Electronic Supplementary Material (ESI) for RSC Advances.

Supporting information

Improvement of wood material properties via in-situ polymerization of styrene into tosylated cell walls

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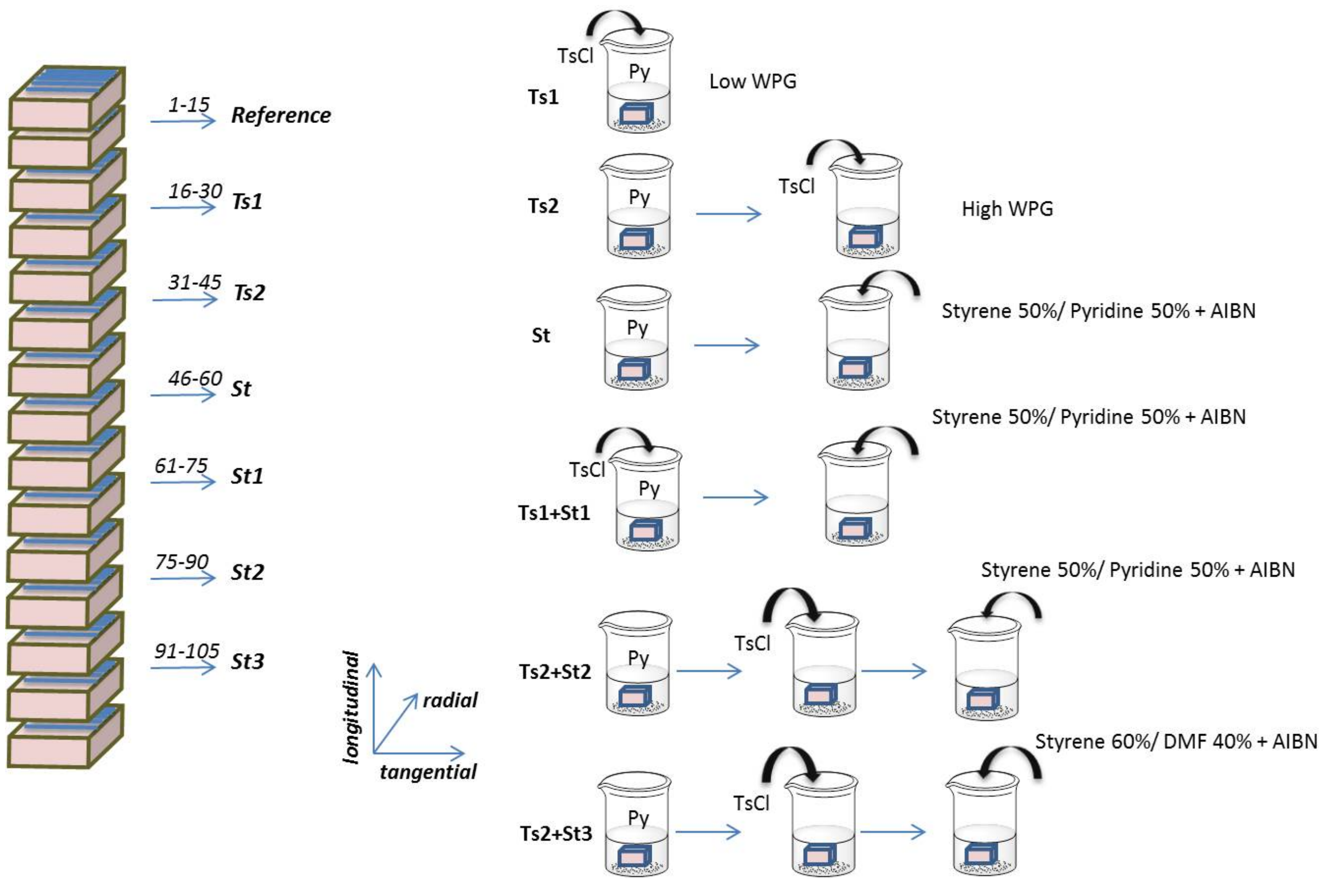


Figure S1. Left: wood sampling: fifteen (1x1x0.5 cm^3) wood cubes for each set cut from spruce, in the longitudinal direction. Right: schematic representation of experimental flow. Ts1 (tosylation – low WPG), Ts2 (tosylation – high WPG), St (Styrene polymerization without tosylation pre-treatment), St1 (low WPG tosylation + styrene polymerization), St2 (high WPG tosylation + styrene polymerization), St3 (high WPG tosylation + styrene polymerization).

