the element analysis, industrial analysis, and calorific value in Table 1, cotton cloth, kitchen waste, and paper are quite similar and quite different from plastic.

The experiment investigated the influence of the volatiles produced by each typical single component of household waste on the volatile process of semi-focus reforming. The experiment was completed on the experimental device system shown in Figure 1. In each group of experiments, plastic, cotton cloth, kitchen waste, paper, sorting residue, and MSW samples were added to the pyrolysis reactor for each component of 100 g, the final temperature of the pyrolysis furnace is still set at 500°C and the nitrogen flow rate is 20 ml/min in the pyrrole reactor. In the pyrolysis/reforming reaction, the guaranteed C/V mass ratio is 1.5, the bulk air velocity is 700 h⁻¹, and the reforming reactor temperature is 600°C. Each garbage fraction was averaged two times.

3. Results and Discussion

3.1. Yield. As shown in Figure 2, the gas and oil output (based on the air dry base quality of the single component) of the typical organic components (plastic, cotton, kitchen waste, paper, and sorting residue) is given, and the gas and oil output of the actual waste is compared.

The calculated value (calculated result) in Figure 2 is weighted by multiplying the yield of each single component by its mass fraction in the actual garbage. The calculation formula is as follows.

In the formula, \( Y_i \) is the yield rate of each single component and \( A_i \) is the proportion of the corresponding single component in the whole garbage fraction, as shown in Table 1. The calculated values mentioned later in this article are also calculated by this method. In Figure 2, the difference between MSW (actual garbage) and the calculated result indicates the result of each component interaction effect.

Judging from Figure 2, after pyrolysis, sorting the residual volatile production (the sum of gas yield and liquid yield) is 21.57% and cotton is 75.68%, volatile production mainly depends on the material composition and material particle size; all kinds of the single components in this experiment are kept uniform size (10 mm), so the volatile acquisition rate is mainly determined by the component properties.
Samples used in this paper—plastic, cotton, kitchen waste, paper, and sorting residual are taken from the actual household garbage, with impurities such as dirt, sorting residual is some small cannot be selected organic matter (including plastic, cotton, kitchen waste, and paper) and muck, ash, fine sand glass, and other inorganic mixture. The inorganic material of cotton cloth selected in garbage has low impurity content and high organic composition, so the yield of volatile content in the pyrolysis process is high, and the sorted residual component contains more impurities such as sand and soil, so the volatile content produced by pyrolysis is less.

Figure 2 also shows the distribution of whole component waste pyrolysis products and the weighted calculation of prediction results are consistent and shows that the single-component pyrolysis conforms the general organic solid waste after pyrolysis distribution, through the single component of volatile and half coke reaction behavior analysis to reveal the whole component of waste volatile and half coke reforming reaction behavior.

According to the single component, half coke yield and quality fraction in the actual garbage can calculate the half coke source, as shown in Figure 3, sorting residual pyrolysis of half coke for more than half (53.57 wt.%), biomass raw materials (paper, kitchen waste, and cotton) pyrolysis half coke accounted for 32.19% of the total half coke, plastic pyrolysis half coke accounted for half coke 14.24 wt.%.

After reforming, the gas yield of each component increases. On the one hand, the increase of the gas yield benefits from the thermal electrolyte component in the volatile process into the gas and the semi-coke reaction, and on the other hand, the semi-coke of the reforming section will also produce a part of the gas, as seen in the analysis in Section 3. The gaseous product yield is the highest, reaching 66.40 wt.% of its own mass, which is 119.74% higher than before reforming. This result shows that the condensing components in plastic pyrolysis volatiles are easy to crack in semi-coke catalytic reforming; but for kitchen waste, the volatile liquid product yield is the highest, reaching 37.22 wt.%, only 2.21% lower than before reforming.

The condensing component is difficult to be cracked because plastic volatiles mainly contain long-chain hydrocarbons, as shown in Figure 4, while biomass (kitchen waste mainly living substances) mainly aromatic compounds,
long-chain hydrocarbons are easier to break as small molecular than aromatic compounds. Therefore, in order to obtain more gas products, the proportion of plastic in the mixed garbage can be increased.

