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Production of Fuel Pellet from the Mixture of Heavy Oil and Biochar with a variety of Blending Ratios

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Abstract: *Pyrolysis is a proved technology that converts biomass into bio-oil and biochar. The heavy portion of bio-oil, termed as heavy oil (HO), is sticky and responsible for coking problems during bio-oil upgrading. However, sticky HO can be an excellent binder for pelletizing biochar. When a sorber filled with biochar is applied, HO can be effectively captured by biochar. Furthermore, if another sorber filled with biomass feedstock is employed, it is practically feasible to tune the blending ratio of HO and char to produce HO/Biochar pellets of optimized properties. In this study, a typical agricultural residue in Japan, rice straw, was pyrolyzed at 400, 450, and 500 °C in an auger reactor to produce HO and biochar, with a HO/biochar mass ratio of R for a given temperature. The resulting HO and biochar were then mixed at different ratios (100%, 75%, 50%, 25%, and 12.5% of R), and pelletized at different temperatures (80 °C, 140 °C, and 200 °C) to produce HO/biochar pellets. The pellets were tested for energy density, tensile strength (TS), and elemental composition. The results showed that the mixed HO/char had different tensile strength, and the maximum TS of HO/biochar pellets were found from 100% R of HO/biochar mixture from 400 °C pyrolysis. The blending HO/char at 100% had a high in ash content and high energy content (HHV), and also lower in the moisture uptake*

Keywords: pellets, energy conversion, pyrolysis, heavy oil and char, blending

INTRODUCTION

Rice straw is one of the most abundant agricultural residues in Japan. The traditional treatment methods such as open burning, pulverization, and return to the field, causing environmental pollutions and leave a considerable amount of energy unutilized. Researches regarding the efficient and environmentally friendly treatment of agricultural residues has gained increasing attention in the past decades. Many technologies turn agricultural biomass into thermal energy or bioproducts.

Pyrolysis is the main step of gasification, and the formulation of condensable organic products, which is generally called tar, while carbon-rich residues are called biochar.[1] In this study briquettes were made from a mixture of biochar and its heavy oil/ tar.

EXPERIMENTAL SECTION

Rice straw (RS) was pyrolyzed in a horizontal auger reactor, which is popular in the biomass pyrolysis, at temperatures of 400, 450 and 500 °C. The details of the reactor are reported elsewhere. [2] The bio-oil was condensed at the reactor downstream with a silica fiber made aerosol filter (150 °C) and three condensers (0, −40, and −70 °C, respectively) in series. Heavy oil (HO) and bio-oil have been mixed by dissolving acetone. Prior to evaporation at a temperature of 60 °C, a mixture of HO/Char was stirred at a stirring rate of 170 rpm for overnight.

The pelletization process was performed using hydraulic press consists of stainless steel cylindrical interior diameter and length are 14.10 mm and 28mm, respectively. Approximately 1 g of powder was filled inside the hole, compacted to a pressure of 128 MPa for holding time 8 min at 200 °C.

RESULTS AND DISCUSSION

Tensile strength (*TS*) is critical for the briquettes because soft hardness might lead to breakage during transportation and handling processes. In the present study, the mechanical properties of the briquette pellets were evaluated in terms of their tensile strength, as illustrated in fig. 1. As expected, all pellets showed relative low tensile strength, with RS-400 100% R mixture having the highest tensile strength of 6.3 MPa.

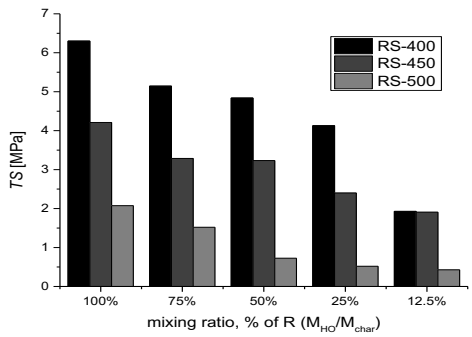

Fig 1. Tensile strength of pellets

All mixing ratios are more strength than without heavy oil and the surface was much smoother, that indicating the interval between particles which are considered heavy oil recrystallizing after the drying process and solid forming to bind the particle. Subsequent to briquetting at high temperature, consistency of polymerized serving as a glue. The surface was much smoother, indicating the interval between particles.

Fig. 2 presents the energy densification of blending of HO/char generated from RS at 400 °C, 450 °C and 500 °C, it was found that some synergetic effects on energy densification. In the under higher blending ratio conditions, the energy densification are great, and the small blending ratio or more char provided low energy densification, it was due to the heavy oil is rich in volatile and also high density, conversely the HO is contained greater of carbon content. Other impacts also occur on

the ash content, the higher the blending ratio of HO/char gives a low ash content, while the small blending ratio generates high the ash content.

