

The Pyrolysis Process in Biochar Production



APPLICATION

In the quest for sustainable energy solutions, biochar derived from waste presents a promising alternative across various contexts, including agriculture, livestock, the cement industry, and the production of lithium battery cathodes. This innovative approach is not only sustainable but also often yields materials with superior performance compared to traditional processes. Advanced furnaces are at the core of the biochar production process, playing a crucial role in transforming waste.

SOLUTION

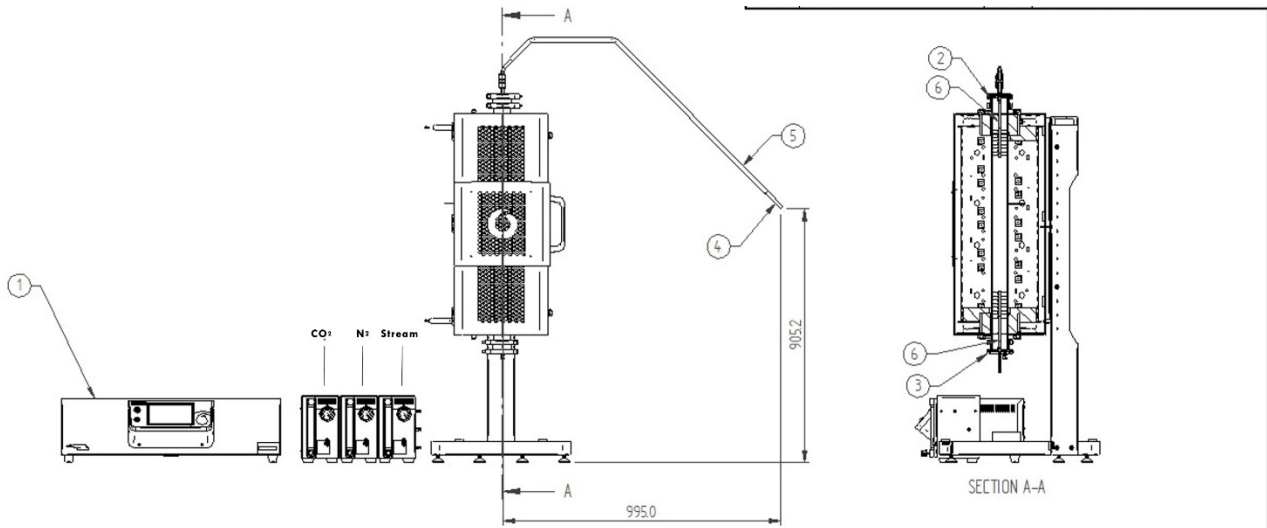
Furnaces are integral to the pyrolysis process, where various types of waste are converted into biochar.

This process involves heating waste material in an inert atmosphere, typically nitrogen, at high temperatures. The laboratory-scale prototype plant, such as the Carbolite custom model TS1 12/60/450B, is designed to handle this process efficiently.

During pyrolysis, waste material is subjected to a controlled heating rate and residence time, ensuring its complete transformation into biochar. The resulting biochar is then activated using steam or CO₂, further enhancing its properties. This activation process involves treating the biochar at elevated temperatures, increasing its surface area and introducing functional groups that enhance its electrochemical performance.

Advantages of Furnace Pyrolysis

1. **Efficiency and Control:** Furnaces offer precise control over pyrolysis conditions, including temperature, heating rate, residence time, and atmosphere. Such control is essential for producing high-quality biochar with consistent properties.
2. **Scalability:** Furnaces enable the scalable production of biochar, making it feasible for industrial applications. This scalability is crucial for meeting the increasing demand for sustainable battery materials.
3. **Versatility:** Furnaces can be adapted for various types of biomass and waste materials, providing flexibility in feedstock selection. This versatility supports the circular economy by enabling the reuse of diverse waste streams.
4. **Environmental Benefits:** By converting waste into valuable biochar, furnaces help reduce landfill waste and lower the carbon footprint of battery production. This aligns with global efforts to promote sustainable and eco-friendly technologies.



Biochar Electrochemical Properties

"The activated biochar produced using furnaces exhibits remarkable electrochemical properties, making it a potentially excellent material for lithium battery anodes. Its high performance is attributed to the hierarchical micro/mesopores and enhanced surface functional groups introduced during the activation process.

Within the Verder Scientific group, several surface area studies have been conducted using our Microtrac systems, allowing in-depth investigations of hierarchical micro/mesopores.

Moreover, biochar anodes address the limitations of conventional graphite electrodes, such as low theoretical capacity and poor diffusion kinetics. By offering a sustainable and high-performance alternative, biochar anodes contribute to the advancement of next-generation lithium-ion batteries.

Example of Gases and Flow Rates

In the process of creating sustainable lithium-ion batteries anodes using biochar from waste materials, the following gases and flow rates were used:

Nitrogen (N₂): During the pyrolysis process, nitrogen is used to create an inert atmosphere. The waste is pyrolyzed under a nitrogen flow of 100 mL/min at 700 °C with a heating rate of 5 °C/min and a residence time of 30 minutes.

Steam: For the steam activation process, the biochar is treated at 800 °C under a 57 vol% steam/N₂ mixture for four hours. The total gas flow rate for this process is 160 mL/min.

Carbon Dioxide (CO₂): In the CO₂ activation process, the biochar is activated under the same reaction conditions as the steam activation but using CO₂ gas as the activating agent.

These gases are used to develop hierarchical micro/mesopores in the biochar and modify the amount of oxygen-containing functional groups on its surface, resulting in high-performance anodes for lithium-ion batteries.

Example of laboratory-scale pyrolysis equipment

STANDARD FURNACE FEATURES

- | 1200°C maximum operating temperature
- | Tube furnaces to suit work tubes with external diameters of 60, 120 & 200 mm.
- | A comprehensive range of heated lengths from 150 to 1200 mm
- | Programmable temperature controllers EPC3016 and CC-T1
- | Excellent temperature uniformity
- | Class leading low energy consumption
- | Ethernet communications
- | Optional Work Tube Packages ideal for working with modified atmospheres
- | Optional Vertical Package to support the furnace and work tube in a vertical orientation
- | Optional Inert Gas Package

TECHNICAL DETAILS (TUBE FURNACE)

TS1 12/60/450

Max temp (°C)	1200
Heat-up time (mins)	30
Internal Diameter: (mm)	60
Heated Length (mm)	450
External Dimensions: H x W x D (mm)	575 x 645 x 480
Heated Zones	1
Max power (kW)	2
Weight (kg) (approx.)	49
Thermocouple Type	N
Configuration	Bench-top

Please note:

- Maximum continuous operating temperature is 100°C below maximum temperature
- Heat up rate is measured to 100°C below max, using an empty chamber