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Co-production of clean syngas and ash adsorbent during sewage sludge gasification: Synergistic effect of Fenton peroxidation and CaO conditioning

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HIGHLIGHTS

- A novel method for synchronous production of clean syngas and ash adsorbent is proposed.
- Fenton/CaO-treated sludge enjoys very good gasification performance.
- Residual Fe and Ca synergistically inhibit the emissions of H_2S, SO_2, NH_3 and HCN.
- Fenton's reagent/CaO boost the adsorption performance of sludge gasification ash.
- Composite conditioning significantly prolonged the life of sludge ash adsorbent.

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ABSTRACT

In order to achieve the complete utilization of both sludge organic and inorganic components, this study proposed a novel method for synchronous production of clean syngas and ash adsorbent during steam gasification process based on composite conditioning. Sewage sludge was pretreated by Fenton's reagent (Fe^{2+}/H_2O_2) and CaO, then gasified in a lab-scale fluidized bed at 873–1273 K. The ash adsorption performance was also evaluated in a self-designed reactor. According to the results, both residual iron and calcium salts were able to promote H_2-rich fuel gas generation. The effect of iron compounds became more strongly with temperature increased, while the influence of calcium substances tend to be more obviously with temperature decreased. Thus after combined conditioning, very good sludge gasification performance and the highest cold gas efficiency were achieved at a wide temperature range. Moreover, separate gasification of Fenton-oxidized or CaO-treated sludge released H_2S emission respectively from sulfonic acid/sulfone/heterocyclic-S and inorganic sulfide in char. However, H_2S releasing amount was less than 1.8% of total sulfur with the co-usage of two conditioners due to oxidation and fixation reactions. Meanwhile, although CaC_xN_y that formed in CaO-added sludge char reacted with steam to produce NH_3, the residual iron and calcium compounds could synergistically inhibit the final emissions of NH_3 and HCN. In this case, no nitrogenous gas was generated at 1273 K. Besides this outstanding role, the remaining conditioners were still able to boost the adsorption performance of sludge gasification ash and significantly prolong its life.

1. Introduction

Energy crisis and environmental pollution are the key global issues, which creates a good opportunity for developing the technologies of energy recovery from some carbonaceous solid waste, such as sewage sludge [1–3]. Usually, the energy utilization of this hydrophilic waste can be realized only through a series of processing approaches: first, removing the high contents of water (93–99.5 wt% [4]) by conditioning, dewatering and sometimes drying [5,6]; second, converting dry/semi-dry sludge to high-added value products by thermochemical conversion or anaerobic digestion [7,8]. Among later alternatives, steam gasification has been evaluated as one of the most promising technologies [9,10]. To achieve higher efficiency, some inexpensive iron and calcium compounds were tried as catalyst. Yamashita et al. [11,12] demonstrated that

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