Compared with the distribution of the actual waste products, the gas yield is slightly higher, and the liquid yield is reduced, which may be due to the condensation reaction between some condensable components in the actual waste volatiles to generate carbon and gas.

3.2. Reforming Gas Components. Figure 5 shows the main gas production obtained after the reforming of each typical single component and the calculated value and the actual waste pyrolysis.

After separate pyrolysis: CO₂ production in volatile gas of kitchen waste decreased slightly from 4.68 mol/kg (empty dry base kitchen) to 3.44 mol/kg (empty dry base kitchen); the output of each gas component in sorted residual volatile gas does not change significantly; after the volatilization obtained by separate pyrolysis, the production of all gas components increases.

According to the research results including Wu [8] and Wen Wen[9], biomass components include paper, kitchen waste, and cotton cloth. Because they are mainly composed of cellulose, hemicellulose, and lignin, they are called similar components in the study. In the whole component waste pyrolysis, the thermal effect of the first reaction has an impact on the later reaction, which may make the later reaction pyrolysis at a lower temperature, or even merge the later reaction into the previous reaction [10, 11].

The study [12] by Stöckker showed that under the heating conditions of 10°C/min program, cotton cloth, kitchen waste, and paper occurred in the temperature range of 230–400°C, the plastic weight stage occurred at 350–500°C, and the plastic may be below 350°C, in the whole component waste pyrolysis. Therefore, the first entering the reforming section is the cotton, kitchen waste, and paper pyrolysis volatile mixture, and then the cotton, kitchen waste, paper, and plastic volatile mixture [13]. Finally, when the basic pyrolysis of cotton, kitchen waste, and paper is completed, part of the plastic volatile may enter the reforming section alone. Therefore, in the volatile reforming section, each single-component pyrolysis volatile will affect each other during the half-focal reaction [14].

The production of H₂, CH₄, C₂H₄, and C₂H₆ increased most significantly after reforming, and these four gases showed a large increase [15, 16], and the specific changes are shown in Table 2. This is because plastic is made up of many monomers by covalent bond polymer, mainly composed of carbon, hydrogen, and other elements, so the pyrolysis volatile components are relatively simple, in the process of reforming, there are some in pyrolysis process decomposition of long-chain hydrocarbons, fracture, C₂H₄, and C₂H₆ at the same time aromatic hydrocarbons dehydrogenation and demethylation reaction.

In this experiment, cotton cloth, kitchen waste, and paper belong to biomass organic solid waste, due to the high oxygen content of biomass raw materials (about 40% quality fraction); therefore, its pyrolysis volatile content contains a large amount of oxygenic organic matter. The production rate of aerobic gases (CO and CO₂) changes significantly, and the output of CO₂ and CO increased from 3.50 mol/kg (air dry paper) and 3.54 mol/kg (air dry paper) to 7.46 mol/kg (air dry paper) and 6.99 mol/kg (air dry paper), respectively. The yield of CO₂ and CO increased from 4.64 mol/kg (air dry-based cotton) and 2.23 mol/kg (air dry cotton) to 4.08 mol/kg (air dry cotton) and 6.42 mol/kg (air dry cotton), respectively. After the reorganization of the kitchen waste volatilization content, the laws of change vary somewhat, CO₂ production decreased from 4.68 mol/kg (empty dry base kitchen) to 3.44 mol/kg (empty dry base kitchen surplus), and CO production increased from 1.69 mol/kg (empty dry base kitchen) to 3.63 mol/kg (empty dry base kitchen). As mentioned above, CO and CO₂ are mainly produced by the decomposition of carboxyl groups and groups in some acids, aldehyde, alcohol, and other components, while CO and CO₂ of biomass components paper, cotton, and kitchen waste change significantly before and after reforming indicating that the content of aerobic organic matter in acids, aldehyde, and alcohols is higher than that of plastics. Comparing the plastic pyrolysis volatile and biomass pyrolysis volatile gas after reforming production can be seen that the yield of plastic volatile gas increased.
H₂ Yield

CO₂ Yield

CO Yield

CH₄ Yield

Figure 5: Continued.
more obviously, indicating that in high temperature and half coke reforming conditions, the reactivity of different components is different, the long-chain fatty hydrocarbons and aromatic hydrocarbons reactivity is higher than oxygen-containing substances [17].

