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ORIGINAL PAPER

Pyrolysis of Fresh and Deposited Sewage Sludge and Investigation of the Products

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Abstract The article presents results of studies of pyrolysis of fresh and deposited sewage sludge (DSS) in two regimes of heat input: conductive heating at a rate of 40 °C/s and convective heating at a rate of 10 °C/min. It was determined that the fresh sewage sludge (FSS) had the higher yield of organic liquid and gas, and the lower char yield. The higher heating rate led to a decrease in the char yield and an increase in the liquid yield. The investigation of liquid products showed that those of the FSS had greater proportions of alcohols, organic acids, and nitrogen-containing compounds, including heterocyclics. The liquid products of the DSS had the greater content of carbohydrates, esters, and unidentified compounds, which were probably condensed compounds.

Keywords Sewage sludge · Pyrolysis · Thermal decomposition · Fresh sewage sludge · Deposited sewage sludge · Liquid products

Introduction

Currently, most wastewater is processed through biological treatment. Consequently, a large quantity of sewage sludge is being produced. The utilization of this sewage sludge is a significant problem because its presence in a landfill environment poses a serious ecological hazard [4, 12, 28].

Sewage sludge can include pathogenic microflora, parasites, causative viruses and microorganisms, foul-smelling substances and other dangerous substances. Thus, it poses the threat of land, ground and water pollution by toxic organic compounds, heavy metals, and pathogens [9, 14, 19].

Technologies for the thermal processing of sewage sludge include liquid-phase oxidation, pyrolysis, and gasification [2, 5].

Pyrolysis is a thermochemical conversion process that involves the heating of feedstock to 450–550 °C in the absence of air, thus providing advantages as compared to other methods [10]. During this process, the thermal stabilization occurs and the products (gas, liquid, char) are produced. These products can be used as fuel, a feedstock for chemical technology, etc. [17]. Also, in the case of pyrolysis, heavy metals (including mercury and cadmium) can readily be separated with the char so that they will not pollute the air as would otherwise occur in direct combustion or gasification [18, 24, 27].

Fast pyrolysis maximizes the yield of the liquid products [3]. The liquid products are dark brown or black and comprise a complex mixture of oxidized carbohydrates [30]. The economic feasibility of the process can be increased by processing the products into marketable goods. For example, the solid products can be converted into adsorbents or fertilizers, while the liquid and gases can be converted into fuel [8].

Accordingly, the thermal processing of sewage sludge is a research area of increasing interest [16].

A recent review on sludge pyrolysis is presented in [25]. This review shows that kinetics and stages of the thermal decomposition of sewage sludge have been actively investigated [1, 6, 11, 20–22, 26]. Also, the influence of regime parameters of the process on the yield and properties of the

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