

Structural Variation of Lignin and Lignin–Carbohydrate Complex in Eucalyptus grandis × E. urophylla during Its Growth Process

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ACS Sustainable Chemistry & Engineering

DOI: 10.1021/acssuschemeng.6b02396

Published: 01/01/2017

Peer reviewed version

Cyswllt i'r cyhoeddiad / Link to publication

Dyfyniad o'r fersiwn a gyhoeddwyd / Citation for published version (APA): Zhao, B.-C., Chen, B.-Y., Yang, S., Yuan, T.-Q., Charlton, A., & Sun, R.-C. (2017). Structural Variation of Lignin and Lignin–Carbohydrate Complex in Eucalyptus grandis × E. urophylla during Its Growth Process. ACS Sustainable Chemistry & Engineering, 5(1), 1113-1122. https://doi.org/10.1021/acssuschemeng.6b02396

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Quantification of the functional groups (mmol/g) in the lignins of L and PL using a quantitative 31 P-NMR method

	Al-OH	S-type OH		G-type OH		H-type OH	СООН	Active sites ^c
		C ^a	NC ^b	С	NC			
L	1.48	0.16	0.47	0.23	0.93	0.68	1.48	2.29
PL	0.24	0.25	0.58	0.21	0.77	3.14	0.61	7.05

^aC, condensed.

^bNC, non-condensed.

^cActive sites means that how much of active sites available for the subsequent chemical modification; Active sites = G-type OH (NC) + H-type OH \times 2.

The element analysis of lignins

	Elements contents (%)			
Samples	С	Н	Ν	S
L	63.48	5.83	-	-
SAPL-1.0	61.16	6.44	8.37	8.60
SAPL-1.5	58.28	7.63	8.38	11.98
SAPL-2.0	57.50	7.64	10.12	14.10
SAL-1.5	60.84	6.64	5.40	4.39

Adsorption capacities of Pb (II) by some lignin-based materials reported in literatures.

Adsorbent	Adsorption capacity (Pb ²⁺)	References
Black liquor lignin	89.5	10
Dithiocarbamate functionalized lignin	103.4	17
Alkali glycerol lignin	9.0	18
Ammoniated and sulfonated lignin	53.9	20
Formic lignin	122.3	21
Aminated epoxy-lignin	55.4	42
Porous lignin-based sphere	27.1	43
SAPL-1.5	130.2	Present study

Langmuir and Freundlich model fitting parameters for Pb (II) adsorption on SAPL-1.5.

Isotherm model	Parameter	Value
	$Q_{\rm m}({\rm mg/g})$	136.9
Langmuir model	$K_{\rm L}$ (L/mg)	0.2099
	R^2	0.9940
	$Q_{\rm m}({\rm mg/g})$	163.2
	$K_{\rm F}~({\rm mg/g})({\rm L/mg})^{1/{\rm n}}$	45.7752
Freundlich model	n	3.8864
	R^2	0.9677

Adsorption kinetics fitting results for Pb (II) on SAPL-1.5 by pseudo-first-order and pseudo-second-order models.

Isotherm models	Parameters	Values
	$Q_{\rm e}({ m mg/g})$	132.3
Pseudo-First-Order Model	<i>k</i> ₁ (/min)	0.3047
	R^2	0.7618
	$Q_{\rm e}({ m mg/g})$	108.7
Pseudo-Second-Order Model	$k_2 \times 10^{-2} [g/(\text{mg·min})]$	0.1889
	R^2	0.9978