In Figure 5, for pyrolysis gas production, the distribution of waste pyrolysis gas products in the whole fraction is CH₄ high, H₂ low, and low compared with the weighted calculated values of each garbage component. From Figure 2, cothermolysis has little effect on the distribution of the product, so the difference between various gas production alone and copyrolysis is mainly caused by the coexistence of the pyrolysis, such as the low thermal conductivity of plastic, the heating rate of copyrolysis is faster than plastic alone, resulting in high CH₄, C₂H₄, and C₂H₆. The increase in CH₄ production may be due to the reverse reaction of methane water vapor reforming reaction, hydrogenation gasification reaction, and methylation reaction; the increase of C₂H₄ and C₂H₆ production may be inhibited by water vapor reforming reaction, steam reforming cracking reaction, and dry reforming reaction; and the above reaction of CH₄, C₂H₄, and C₂H₆ production is suppressed, corresponding to the production of H₂, CO₂, and CO.

For reforming gas production, the actual H₂, CO₂, and C₂H₄ of the whole component waste pyrolysis-reforming gas product distribution is high, while CO, CH₄, and C₂H₆ are low compared with the weighted calculated value of each waste component. Compared with the discussion above, the actual waste pyrolysis gas product distribution and the weighted calculated value of the garbage components, H₂ production from low to high, combined with the actual liquid yield in Figure 2, shows that copyrolysis volatile reforming, chain cyclization, and aromatic dehydrogenation reaction is more intense. The CO₂ production from actual high to low indicates that cothermolysis is more sufficient; the actual CH₄ and C₂H₆ production are converted from high to low for reforming and hydrocarbon cracking, and the CH₄ production is converted from high to low indicating that the reforming reaction of methane, hydrogen gasification reaction, and methane are strengthened.

Figure 6 shows the molar concentration of the main gas in the gas obtained after reforming each typical single component, calculated value, and pyrolysis volatilization of the actual garbage, respectively.

After reforming, the volatile content produced by each single component decreases only for the mole fraction of H₂,
**Figure 6: Continued.**

(a) \( \text{H}_2 \) mole fraction

(b) \( \text{CO}_2 \) mole fraction

(c) \( \text{CO} \) mole fraction

(d) \( \text{CH}_4 \) mole fraction

- Pyrolysis
- Reforming
while the remaining single components increase. Especially for plastics, the $H_2$ ratio after reforming is 37.33 mol%, increasing by 247.84%, which is 1.60 times the volume concentration of $H_2$ in the kitchen waste reforming gas. Compared with the $CO_2$ molar fraction in the reforming gas, the plastic decreased by 62.87%, and the remaining garbage components were also reduced, but the $CO_2$ reduction of paper and sorting residues was not obvious, reduced by 4.03% and 4.04%, respectively. For the $CO$ mole fraction in reforming gas, only the mole fraction in specific pyrolysis gas is increased after reforming, and the $CO$ mole fraction in kitchen waste reforming gas reaches 35.88 mol%, increasing by 89.37%; the lowest $CO$ mole fraction in sorted residual reforming gas is only 8.70 mol%, 33.49% lower than the molar fraction in pyrolysis gas. The highest molar fraction of $C_2H_4$, $C_2H_6$, and $C_2H_6$ in the reforming gas appeared after the reforming of plastic volatilization, and the most obvious increase in molar fraction compared with pyrolysis gas was mainly due to the high $H/C$ ratio in plastic. After reforming, the molar fraction of $CH_4$ in cotton, kitchen waste, paper, and sorting residue also increased. Combined with Figure 5, the increase rate of $CH_4$ in the single component reforming gas mentioned above is greater than the average growth value of its reforming gas. After reforming, both $C_2H_4$ and $C_2H_6$ molar scores decreased. Combined with Figure 5, the production of $C_2H_4$ and $C_2H_6$ in cotton also increases, so the molar fraction of $C_2H_4$ and $C_2H_6$ decreases because the increase rate of $C_2H_4$ and $C_2H_6$ in cotton reforming gas is less than the average value; the residual $C_2H_4$ and $C_2H_6$ decrease because the yield of $C_2H_4$ and $C_2H_6$ in the sorting residue remains basically unchanged, while the total output of reforming gas is increasing [18].

