KINETIC STUDY OF STEAM GASIFICATION OF LIGNOCELULLOSIC BIOMASS CHAR OBTAINED FROM PYROLYSIS

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Currently, 83.1 % of the world primary energy consumption comes from fossil fuels, but due to its deprivation, high costs and problems derived from its use, such as environmental pollution and global warming, result of vital importance to find an alternative more renewable and cleaner [1]. In this sense, a promising alternative for the substitution of these fuels may be biomass gasification with water vapor, due to its high availability and low cost, where the gas produced can be used directly as fuel or raw material to produce high value-added chemicals [2]. The aim of this work is to perform the steam gasification of the solid residue obtained from biomass pyrolysis to optimize the hydrogen production.

Three types of lignocellulosic biomass (almond shell (AS), olive stone (OS) and hemp (H)) were evaluated as raw material for steam gasification. The corresponding chars were obtained by conventional pyrolysis in a fixed-bed reactor at a temperature of 800 °C for 1 h, with a heating rate of 10 °C/min. These chars were later gasified with 30 %v steam in a downdraft fixed-bed reactor, at a temperature range of 800-900°C. The evolution of CO, CO_2, CH_4 and H_2 was continuously analyzed in a Siemens Ultramat 23 and Calomat systems. A kinetic model that takes into account the gas product distribution and the weight loss during the gasification reaction was developed using representative gas-solid models such as the volumetric model (VM), the grain model (GM) and the random pore model (RPM). The experimental data was fitted to the different models using a non-linear optimization method, determining the corresponding kinetic parameters and correlation coefficients.

The most accurate model for predicting the reactivity of the chars during steam gasification was the RPM (Table 1). The values of the structural parameter (φ) point out that porosity is developed during gasification, being this effect especially pronounced for the char derived from hemp residue. From the reaction rate constants of this model at the different temperatures, the kinetic parameters such as pre-exponential factor (k_0) and activation energy (E_a) were obtained. The E_a values extend over a wide range between 61 kJ/mol (sample AS), 153 kJ/mol (sample OS) and 184 kJ/mol (sample H). The k_0 value also experiences a wide variation between samples (0.43, 2961 and 281542 s^{-1}, respectively). The parameters obtained are within the range of values established by the literature (53-259 kJ/mol) [3].

Table 1: Rate constants (k) and correlation coefficient (R^2) of different model for each biomass

Sample	T (°C)	k_{VM} (s^{-1})	R^2	k_{GM} (s^{-1})	R^2	k_{RPM} (s^{-1})	φ	R^2
AS	850	0.0007	0.9346	0.0006	0.9579	0.0006	6.34	0.9991
	875	0.0009	0.9301	0.0007	0.9535	0.0007	6.70	0.9996
	900	0.0003	0.9158	0.0003	0.9175	0.0008	7.09	0.9985
OS	850	0.0002	0.9956	0.0002	0.9996	0.0002	5.26	0.9765
	875	0.0003	0.9814	0.0003	0.9917	0.0003	5.39	0.9916
	900	0.0005	0.9782	0.0004	0.9897	0.0004	5.96	0.9930
H	850	0.0012	0.8779	0.0010	0.9080	0.0008	11.54	0.9940
	875	0.0020	0.9332	0.0017	0.9548	0.0011	14.11	0.9998
	900	1.6136	0.9763	0.0020	0.9253	0.0018	8.04	0.9963

References

[1] C.K.R. Pocha, W.Y. Chia, et al. *Fuel* **2023**, 340, 127472

[2] A. Fernandez, L.Rodriguez, et al. *Journal of Enviromental Chemical Engineering* **2020**, 8 (4), 103829

[3] M.P. González, R. García, et al. *Energy* **2018**, 155, 426-437

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