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Application News

Simultaneous TG/DTA

Measurement of Fixed Carbon, Volatile Matter, and Ash of Biocoke

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User Benefits

- The fixed carbon, volatile matter, and ash of biocoke can be measured by the DTG-60.
- The combustion characteristics of biocoke can also be evaluated by using the DTG-60.
- TG-DTA measurement can simultaneously grasp the endothermic and exothermic behaviors during pyrolysis and combustion, allowing a more comprehensive evaluation.

■ Introduction

Biocoke is a type of solid fuel produced using plant-derived organic resources (biomass) as the raw materials. Biocoke enables high-temperature combustion over an extended time period, and has also attracted attention as a zero-emission fuel which does not generate waste in the production process. It is produced by heating biomass under high-temperature and high-pressure conditions. A stable fuel with high compressive strength can be obtained by this process, allowing easy transportation and storage, as well as long-term preservation. As a fuel for industrial furnaces and boilers, biocoke is used as a substitute for conventional fossil fuels. It is also expected to be used as a sustainable energy source because its CO_2 emissions are lower than those of fossil fuels. The diversity of the raw materials that can be used to produce biocoke, which include woody materials and agricultural residues, is also another feature.

In this article, the volatile matter, fixed carbon, and ash of biocokes produced from waste wood and buckwheat husks were evaluated using a Shimadzu DTG-60 simultaneous TG/DTA.

Fig. 1 Appearance of DTG-60 Instrument

■ Samples

Fig. 2 Biocoke Produced from
(Left) Waste Wood and (Right) Buckwheat Husks

■ Sample Preparation

The samples for measurements were prepared by grinding the respective biocoke samples and collecting the under 250 µm powder after screening with a 250 µm sieve (Fig. 3).

Fig. 3 (Left) Waste Wood and (Right) Buckwheat Husks
after Screening with 250 µm Sieve

■ Evaluation of Combustion Characteristics by TG-DTA Measurement

TG-DTA measurements of the size-adjusted waste wood biocoke and buckwheat husk biocoke were conducted under an air atmosphere. Table 1 shows the analysis conditions.

Table 1 Analysis Conditions of Waste Wood Biocoke and Buckwheat Husk Biocoke

Instrument	: DTG-60
Heating rate	: 10 ˚C/min
Temperature range	: 30 ˚C - 700 ˚C
Sample weight	: 8 mg
Atmosphere	: Air

A detailed understanding of the combustion characteristics of biocokes can be obtained by conducting TG-DTA measurements under an air atmosphere [1]. Fig. 4 shows the TG-DTA curves of the waste wood biocoke and buckwheat husk biocoke. A three-step weight loss can be observed with both biocokes. It is thought that the first-step weight loss is due to evaporation of moisture (Fig. 4 a), the weight loss from around 250 ˚C to around 400 ˚C is attributable to combustion of the volatile matter (Fig. 4 b), and the weight loss after 400 ˚C is caused by surface combustion of fixed carbon (Fig. 4 c) [2]. The extents of the second-step and third-step weight loss are different, depending on the type of biomass. In addition, the combustion starting and end temperatures can be confirmed from the DTA curves, and from the DrTG curves (derivative thermogravimetric curve), it can be understood that the peak positions and heights are different. It is known that the peak height is proportional to reactivity, while the peak temperature is inversely proportional to reactivity [3].

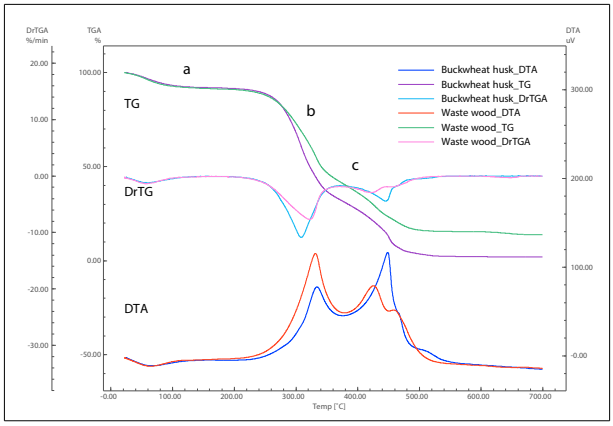

Fig. 4 TG-DTA Curves of Buckwheat Husk Biocoke and Waste Wood Biocoke
(Under Air Atmosphere)

■ Evaluation of Fixed Carbon by TG-DTA Measurement

The adjusted waste wood biocoke and buckwheat husk biocoke were heated up to 900 ˚C under a nitrogen atmosphere, after which the atmosphere was switched to air and heating was continued to 1000 ˚C. Table 2 shows the analysis conditions.

