Fast Pyrolysis of Ecuadorian Residual Biomasses

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ABSTRACT

Biomass pyrolysis is considered as a potential resource for obtaining biofuels and biochemicals. In this study, the composition of gases and liquids obtained from the fast pyrolysis in a vertical free fall high temperature tubular reactor of seven Ecuadorian residual biomasses, were analyzed analytically. The composition of the pretreated biomass was analyzed. The characterization showed that the biomasses have a content of ash between 1-20%, fat between 1-10%, protein contents up to 15% and total carbohydrates in a range of 60-90%; the content of cellulose, lignin and hemicellulose varies from 20-40%, 15-35%, and 10-40%, respectively. Subsequently, each dry base biomass was fed to the reactor at a temperature of 600°C. Three different products were obtained from the pyrolysis: pyrolysis gas, bio-oil and bio-char. The product distribution of the biomass samples presented a bio-oil and gases yield near 30% and 5% to 38%, respectively. The liquid and gaseous products were analyzed by gas chromatography–mass spectrometry. Four main compounds were identified in the chromatograms of the gaseous products: methane, ethane, acetylene, and ethylene. While the liquid main products were: 2-methyl furan, 2-furanol, furfural, butyrolactone, butanoic acid, tetrahydro-2-methylfuran, and levoglucosan.

MOTIVATION

Pyrolysis: Thermal decomposition process that occurs in the absence of oxygen. It consists of 3 stages.

FEED- BIOMASS Agro-industrial residues → **REACTION** Pyrolysis → **PRODUCTS** Bio-oil, char and gaseous

BIOMASS Ecuadorian


Coffe bean husks


Cacao bean husks


Palm Fiber


Banana Spine


Wood Sawdust


Palm Nut


Sugarcane Bagasse

PRODUCTS PYROLYSIS

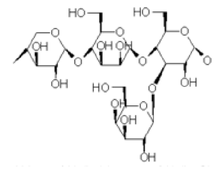
Pyrolysis Oil (BIO-OIL)

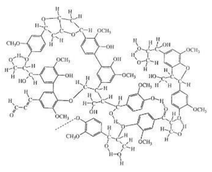
BIOCHAR

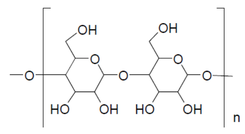
Pyrolysis Gases (BIOGAS)

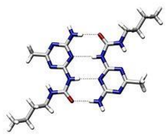
BIOMASS CHARACTERIZATION

BIOMASS COMPOSITION


HEMICELLULOSE


LIGNIN


CELLULOSE


PROTEIN

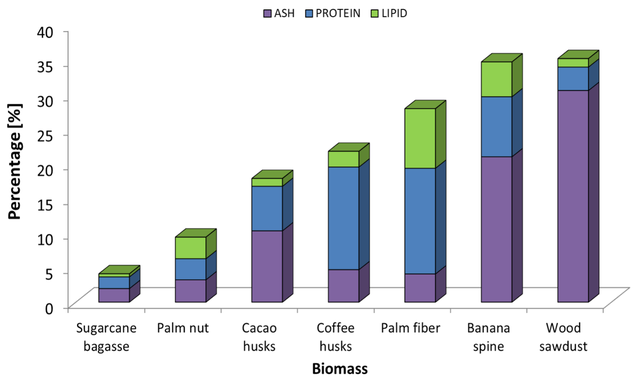


Figure 2: Percentage of ashes, proteins and fats of the different biomasses

Table 1: Distribution of carbohydrates in the investigated biomasses: cellulose, lignin and hemicellulose

Sample	Cellulose [%]	Lignin [%]	Hemicellulose [%]
Coffee husks	40.40 ± 2.70	34.00 ± 0.56	3.82 ± 2.52
Cocoa husks	37.91 ± 1.01	31.67 ± 0.29	12.56 ± 0.95
Banana spine	21.80 ± 0.84	26.35 ± 0.96	17.16 ± 1.24
Palm fiber	23.51 ± 0.61	28.83 ± 0.86	19.72 ± 3.47
Wood sawdust	31.10 ± 1.08	30.02 ± 1.38	30.18 ± 1.24
Palm nut	20.07 ± 0.57	43.27 ± 1.11	27.27 ± 1.51
Sugarcane bagasse	18.08 ± 0.11	19.57 ± 0.48	58.25 ± 0.48