$S(\%) = \frac{(V_i - V_{ii})}{V_{ii}} \times 100$	$ASE(\%) = \frac{S_{um} - S_m}{S_{um}} \times 100$	$WU(\%) = \frac{(w_{ii} - w_i)}{w_i} \times 100$
where S(%): volumetric swelling; V_i: wood volume after wetting with liquid water; V_{ii}: wood volume of oven-dried samples before wetting	where ASE(%): antishrinking/antiswelling efficiency resultin from the modification; S_m: modified volumetric swelling coefficient; S_{um}: unmodified volumetric swelling coefficient.	where WU(%): percentage of water uptake of the samples; w_i: initial weight of the sample; w_{ii}: wet weight of the sample after water-soaking

Figure S2. Equations for Swelling (S), Anti-swelling efficiency (ASE), and Water Uptake (WU)

$$EMC(\%) = \frac{(m - m_{od})}{m_{od}} \times 100$$

where EMC: is the moisture content;
m is the mass of the wood (with moisture) and
m_{od} is the oven-dry mass of the wood (i.e. no moisture)

Figure S3. Equation for Equilibrium Moisture Content (EMC).

<u>Raman imaging and spectroscopy - Advanced Fitting tool:</u>

The tool for advanced fitting (WitecPlus software) allows spectra to be fitted with Gaussian curve function. First dataset was background subtracted, and used to fit polystyrene curve at 1005 cm^{-1} to the data set by keeping the width of the curve constant.

(a)

$$y = y_0 + \sum_{i=0}^{n-1} Amp_i e^{-0.5\left(\frac{x-x_i}{s_i}\right)^2}$$

$$w_i = s_i \sqrt{8\ln(2)}$$

$$A_i = Amp_i s_i \sqrt{2\pi}$$

n = *Number of Gauss Functions*
y_0 = *Offset*
x_i = *Center*
s_i = *Width (Standard Deviation)*
Amp_i = *Amplitude*
w_i = *Width (FWHM)*
A_i = *Area*

