Potential of pyrolytic gas from pelletized residual biomass of rice husk and corncob blends: analysis of non-condensable gas evolution in a batch reactor

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1. Introduction.

Pyrolysis is the primary chemical reaction preceding combustion and gasification, where organic matter is heated in the absence of oxygen, producing condensable gases, non-condensable gases, and biochar, a carbon-rich solid product [1].The pyrolysis products are formed through the primary reactions of biomass after a drying process. As temperature increases, the secondary reactions of volatiles and condensables lead to the formation of tars and low-molecular-weight gases.

This study evaluates the composition of combustible gases—hydrogen, carbon monoxide, and methane—to assess the effect of temperature on the calorific value of non-condensable gases and hydrogen production yield. The novelty of this process lies in performing pyrolysis without using carrier gas; instead, the devolatilization itself generates pressurization, forcing gas flow through a capillary.

2. Materials and Methods

The prepared biomass pellets are introduced into an electric furnace for pyrolysis in the absence of oxygen. The process is conducted at different controlled temperatures, varied in 100°C intervals, to observe how gas composition evolves. Figure 1 illustrates the general pyrolysis process configuration, beginning with an electric furnace heating the biomass in an oxygen-free environment (a); the generated vapors and gases are then directed to a condenser (b), where condensable fractions are separated. A filter (c) subsequently removes solid particles and contaminants before the gas is collected in Tedlar bags (d) for further analysis. The pyrolytic gases are captured at different temperatures (300°C to 800°C). The collected gas samples undergo chromatographic analysis to assess the impact of temperature on gas composition.

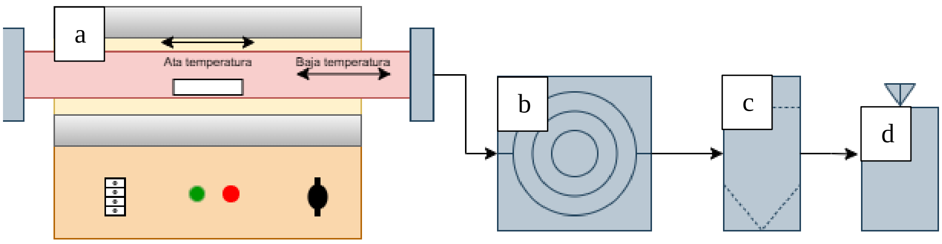
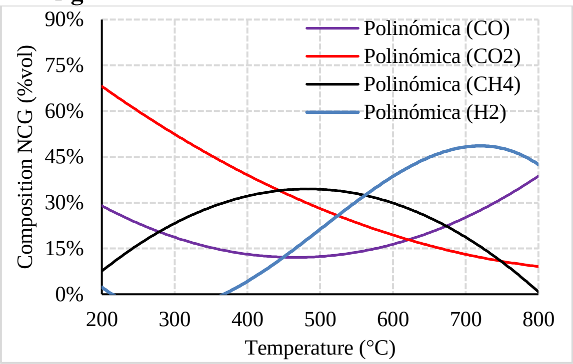


Figure 1. Experimental scheme

3. Results

Below 300°C, the gases contain high amounts of CO_2 and vapors, which do not enhance pyrolytic gas quality. Above 300°C, a sustained flame was observed at the gas outlet (Figure 2a), characterized by a clean, stable blue flame, primarily composed of CO, H_2, and CH_4. The absence of soot suggests a high volatile content in the biomass. Gas evolution as a function of temperature is shown in figure 2b. CO_2 decreases with increasing temperature, while CO and H_2 concentrations rise. Previous studies have predicted this behavior [2], which is typical in pyrolysis, as higher temperatures promote tar reforming with steam, leading to increased H_2 and CO production [3]. (Additionally, methane exhibits a peak concentration around 500°C before decreasing to approximately 3.5% at 800°C, likely due to methane steam reforming reactions, given the continuous rise in hydrogen levels. The average calorific value of non-condensable gases is estimated at **12 MJ/Nm³** for temperatures between 300°C and 500°C, with hydrogen generation yields exceeding **320 mL H_2/g biomass**.

(a)



(b)

Figure 2. Pyrolysis gas flame (a),Trend non condensable gas evolution (b)

Conclusions

- ✓ The study confirms that batch pyrolysis can be conducted without carrier gas, relying on self-generated pressure. This simplifies the process while producing a hydrogen-rich gas with yields exceeding **320 mL H_2/g biomass**, making it a promising renewable hydrogen source.

- ✓ As temperature increases, CO_2 decreases while CO and H_2 concentrations rise, reaching an optimal calorific value of **12 MJ/Nm³** between **300–500°C**. Methane peaks around **500°C**, then declines due to reforming reactions, further boosting hydrogen production.

- ✓ The high-quality combustible gas, particularly above **600°C**, and the reduction of CO_2 below **20%** highlight the potential of pyrolysis gas for clean energy applications, including combustion, syngas production, and decentralized hydrogen generation.

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