According to the above results, the most effect on plastic volatile reforming, the volume fraction of $H_2$, $CH_4$, $C_2H_4$, and $C_2H_6$; $CO$ and $CO_2$ mole fractions significantly reduced. Therefore, the reforming gas with higher $H_2$, $CH_4$, $C_2H_4$, and $C_2H_6$ mole fractions and lower CO and $CO_2$ mole fractions can be obtained by increasing the plastic mass ratio in the thermolysis section garbage. After reforming, kitchen waste volatilization is the only component that can increase the $CO$ mole fraction, so the CO volume fraction in the reforming gas can be regulated by adjusting the mass ratio of kitchen waste in the pyrolysis section.

After reforming, the actual waste pyrolysis fraction is reduced from 4.59 mol% to 1.92 mol%, while $C_2H_6$ is basically unchanged, mainly because during the catalytic lysis of pure hydrocarbons, the same number of carbon atoms is arranged in the following order: alkane > alkane > alkane > aromatics. Because the olefins have double bond electrons, protonic acid with catalytic effect is favored.

### 3.3. Fractions of the Reforming Fluid

After volatile reforming, the distribution of aqueous and oil phases in the liquid products of each single component is shown in Figure 7. Aqueous phase products are mainly composed of water and some water-soluble organic matter, such as the small molecular weight of aerobic organic matter containing acetic acid, methanol, and acetone.

Because cotton cloth, kitchen waste, and paper are composed of cellulose, hemicellulose, and lignin, they will produce a lot of water in the process of pyrolysis, so the pyrolysis volatile of cotton cloth, kitchen waste, and paper contain a lot of water, and the aqueous content in the final reforming liquid is also higher. In the liquid obtained after reforming, the liquid 

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**Figure 6: Molar fraction (mol%) of main gas after pyrolysis of waste Treform = 600°C.** (a) $H_2$ mole fraction. (b) $CO_2$ mole fraction. (c) $CO$ mole fraction. (d) $CH_4$ mole fraction. (e) $C_2H_4$ mole fraction. (f) $C_2H_6$ mole fraction.
reforming of paper, the concentration of the reforming liquid is the highest: 297.39 g/kg (empty dry base kitchen surplus).

The water content of plastic pyrolysis volatiles is relatively low, mainly because plastic is composed of relatively single polymer organic compounds, the water of the thermal electrolyte is a small amount of physical water brought by the plastic sample, so its volatilization after reforming to get the liquid contains no aqueous phase. Although the proportion of the oil phase in plastic pyrolysis and volatile liquid products is high, the liquid yield is low after reforming, and most of the oil phase is decomposed during the reforming process. The yield of the liquid oil phase is the highest at 218.68 g/kg (empty dry-based cotton cloth).

The reforming fluid and oil phase component is still divided into six categories as described in the previous chapter: (1) aerobic heterocyclic rings, mainly including phenol, alcohol, lipids, ketones, and carboxylic acids; (2) light aromatic (1 benzene ring), usually single-ring light hydrocarbons, which do not constitute a problem about condensation and solubility. Main components include benzene, toluene, ethylbenzene, xylene, and styrene; (3) nitrogen ring, mainly including pyridines, amines, nitrile, and amides; (4) light polycyclic aromatic compounds (2–3 benzene rings), usually contain 2–3 benzene rings, even at a very low concentration, will be concentrated at low temperature. Main components are ind, naphthalene, methyl naphthalene, biphene, ene, and anthracene; (5) fat hydrocarbon compounds, mainly including alkanes, alkenes, and cycloalkanes. (6) Heavy polycyclic aromatic hydrocarbon compounds (4–7 benzene ring), attributes greater than 3 benzene ring, these compounds will also condense in low concentration, high temperature conditions. The main ingredients are phenanthrene, pyrene, flexion, and hexabenzene. The GC-MS measurement is performed by qualitative measurement method, so the percentage of a liquid component refers to the proportion of the peak area of the substance in the total ion flow map to the total area of all detected objects.

