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Effect of mass flow rate and temperature on the gasification of animal fat

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Abstract

In this work, gasification of animal fat was studied. Tests were performed with an emulsion of fat and water and temperature and mass flow rate effects were evaluated. Gas chromatography was used to analyze the composition of producer gas. Carbon and hydrogen conversion efficiencies, dry gas yield, cold gas efficiency, and higher heating value of producer gas were determined. The results showed that temperature and mass flow rate determine the composition of the gas obtained and the performance of the gasification process. The gasification parameters increased with the temperature rise. The increase of mass flow rate contributes to a decrease in the overall performance of the gasification process.

Introduction

Tannery industry produces a vast amount of environmental pollutants in solid form, which can contain about 40% of low-value fat. Currently, the available disposal technique for this waste is the landfill. The gasification of animal fat can be an option for valuing this waste for which there are currently no sustainable options. The gasification process involves a complex sequence of reactions (Table 1).

Table 1. Summary of the chemical reactions in gasification phase.

Reaction name	Stoichiometric reaction equation	$\Delta H_{298,15k}$ (kJ/mol)
Water-gas shift reaction	$CO + H_2O \rightleftharpoons CO_2 + H_2$	- 41.2
Boudouard reaction	$C + CO_2 \rightleftharpoons 2CO$	+ 172.58
Steam char reaction	$C + H_2O \rightleftharpoons CO + H_2$	+ 131
Methane steam reforming	$CH_4 + H_2O \rightleftharpoons CO + 3H_2$ $CH_4 + 2H_2O \rightleftharpoons CO_2 + 4H_2$	+ 206 + 165
Methane dry reforming	$CH_4 + CO_2 \rightleftharpoons 2CO + 2H_2$	+ 247
Tar/Hydrocarbon reactions		+ [200-300]
Thermal cracking	$pCnHx \rightarrow qCnHy + rH_2$	
Tar steam reforming	$CnHx + nH_2O \rightarrow (n + \frac{x}{2})H_2 + nCO$	
Tar dry reforming	$CnHx + nCO_2 \rightarrow \frac{X}{2}H_2 + 2nCO$	
Tar carbon formation	$CnHx \rightarrow \frac{X}{2}H_2 + nCO$	

Materials: fat characterization

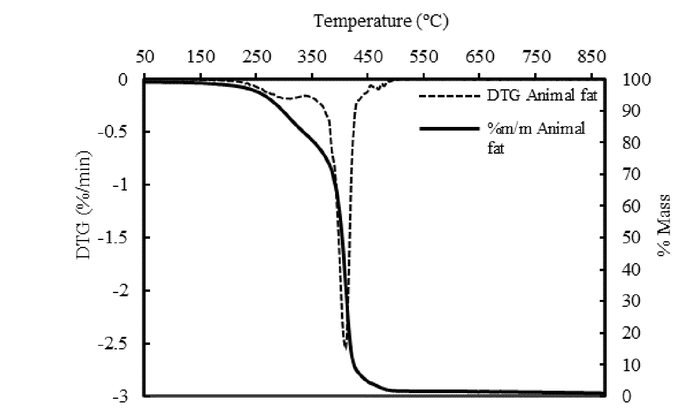


Table 2. Animal fat characterization.

Ultimate analysis	(w/w % d.b.)
Carbon	73.54
Hydrogen	11.75
Nitrogen	0.06
Ash	0.93
Oxygen (by diff.)	13.72
Higher heating value (HHV) (kJ/g d.b)	37.48

