Hydrothermal carbonization of construction wood waste into a valuable product

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Highlights

- The model was successfully developed for hydrothermal carbonization process.
- Hydrochar with improved nutrient availability can be beneficial for soil amendments.
- Hydrothermal carbonization is able to retain carbon and nutrients in hydrochar.

1. Introduction

Hydrothermal carbonization (HTC) is an economical, practical, and environmentally friendly process. In comparison to pyrolysis, HTC offers advantages such as a lower carbonization temperature and no need for pre-drying [1]. Key factors such as reaction temperature, residence time, and raw materials in the HTC process significantly influence the properties of the resulting hydrochar. The pressure in the HTC process is typically generated by water vapor and varies based on the type of raw material used. The reaction mechanisms, including hydrolysis, dehydration, decarboxylation, aromatization, and re-condensation, occur simultaneously [2]. The hydrochar yield from the HTC typically falls within the range of 35% to 65% of the initial dry feedstock. Hydrochar is a valuable product that can be used for soil amendment, as a precursor for activated carbon and in the preparation of catalytic composite materials for water purification [3]. This study aims to prepare a valuable product that can be used for soil amendments. It also seeks to identify models that capture the dynamics between heating power and reactor temperature. To minimize tracking error and optimize power consumption, these models were used in process simulations for the HTC process.

2. Methods

In this study, construction wood waste (Class A wood) was used as the raw material. The wood was collected from Kiertokaari (Oulu, Finland). It was chopped into 10-20 mm size and crushed using a Rapid 200 Series granulator. The crushed material was screened to a size 1-5 mm. The hydrothermal carbonization was done with a high-pressure Parr reactor (4575/76 HP/HT Pressure Reactors, USA), equipped with a 4848-reactor controller. About 45.5 g of pure wood and distilled water based on the biomass to water ratio (1:3 and 1:5) were put in the reactor. The natural pH of the mixture was around 5. NaOH was used to adjust the pH at 7 and 9. About 30 % of air space was maintained in the reactor. The HTC process was carried out at 180 °C and 200 °C for 4 and 6 hours. The pressure varied between 10 to 20 bars based on the processing temperature. Vacuum filtration was used to separate the sample from liquid phase after the system was naturally cooled down. Finally, the wet solid product was dried in an oven at 80 °C for 24 hours. Hydrochar preparation is illustrated in Figure 1a. Also, data gathered from laboratory experiments were employed to identify dynamic models, which were then incorporated into process simulations. Furthermore, the approach used for evaluating energy use was validated through the utilization of energy consumption data.

3. Results and discussion

Fig. 1b,c illustrates the reactor temperature and the calculated energy consumption in one experiment (Temperature = 200 °C, Time = 4 hours). In the start, the reactor was heated with high power until it reached the set point in 52 minutes, as shown Fig. 1b. The energy consumption was thus assumed periodic as shown in Fig. 1c. The experiment ended after the 291st minute, when four hours of processing around the target temperature was reached. The hydrochars were characterized by XRF, FESEM, BET, Raman, and FTIR to find out connections between process conditions and hydrochar quality. The hydrochars showed low specific surface area and rough and irregular surface. They also contain P, Ca, and K elements, beneficial for soil amendments.

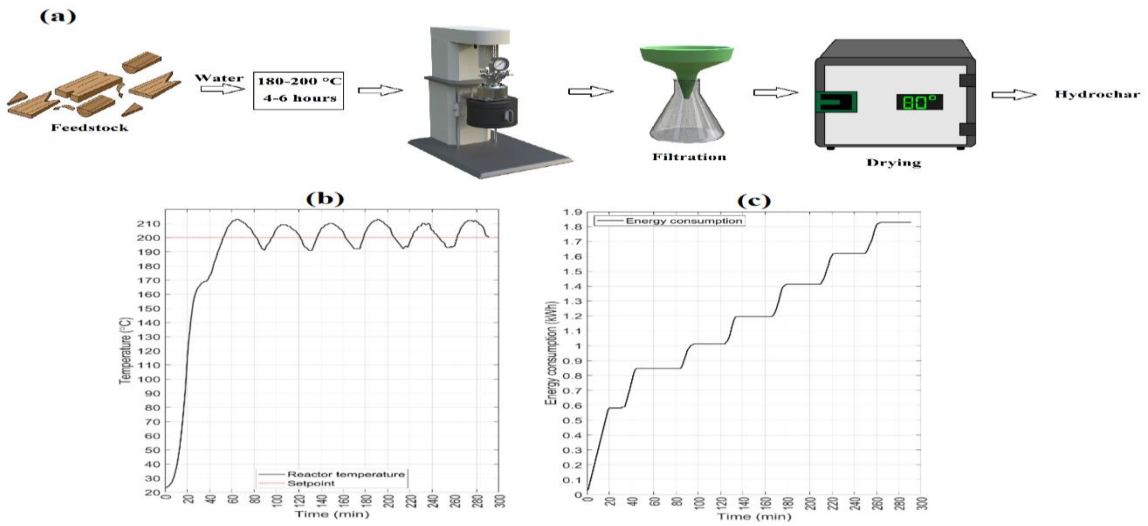

Figure 1. (a) Schematic representation of hydrochar preparation, (b) reactor temperature, and (c) energy consumption changes during an experiment

4. Conclusions

Hydrothermal carbonization would be advantageous for carbonization of the raw material. The energy consumption during processing was estimated indirectly, based on the control values, and validated based on energy consumption measurements in laboratory experiments. The analysis is still ongoing, and more information will be presented at the conference.

References

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Keywords
Hydrothermal carbonization, wood waste, energy consumption.