PRODUCTS DISTRIBUTION AND COMPOSITION

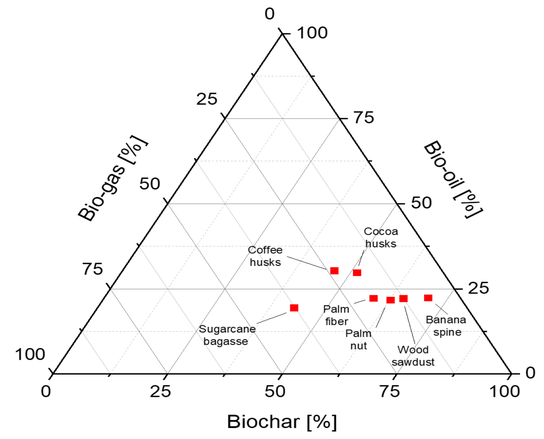


Figure 3: Pyrolysis product distribution of each biomass sample

- **Bio-oil Yield**
  - Range: 19-30%
- **Bio-char Yield**
  - Range: 43-71%
- **Gas Yield**
  - Range: 13-38%

Biomasses with high values of bio char product generate less amounts of bio oil and gases

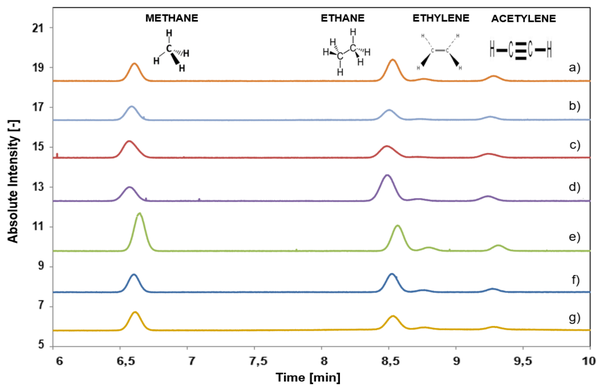


Figure 4: Gases chromatographs and product components of the seven biomasses

Table 2: Percentage of the four gases of each biomass

Biomasses	Percentage [%]			
	Methane	Ethane	Ethylene	Acetylene
a) Coffee husks	36.51	47.52	4.39	11.58
b) Cocoa husks	46.84	38.37	3.41	11.38
c) Banana spine	48.35	36.16	2.77	12.71
d) Palm fiber	28.24	56.14	4.57	11.04
e) Wood sawdust	51.44	36.34	4.34	7.88
f) Palm nut	40.94	45.99	4.46	8.61
g) Sugarcane bagasse	47.71	38.48	4.34	9.46

