Effect of Carbon-based Additives on Hydrogen Production in the Air/Steam Gasification of Dried Sewage Sludge

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Sewage sludge is indeed a by-product generated during the sewage treatment process. It is a complex material composed of various components, including organic substances such as proteins, polysaccharides, lipids, and aromatic amines. Additionally, sewage sludge can contain heavy metals like copper (Cu), zinc (Zn), lead (Pb), chromium (Cr), nickel (Ni), and other pollutants.

Compared to conventional methods of sewage sludge treatment, such as landfilling, composting, and marine dumping, have been utilized, thermochemical conversion technologies, such as pyrolysis and gasification, have gained attention in recent years as alternative sewage sludge treatment methods. Pyrolysis and gasification offer several advantages over conventional treatment methods, including shorter treatment times, reduced volume of waste, and the potential for recovering energy and valuable by-products. Moreover, these technologies have shown promise in effectively controlling environmental pollutants, including heavy metals, through processes such as volatilization and immobilization, thereby reducing the risks associated with sewage sludge disposal and promoting environmental sustainability.

Gasification is a process that converts organic or fossil fuel-based carbonaceous materials into carbon monoxide, hydrogen, and carbon dioxide by reacting the raw materials at high temperatures with a controlled amount of oxygen and/or steam. This thermochemical process is a way to efficiently convert various feedstocks, such as coal, biomass, or municipal solid waste, into a synthesis gas (syngas) consisting mainly of carbon monoxide (CO) and hydrogen (H_2).

In gasification, the feedstock is subjected to high temperatures (typically above 700℃) in the presence of a controlled amount of oxygen, air, or steam. The absence of a full combustion process distinguishes gasification from traditional combustion methods. The produced syngas can be used as a fuel for power generation, as a feedstock for the production of chemicals and fuels, or for various other applications.

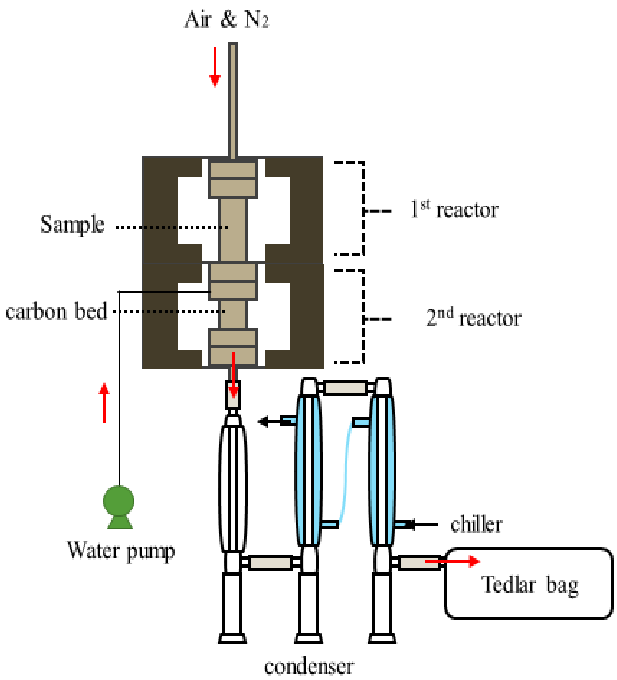

Figure 1. A schematic diagram of the fixed-layer two-stage gasification process

In this study, an experiment was conducted to investigate the hydrogen production characteristics when utilizing steam and carbon-based additives in a two-stage fixed bed gasification system using dry sewage sludge. The study employed activated carbon, bio-char, and lignin char as carbon-based additives, with a constant supply of 5, 10, and 15 ml of steam during the gasification process. Air was introduced as the gasifying agent, with ER 0.2, and the gasification temperature was maintained at 750~850℃. The experimental setup used 10 g of dried sewage sludge. Hydrogen production increased as the temperature rose, with lignin char, activated carbon, and biochar appearing in that order. In cases where steam was injected, hydrogen production increased depending on the amount of steam injected. Among additives, lignin char showed the highest hydrogen production yield.

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