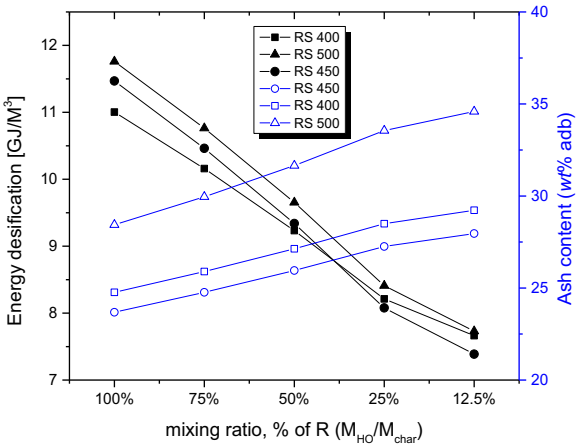

Fig 2. Tensile strength of pellets

As discussed above, the noticeable synergies always occur under conditions of a higher mixing ratio condition. This due to the sufficient quantity of HO in the mixture is needed to offer plenty of carbon donors.

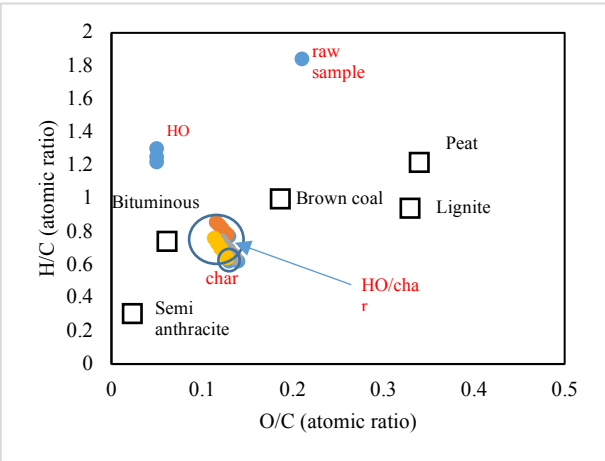

Fig. 3. Van Kreven diagram of blending ratio

Fig.3 It shows the Van Krevelen plot of pyrolyzed rice straw and shows the changes in H/C and O/C atoms used to determine the level of maturation of pyrolysis products. The van Krevelen diagram also provides information about differences in the composition of elements (C-H-O). The Van Krevelen diagram shows that the characters obtained from the pyrolysis of rice straw HO and char have a ratio of H/C and O/C which is much lower than raw rice straw. This shows the gradual loss of hydrogen and oxygen and char enrichment of carbon. In this figure the composition of blending HO/char shows that H/C and O/C are very close to Bituminous coal. It's clear that blending HO/char compared to bituminous coal contains more oxygen.

Fig. 4 shows the measured moisture uptake of pellets RS-400 at 25 °C and 80% relative humidity. It was observed that the pellets reached saturation in about 10 h. The hydrophobicity improved when the HO/char high mixing ratio and long residence time were used, with RS-400 100% exhibiting the lowest moisture content, at around 3.8%.

Among the mixing ratio of HO and char, the high hydrophobicity of the pellets due to the HO intercalation, which is the hygroscopicity of bio-char played of preponderant in moisture uptake. In addition, suggest the pellets high of mixing ratio can be stored safely in a humid environment for a long time [3].

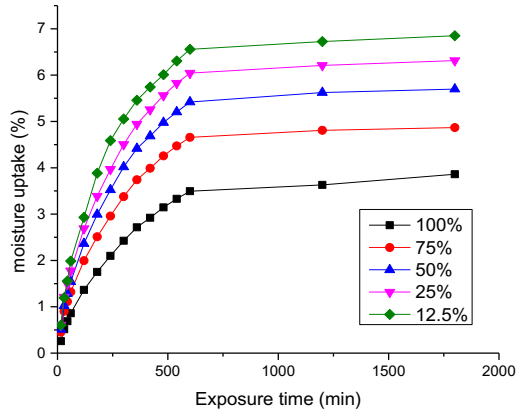

Fig. 4. Moisture uptake of pellets RS-400

CONCLUSIONS

In this work, typical agricultural biomass, rice straw was briquettes under different mixing ratio of HO and char to obtain pellets. High mixture HO/char pellets exhibited increased tensile strength and density. The mixing ratio 100% has higher TS around 6.3, the increased TS due to strengthening from HO. The hydrophobicity of pyrolyzed char pellets increased with increasing the mixing ratio.

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