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Thermal and Catalytic Pyrolysis of Wood Plastic Composite over HZSM-5

Young-Min Kim[1,*], Tae Uk Han[1], Hyung Won Lee[2],
Young-Kwon Park[2,*], Se Young Park[2], Atsushi Watanabe[3]

1 Department of Environmental Sciences and Biotechnology, Hallym University, Republic of Korea

2 School of Environmental Engineering, University of Seoul, Republic of Korea

3 Frontier Laboratories Ltd., 4-16-20, Saikon, Koriyama, Fukushima, Japan

**Corresponding author: analyst@hallym.ac.kr*

Highlights

- Pyrolysis properties of wood plastic composite (WPC) was performed by thermogravimetric analysis and pyrolyzer-gas chromatography/mass spectrometry.
- Pyrolysis of WPC was consisted the decomposition of wood, plastics, and $CaCO_3$.
- Catalytic pyrolysis of WPC over HZSM-5 produced large amount of aromatics.

1. Introduction

Wood plastic composite (WPC), made by extruding the mixture of wood particles, thermoplastics, and several additives, is known as a new environmentally friendly material which can be used for manufacturing consumable furniture. Production amount of WPCs is being estimated to be increased due to their advantages. WPC is more resistant to rot and need less maintenance than conventional wood materials, however, it is difficult to be decomposed by biological treatment because large amount of synthetic polymer was also contained in WPCs. One of the possible solution is pyrolysis or catalytic pyrolysis of WPC because large amount of bio-oil or chemical feedstock can be obtained by the thermal treatment of WPC [1]. Recently, synergistic formation of aromatic hydrocarbons via the catalytic co-pyrolysis of biomass and plastics was reported by many researchers. Although several researches for the catalytic pyrolysis of WPC were performed, most of them could not use the commercial WPCs containing other additives such as $CaCO_3$, lubricant, coupling agent, antioxidant, UV blocking agent, and pigment.

In this study, thermal and catalytic pyrolysis of a commercial WPC over HZSM-5 were investigated using a thermogravimetic (TG) analysis and tandem μ-reactor (TMR)-gas chromatography (GC)/mass spectrometry (MS)/flame ionization detector (FID) in this study.

2. Methods

WPC, obtained from a local WPC manufacturing company in Korea, was milled and sieved to make its particle size lower than 250 μm. Table 1 shows the material composition of WPC. The WPC contains large amount of wood powder, PE, and PP as main components together with the considerable amount of $CaCO_3$ (8.5%) as a reinforcing filler. HZSM-5 (SiO_2/Al_2O_3: 23) was purchased from Zeolyst and calcined at 550°C in air.

For TG analysis, 1 mg of WPC was heated from ambient temperature to 800°C at 20°C/min under nitrogen atmosphere. In case of TMR-GC/MS/FID experiments, the mixture of WPC (1 mg) and HZSM-5 (1 mg) was free fallen into the center position of the preheated 1st furnace of TMR (600°C) under 100 mL/min of helium gas. The product vapor evolved from TMR and transferred to GC was separated in the separation column by oven heat program and detected by MS or FID. The peaks on the total ion chromatogram were identified by MS library searching and their production amounts were compared with the integrated areas of FID peaks.

Table 1. Composition of WPC used in this study (Unit: wt. %)

Wood	PE	PP	CaCO3	Lubricant	Coupling agent	Antioxidant	UV blocking agent	Pigment
58.0	9.0	18.0	8.5	2.5	2.0	0.1	0.1	2.0

3. Results and discussion

Fig. 1 shows the TG and derivative TG (DTG) curves of WPC. Thermal decomposition of WPC was divided into three temperature regions; First (200~400°C) and second (400~520°C) decomposition regions can be assigned as the decomposition of wood and plastics (PE and PP), respectively [2]. The final decomposition region (650~750°C) indicates that residual $CaCO_3$ is converted into CaO and CO_2 by its decomposition [3].

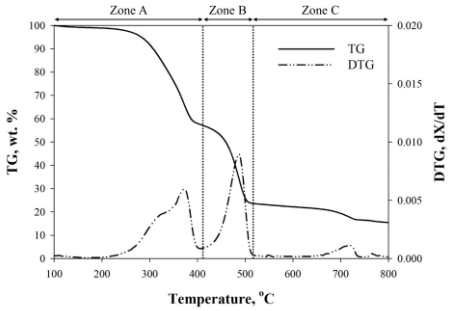

Figure 1. TG and DTG curves of WPC obtained from non-catalytic pyrolysis.

Table 2 indicated absolute FID peak areas of aromatic hydrocarbons obtained from the thermal and catalytic pyrolysis of WPC over HZSM-5. Compared to thermal decomposition, catalytic pyrolysis of WPC over HZSM-5 produced much larger amount of aromatic hydrocarbons due to the high acidity and shape selectivity of HZSM-5 catalyst. This indicates that catalytic pyrolysis of WPC over HZSM-5 can be a desirable method to produce value added chemicals.

Table 1. Absolute FID peak areas for the aromatic hydrocarbons obtained from the thermal and catalytic pyrolysis of WPC over HZSM-5 at 600°C [Unit: FID peak area x 10^{-6}]

Non-catalytic pyrolysis	Catalytic pyrolysis over HZSM-5
9.8	562.6

4. Conclusions

TG and DTG curves of WPC had three weight loss regions consisted with the decomposition of wood, plastics, and $CaCO_3$. TMR-GC/MS/FID experiments indicated that the large amount of aromatic hydrocarbons can be obtained by applying catalytic pyrolysis of WPC using HZSM-5. This can suggest the potential of catalytic pyrolysis as a desirable treatment method to produce value added chemicals from waste WPC.

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Keywords
Wood plastic composite; Catalytic pyrolysis; HZSM-5; Aromatic hydrocarbons.