Figure 8 shows the proportion of the resulting oil phase components in the typical single-component pyrolysis volatilization after reforming.

After reforming, the pyrolysis volatilization of plastic oxygenation in the liquid completely disappeared, only hydrocarbons, mainly aromatic hydrocarbons, among which the single-cyclic aromatic hydrocarbons contain the highest content, reaching 70.48 area%, which increased by 420.53% compared with before reforming. Next by fatty hydrocarbons containing 14.16 area%; besides light polybenzene ring (2–3) 13.36 area%, while heavy polybenzene ring components completely disappeared. The reforming solution does not contain nitrogen compounds, because the plastic itself contains almost no nitrogen elements.

Kitchen waste in this experiment mainly includes all kinds of fruit shells and leaf and other biomass components, the nitrogen content is high, so the electrolyte nitrogen compounds quality fraction is the highest, after reforming nitrogen compounds absolute value also decreased, but the mass fraction still rose slightly, from before reforming 18.30 area% to 19.19 area%, mainly because the reaction activity of nitrogen compounds and other components, so nitrogen compounds removal efficiency is lower than the overall removal level.
FIGURE 8: The portion of each component (area%) in the oil phase after typical single component $T_{\text{reform}} = 600^\circ\text{C}$. (a) Oxygen compound. (b) Nitrogenous compounds. (c) Light aromatic hydrocarbons. (d) Light polycyclic aromatic hydrocarbons. (e) Fatty hydrocarbon. (f) Heavy polycyclic aromatic hydrocarbons.
After reforming paper pyrolysis volatiles, the resulting liquid oil phase contains no fatty hydrocarbon and very little aromatic hydrocarbon, only 1.27 area%, as high as 54.52 area%, and 6.21 area%. Paper is mainly composed of cellulose, but also includes various additives added in the paper-making process. Gao [19] study found that cellulose molecules in the process of pyrolysis first decomposition into cellulose monomer, then cellulose monomer hydroxyl functional group priority removal, the intermediate product of liquid products, so paper reforming volatile will contain a large number of hydroxyl functional group, finally after reforming the liquid, oxygenation content is still relatively high. These findings in this article have potential application prospects in the manufacturing industry [20–27].

Oxygenic compounds [28–30] in biomass thermal electrolyte mainly contain carboxyl, base, and hydroxyl groups, and the reduction of oxygenic compounds is mainly due to the removal reaction of these three groups.

3.3.1. Decarboxylation Reaction. As shown in equation (1), mainly the fracture of -COOH bond, mainly organic acids, including acetic acid, oleic acid, and palmitate, which will produce methane or ethylene; oleic acid and palmitate are usually saturated alkane. But the decarboxylation process produces a large amount of residual carbon, causing the catalyst to rapidly inactivate.

\[ R_1\text{COOH} \rightarrow R_1\text{H} + \text{CO}_2 \]  

(1)

3.3.2. Unbased Reaction. It is mainly the fracture of C=O bond. The substances in the thermal electrolyte mainly include ketones, aldehydes, and furans, and the branched chains are mostly hydrocarbons, mainly including alkanes and aromatic hydrocarbons. Therefore, the above substances mainly produce alkanes and aromatic hydrocarbons after removing the radicals.

3.3.3. Dehydroxy Group Reaction. It is mainly the breakage of -OH bonds, including phenyl and alcohol hydroxyl groups. The hydroxyl functional group mainly includes alcohols and phenols. The generation of aromatic hydrocarbons mainly comes from the dehydroxy reaction of alcohols.