Table 2 Analysis Conditions of Waste Wood Biocoke and Buckwheat Husk Biocoke

Instrument	: DTG-60
Heating rate	: 10 ˚C/min
Temperature range	: 30 ˚C - 1000 ˚C
Sample weight	: 8.37 mg (waste wood), 8.26 mg (buckwheat husks)
Atmosphere	: Nitrogen → Air

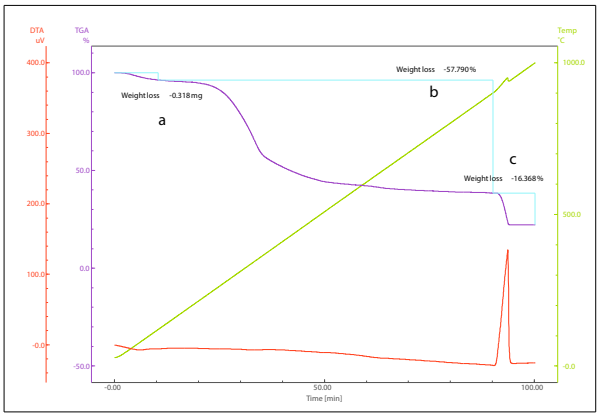

Fig. 5 TG-DTA Curve of Waste Wood Biocoke (with Switching from Nitrogen to Air)

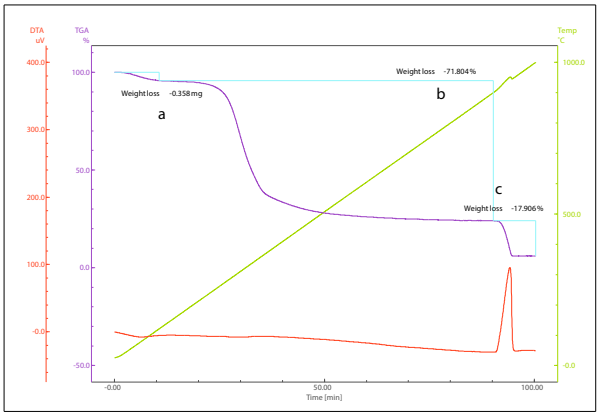

Fig. 6 TG-DTA Curve of Buckwheat Husk Biocoke (with Switching from Nitrogen to Air)

When heated under a nitrogen atmosphere, both samples show a weight loss due to evaporation of moisture up to 120 ˚C (a in Fig. 5 and Fig. 6). The weight loss from around 250 ˚C shows a process in which volatile components are released by thermal decomposition (pyrolysis) (b in Fig. 5 and Fig. 6). When the atmosphere is switched to air at 900 ˚C, a weight loss due to combustion of carbon can be seen (c in Fig. 5 and Fig. 6), and the residue after combustion is the ash.

The moisture percentage was calculated by adding the moisture content that evaporated during replacement of the atmosphere with nitrogen prior to the start of measurement to the amounts of moisture obtained from a in Fig. 5 and Fig. 6. The remaining components (volatile matter, fixed carbon, ash) were then converted to a dry base, as shown in Table 3. These results were obtained based on JIS M 8812, “Coal and coke - Methods for proximate analysis” (Test methods for determination of moisture, ash, volatile matter, and fixed carbon). The combustion quality of the fuel can be understood from the component ratios of these substances.

Table 3 Component Ratio of Volatile Matter, Fixed Carbon, and Ash (Dry Base)

Sample material	Volatile matter (mass%)	Fixed carbon (mass%)	Ash (mass%)
Waste wood biocoke	62.8	17.8	19.4
Buckwheat husk biocoke	78.4	19.6	2.0

■ Conclusion

The combustion characteristics and fixed carbon content of waste wood biocoke and buckwheat husk biocoke were evaluated using a DTG-60 simultaneous TG/DTA. TG-DTA measurement is an effective method which can determine the combustion characteristics of biocokes under an air atmosphere and the composition ratio of the volatile matter, fixed carbon, and ash under a nitrogen atmosphere. Moreover, TG-DTA enables a more comprehensive evaluation, as the endothermic and exothermic behaviors during pyrolysis and combustion can be measured simultaneously. Since the properties of various types of biocokes differ depending on the raw material used and the production conditions, TG-DTA measurement is also useful for comparative studies of biocoke quality. In addition, when a mixture of various types of biomass is to be used, it is important to know the carbon content (fixed carbon content) of each raw material.

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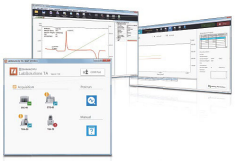

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