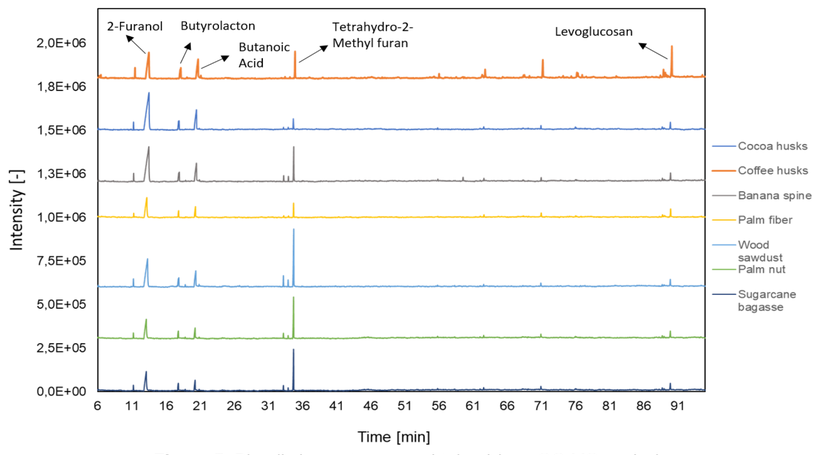


Figure 5: Bio-oil chromatograms obtained from GC-MS analysis

EXPERIMENTAL SET UP

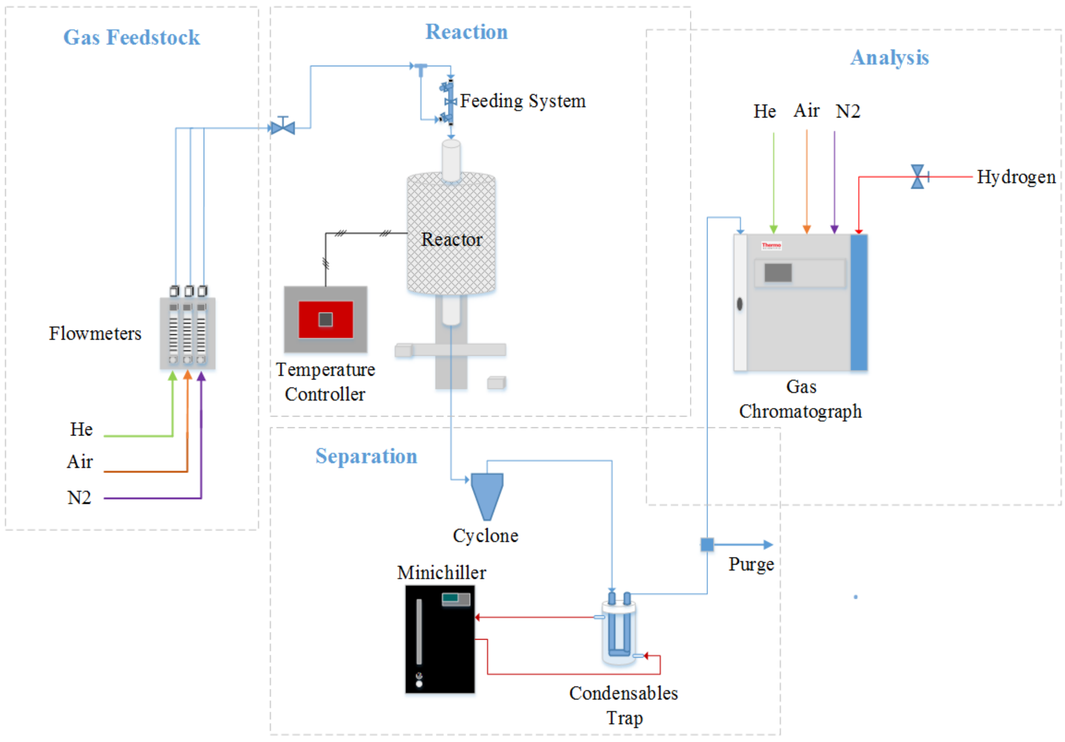


Figure 1: IDEMA Pyrolysis Equipment Diagram

Reactor: Tubular quartz
Analysis: Gas chromatograph with two detectors: FID and TCD to quantify the gaseous products of pyrolysis. Liquid products were analyzed qualitatively in the GC-MS chromatograph

CONCLUSIONS

- ✓ Three principal products were obtained from the pyrolysis: bio-char, bio-oil and gases. Coffee husks and cocoa husks have the highest production of bio-oil yield near 30 %-w/w. While banana spine and wood sawdust present the highest values of bio-char near 70 %-w/w. The gases obtained have a yield of 5 to 38 %-w/w.
- ✓ Gaseous products were analyzed using GC- FID. The results present four main compounds: methane, ethane, acetylene and ethylene, with methane and ethane as the main gaseous products. On the other hand, the liquid products were analyzed using a GC-MS. The main products include: 2-methyl furan, 2-furanol, furfural, butyrolactone, butanoic acid, tetrahydro-2-methylfuran and levoglucosan.
- ✓ Higher percentage of bio–oil can be obtained from biomasses with a higher content of protein and cellulose. In addition, a higher amount of bio char can be obtained if the biomasses present an important content of ash

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