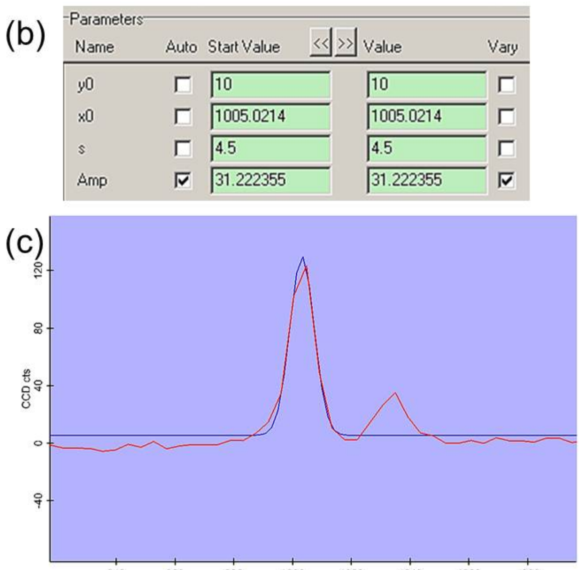
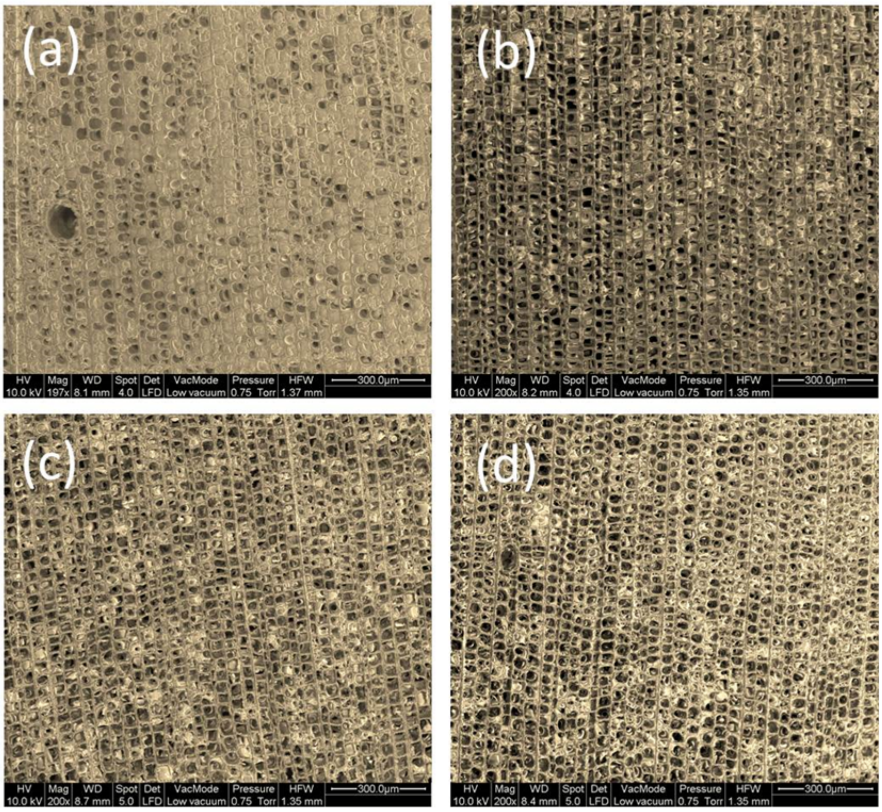


Figure S4: (a) Gaussian function and nomenclature of parameters used in the function. (b) parameter values to obtain related polystyrene image. (c) Gaussian fit of polystyrene curve at 1005 cm^{-1} in the data set.

WPG% / Area Fraction Analysis:



(e)

	Image area (mm²)	Filled area (mm²)	Cell wall area (%)	Cell wall area (mm²)	Polymer area (mm²)	WPG (%)	M (untreated wood) (g)	M (PSt added) (g)	M (PSt) in lumen (g)	M (PSt in the cell wall) (g)	% of PSt in the cell wall (%)
St	1,712	1,368	37,13	0,636	0,732	38,8	10,00	3,88	3,88	0,00	0,0
St1	1,712	1,27	35,33	0,605	0,665	35,7	10,00	3,57	3,52	0,05	1,3
St2	1,712	0,959	38,11	0,652	0,307	19,7	10,00	1,97	1,62	0,35	17,6
St3	1,712	1,093	38,1	0,652	0,441	30,2	10,00	3,02	2,34	0,68	22,7

Figure S5: SEM images of (a) St, (b) St1, (c) St2, and (d) St3 samples used for semi-quantitative polymer WPG% determination in the cell walls. (e) WPG% and area values to calculate polymer content in cell walls.

From the SEM pictures, we can determine the area occupied by the cell wall material (Cell wall area), and the area occupied by the polymer in the lumen (Polymer area).

(Polymer area) = (Filled area)-(Cell wall area)

From the total weight percent gain determined after full modification, we know exactly how much polymer (in grams) was added to the wood. Assuming that for experiment St (no pretreatment), the polymer added is only located in the lumen part (which is consistent with literature), we can calculate the amount of polymer located in the lumen of other experiments (M (PSt) in lumen) as a function of the area occupied by the polymer on the SEM picture.

(M (PSt) in lumen) = (Polymer area of St1)/ (Polymer area of St) x (M (PSt) in lumen for St)

Once we have the weight of polymer in the lumen, we can get to the weight of polymer in the cell wall since we know the total amount of polymer:

M(PSt in the cell wall) = M (PSt added) – M(PSt in the lumen)

% of Pst in the cell wall = M (Pst in the cell wall)/ M (Pst added) x 100