KINETIC STUDY OF THE REACTION OF DIFFERENT HARDWOOD SAWDUST CHARS WITH OXYGEN. CHEMICAL AND STRUCTURAL CHARACTERIZATION OF THE SAMPLES

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ABSTRACT

The reaction of sawdust chars prepared from three typical native hardwood species and lignin at different oxygen concentrations and reaction temperatures was studied by isothermic thermogravimetric analysis.

Samples composition was determined by proximate and ultimate analysis. Apparent surface areas of the devolatilized samples were evaluated from nitrogen and carbon dioxide adsorption isotherms by the BET method and applying the Dubinin-Radushkevich equation, respectively. Porosimetry and electronic scanning microscopy measurements were also carried out.

Chemically controlled reaction rates were satisfactorily fitted by a random pore model reported in the literature. Sawdust chars were found to be more reactive than those prepared from lignin and cellulose under similar reaction conditions. The effect of samples composition on the intrinsic activation energy values and reactivity data was analyzed. An expression which relates sawdust chars reactivity and samples carbon content was found. Furthermore, for each char, the reaction behavior at the different reaction temperatures was characterized.

NOTATION

C : gas concentration; [mol/m³]
dp : particle or sample diameter; [µm]
E : activation energy; [Kcal/mol]
ks : reaction rate constant for surface reaction; [(m³/mol)ⁿ m⁻²/sec]
L₀ : total length of the pore per unit solid volume at time zero; [m]
n : reaction order with respect to the gas; [-]
p : partial pressure; [atm]
Qg : total gas flow rate; [cm³/min]
Ro : initial particle radius; [μm]
S : reaction surface area per unit solid volume at any given time; [m²/m³]
S₀ : initial reaction surface area per unit solid volume; [m²/m³]
t : time; [sec]
T : reaction temperature; [K]
W₀ : initial weight; [mg]
W : final weight; [mg]
Wₘ : weight at any given time; [mg]
X : (W₀-Wₘ)/(W₀-Wₖ): char conversion; [-]

Greek letters
ε₀ : initial value of porosity
τ : dimensionless time parameter
ψ : structural parameter
σ : particle size parameter

INTRODUCTION

Interest in biomass as a fuel is growing up in many areas. Particularly, the quantity of wood and forest biomass available for energy is very large and constitute an attractive alternative source of energy supplies [1]. Thermal conversion processes of wood wastes, such as pyrolysis, combustion and gasification, are complex. Hence, a thorough knowledge of the reaction rates involved together with the solids characteristics is necessary in order to develop high efficiency and economically competitive technologies based on these reaction systems. The objective of the present work is to determine the kinetic parameters of the reaction with oxygen of sawdust chars, prepared from different typical native hardwood species, and lignin, one of wood major components, and the chemical and structural characteristics of the samples.

EXPERIMENTAL SECTION

Materials
Three characteristic hardwood species without bark were milled and sieved for carrying out the measurements. These were: Algarrobo Blanco (Prosopis Alba Gris), Lenga (Prosopis Caldenia Burk) and Caldén (Nothofagus Pumilio). Likewise, lignin obtained from a hardwood species was employed [2], [19].

Char Preparation
Chars were prepared by devolatilization of the original wood samples in an electric furnace at 883 K under a nitrogen stream. Samples were heated at a rate of 3 K/min to this temperature and then kept constant for 1 hour. The chars were cooled under flowing nitrogen to ambient temperature and sieved. The fractions corresponding to particle diameters lower than 88 μm were carefully stored under nitrogen atmosphere for carrying out kinetic measurements.

Samples Composition
Proximate analysis of the three wood species and their chars as determined by conventional ASTM techniques are shown in Table 1. Table 2 presents the ultimate analysis of the chars samples, dry and ash