EFFECT OF WOOD STRUCTURE ON THE CELLULASE HYDROLYSIS

Ivo Valchev, Stoyko Petrin, Nikolay Yavorov

Department of Pulp, Paper and Printing Arts

University of Chemical Technology and Metallurgy

8, Kliment Ochridski Blvd., Sofia 1756, Bulgaria

BACKGROUND

Biomass from plantations of fast growing tree species represents large renewable resources for lignocellulosic bioconversion.

One of the most popular fast growing trees are willow, poplar, eucalyptus, paulownia, etc.

The susceptibility of lignocellulosic substrates to cellulase depends on the structural features of the substrate including the cellulose crystallinity, the degree of cellulose polymerization, the surface area, and the lignin content.

PURPOSE

The aim of this study is to investigate the role of the wood structure on the efficiency of the cellulase hydrolysis of steam-exploded fast growing tree species.

OBJECT

The object of this investigation is to establish the suitability of fast growing hardwood species cultivated in Bulgaria as a potential sources of fermentable sugars for bioethanol production:

- *Populus alba;*
- *Salix viminalis rubra;*
- *Paulownia tomentose;*
- *Paulownia elongate.*

OBJECT

Experimental Stations for Fast-Growing Forest Species in Svishtov and Pazardjik

Paulownia elongate **(cultivated in the southern regions close to Greek and Turkish border)**

Methods

The tree species were analysed for cellulose (Kurschner et al. 1933), lignin (TAPPI standard T222 om-11), pentosans (T 223 cm-10), and ash (TAPPI standard T211 om-12).

The steam explosion pretreatment of wood chips was performed in 2 dm^3 stainless steel laboratory installation at hydromodul ratio 1:10; an initial temperature of 100ºC; a maximum temperature of 190 and 200ºC; heating time of 60 min followed by additional 10 min at the maximum temperature.

Methods

The cellulase complex NS 22086 and β-glucosidase NS 22118 were used in a ratio of 10:1 for the enzymatic hydrolysis. The enzymatic treatment was carried out at 50 °C, pH 5.0 – 5.6, 5% enzyme charge and reaction time 72 h.

The glucose content was analyzed by a Dionex HPLC system in accordance with the NREL standard biomass analytical procedure.

Experimental

Table 1. Chemical composition, density and glucose yield

	Lignin, %	Cellulose, %	Pentosans, %	Ash, %	ρ, kg/m^3	Cellulose to glucose conversion, %
Paulownia elongata	21.9	44.0	18.2	1.0	280	71
Paulownia tomentosa	20.2	39.2	23.8	1.4	290	66.6
Salix viminalis rubra	24.7	46.4	20.4	1.6	420	40.5
Populus alba	25.3	49.7	20.6	1.6	400	41.1

Correlations between chemical composition and cellulose to glucose conversion are not observed.

Experimental

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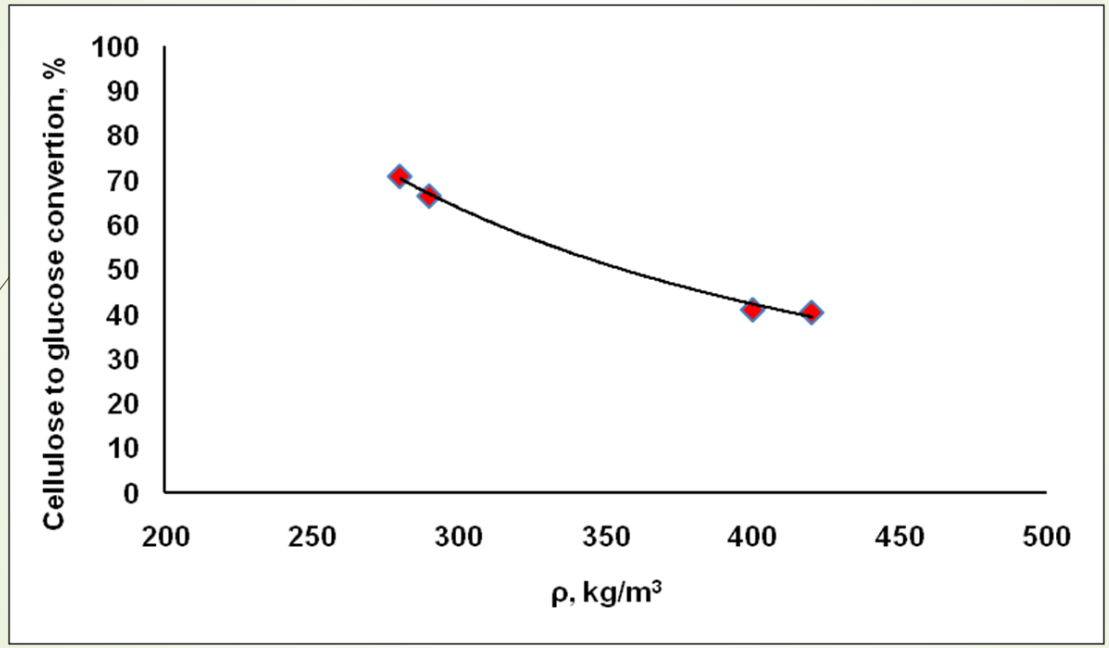
The enzymatic efficiency depends in the great extent on the wood density.