Pyrolysis solutions contain some furan derivatives, and these compounds are thought to be typical of hemicellulose pyrolysis, while hydroxy and hydroxyl groups are thought to arise from thermal lysis of cellulose, whereas phenols and methoxy groups are resulting from thermal lysis of lignin.

Compared with the calculated value and the actual waste pyrolysis liquid, it can be found that the actual waste pyrolysis liquid does not contain aromatic hydrocarbons, the content of oxygen and nitrogen heterocyclic ring decreased, the content of aromatic hydrocarbons increased, the proportion of light polybenzene ring aromatic hydrocarbons reached 397.09% of the calculated value, and the content of single benzene ring also increased by 303.87%. It shows that when mixed together, the volatiles produced by different single components will react with each other during the reforming process, and will affect each other, making more

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**Table 3: The liquid pH after reforming of pyrolysis of waste.**

| Working condition | Classification    | Data            |
|-------------------|-------------------|-----------------|
|                   | Plastics          | 2.73 ± 0.10     |
|                   | Cotton cloth      | 1.46 ± 0.05     |
|                   | Kitchen waste     | 9.11 ± 0.06     |
|                   | Paper products    | 1.84 ± 0.05     |
|                   | Select the remnants | 6.79 ± 0.11   |
|                   | Rubbish           | 4.30 ± 0.11     |
|                   |                   |                 |
| Before restructuring |                 |                 |
|                   |                   |                 |
| After restructuring |                 |                 |

**Table 4: Liquid caloric value (MJ/kg) before and after reforming of typical single-component pyrolysis.**

| Working condition | Classification    | Data            |
|-------------------|-------------------|-----------------|
|                   | Plastics          | 43.16 ± 2.19    |
|                   | Cotton cloth      | 13.15 ± 1.04    |
|                   | Kitchen waste     | 9.32 ± 0.62     |
|                   | Paper products    | 10.25 ± 0.58    |
|                   | Select the remnants | 12.17 ± 0.70   |
|                   | Rubbish           | 19.81 ± 1.21    |
|                   |                   |                 |
| Before restructuring |                 |                 |
|                   |                   |                 |
| After restructuring |                 |                 |

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**Figure 9: Change of semi-coke mass and carbon deposition in the process of pyrolysis.**
After reforming each single component and the actual waste pyrolysis volatilization, the resulting liquid no longer contains heavy PAH compounds, indicating that heavy PAHs will be decomposed during restructuring.

Because the components are complex and contain water, pyrolysate is difficult to use directly. But hydrothermal electrolyte is actually an important industrial chemical raw material, such as the main components of thermal electrolyte benzene, styrene, toluene, ind, and so on.

The pH value of the pyrolysis volatilization of the liquid products obtained before and after reforming are shown in Table 3. For the hydrothermal electrolyte pH value, not only the kitchen waste hydrothermal electrolyte is alkaline, and the remaining single components and the actual waste hydrothermal electrolyte are acidic. This is because kitchen waste has a high content of nitrogen compounds, while nitrogen compounds such as amines and pyridines are all alkaline. The rest of the hydrolysate is acidic mainly contains acidic substances such as methoxy derivatives and phenols. The liquid obtained after reforming increases with the liquid obtained before reforming, with the pH value greater than 8. The liquid pH value of volatile reorganization of kitchen waste is still the highest, and the liquid pH value of paper volatiles is the lowest. After reforming, the content of oxygen compounds in each single component reforming liquid decreases, so the pH value of the reforming liquid will increase.

The pH value of hydrothermal electrolyte is another important parameter to measure its chemical properties. The pH value of hydrothermal electrolyte is small and the acidity is large, which is not conducive to its storage and transportation, and it is corrosive as a fuel, which needs to be refined to be used.

Under the coupled treatment condition of pyrolysis at 500°C, the calorific value changes of liquid products before and after volatile reforming of the typical single-component pyrolysis at 600°C are shown in Table 4.