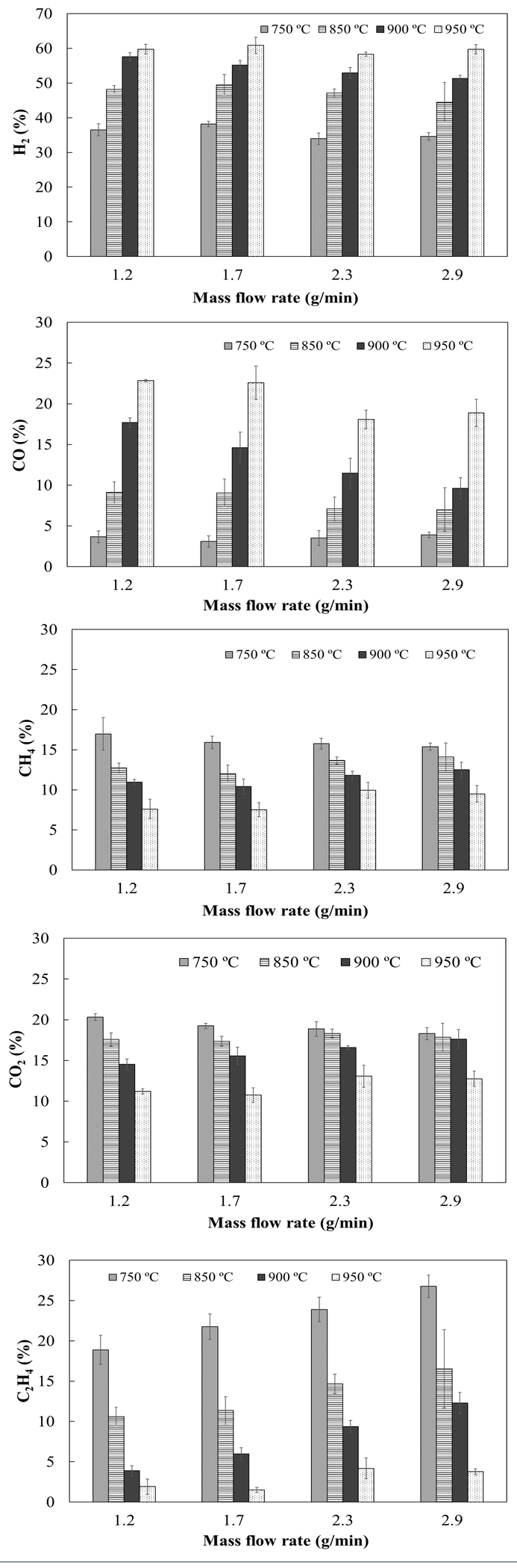
Methodology: operation conditions

feed	Gasification	Producer gas
40 % fat 60 % water **SBR=1.5**	Downflow fixed bed reactor Gasifying agent: steam	H_2, CO, CO_2, CH_4, C_2H_4, C_2H_6

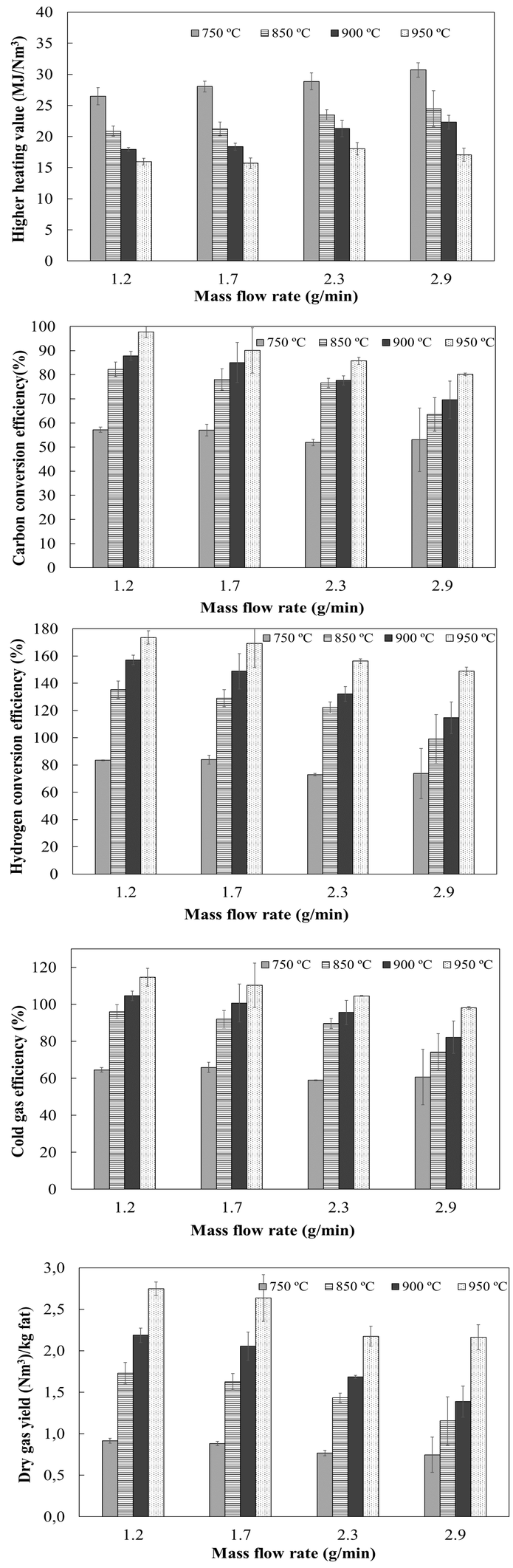
Effect of temperature
Flow rate: 2.3 g/min
Temperature: 750 to 950 °C
Bed: Alumina

Effect of mass flow rate
Flow rate: 1.2, 1.7, 2.3, 2.9 g/min
Temperature: 750 °C to 950 °C
Bed: Alumina

Results: producer gas composition



Results: gasification parameters



Conclusions

The temperature rise:

- strong influence on the gas composition;
- increase the H_2 concentration;
- reduction of HHV of the producer gas and an increase in the other gasification parameters.

The decrease in mass flow rate:

- Increase the concentration of H_2 and CO;
- decrease the concentration of hydrocarbons;
- reduction of HHV of the producer gas and an increase in the other gasification parameters.

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