Experimental

Fig. 1. Dependence between wood density and cellulose to glucose conversion



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Experimental

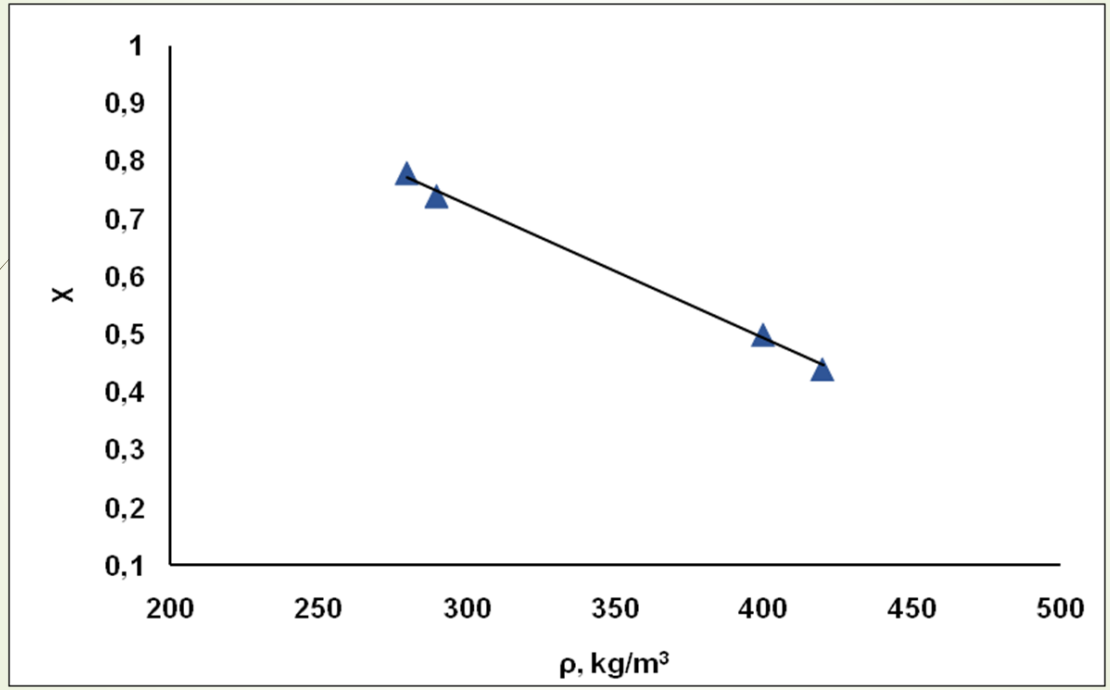
In all cases, the cellulase hydrolysis is described by the topochemical kinetic equation of Prout-Tompkins.

$$\frac{\alpha}{1-\alpha} = (k_1 . t)^{\chi}$$

Linear dependencies are obtained for the correlations between the wood density and the kinetic characteristics of the hydrolysis process (rate constants $\ln k_1$ and power factors χ, that characterizes the system).

Experimental

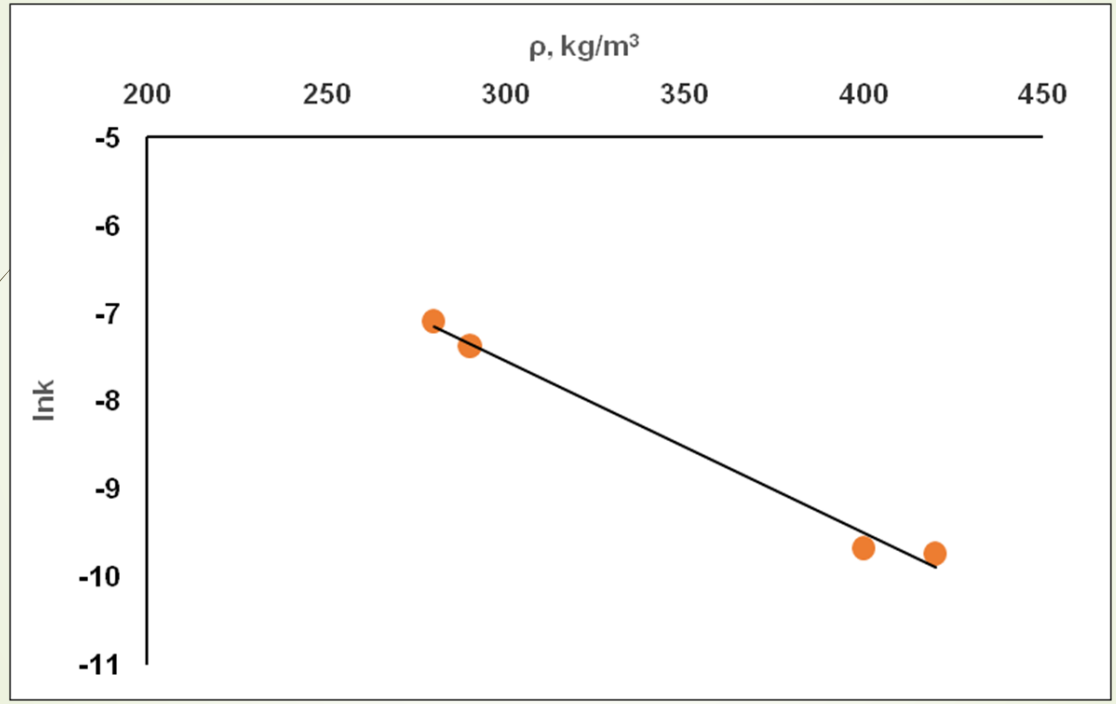
Fig. 2. Dependence between wood density and power factors χ



$$\frac{\alpha}{1-\alpha} = (k_1.t)^{\chi}$$

Experimental

Fig. 3. Dependence between wood density and $\ln k_1$



$$\frac{\alpha}{1-\alpha} = (k_1 . t)^x$$

CONCLUSIONS

The carried out investigation shows the significant effect of the wood structure and especially the wood density on the enzyme hydrolysis.

The chemical composition does not have a determining influence on the efficiency of the enzymatic process.

Due to the specific structure and lowest density Paulownia elongata is the perfect source for bioethanol production.

Tank you for your attention!