The calorific value of volatile liquid product after reforming of each single-component pyrolysis is lower than before reforming, with the paper dropping by 43.02%; the absolute value of plastic falling is the most, decreasing by 15.58 M J/kg compared with before no reforming. The reason may be that after reforming, most of the oil component in the hydrothermal solution can be catalyzed cracked, the water component is difficult to be consumed or the substances dissolved in water cannot be catalyzed decomposed, the water will increase, and the proportion of the oil phase decreases, so the calorific value decreases.

3.4. Changes of the Half Focus after Reforming. After the volatilization of each typical single component of the reforming waste, the mass change and carbon deposition of the pyrolysis of the domestic waste are shown in Figure 9.

The differences in the composition, structure, and properties of different sources of thermal electrolyte make the catalytic transformation process different. The more the aromatic thermal electrolyte, the more serious the treatment process, and the removal of the carboxyl group will also produce a large amount of carbon deposition. Obviously, in the reforming process of paper pyrolysis, the carbon accumulation is 20.03 wt.%, and the sorting residual carbon accumulation is only 2.64 wt.%. This is mainly because the paper is mainly composed of cellulose and hemicellulose and the aromatic component in the reforming section is high (Figure 8). According to Table 2, the pH value of paper electrolyte before reforming is only 1.84, so it contains a lot of carboxylic acids and is easy to produce carbon accumulation, and the residual organic component is less and the total volatile amount is less. In addition to paper, other typical single components and actual waste pyrolysis volatilization and semi-coke, the net quality of semi-coke is reduced, indicating that carbon gasification and volatilization are in the reforming process. However, the amount of volatile carbon deposition for paper is greater than its volatile amount.

4. Conclusion

This article studies the product characteristics of volatile and semifocal reforming of separate pyrolysis of each typical single component of domestic waste and compares them with the products of overall pyrolysis and reforming. To explore the effects of the different components in the hydromolate, the products of the aqueous and oil phase reforming of the hydromolate were studied separately. The following conclusions are obtained from the experiment.

(1) Product distribution: after reforming of plastic pyrolysis, the highest gas yield is 66.40 wt.%, 119.74% higher than before reforming; the liquid product yield of kitchen waste is the highest, only 2.21% lower than before reforming. At the same time, after the reforming of plastic pyrolysis, the highest yield of H2 is 13.14 mol/kg (air dry-based plastic), and the largest molar fraction in the reforming gas is 37.33 mol%. (2) The liquid obtained after reforming of plastic pyrolysis no longer contains aqueous phase (including water and organic components soluble in water), and aerobic compounds completely disappear, only hydrocarbons, mainly aromatic hydrocarbons, among which the monocyclic aromatic hydrocarbons have the highest content, reaching the 70.48 area% of the oil phase component after reforming. The liquid obtained after paper pyrolysis volatile reforming has the largest aqueous proportion, reaching 83.30 wt.%, and the content of oxygenated in the oil phase component is still 54.52 area%. The liquid obtained after the yield of the highest oil component reaches 218.68 g/kg (empty dry base cotton cloth). The liquid obtained after the reorganization of the aqueous component yield is the highest, reaching 297.39 g/kg (empty dry base kitchen surplus). To reduce the content of the aqueous phase in the pyrolysis oil, it is suitable to separate the biomass components before the pyrolysis. (3) After reforming, the liquid is obtained with the liquid obtained before reforming, pH value increases, pH value is greater than 8. The calorific value of volatile liquid product after reforming of each single component is lower than before reforming, with the paper
dropping 43.02% and the absolute value of plastic 15.58 MJ/ kg compared with before no reforming. The pyrolysis of paper is 20.03 wt%. According to the above results, after semi-coke reforming, plastic pyrolysis volatilization can get more gas, and the H₂ production is the largest, the obtained liquid product quality is also the best. For biomass components, semi-coke reforming can significantly reduce the acidity of the liquid products and reduce their corrosion. (4) By each component, separate pyrolysis volatile reforming results and garbage overall pyrolysis-reforming results comparison: each component coexistence of the reforming process promotes the hydrothermal molecular deoxygenation reaction and other cracking reaction, make the liquid product oxygen compound content reduced, and H₂ and CO₂ production increase.

Data Availability

The data used to support this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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