SUPPLEMENTARY INFORMATION

Adhesion-Related Properties of Silver Birch (*Betula Pendula* ROTH) Wood as Affected by Hydrophilic Extraction

Journal: Wood Science and Technology
Journal of the International Academy of Wood Science

Authors:

Max ENGELHARDT[1,*]
orcid.org/0000-0002-9781-7476 (engelhardt@hfm.tum.de)

Hans Albert GILG[2]
orcid.org/0000-0003-4304-9763 (agilg@tum.de)

Klaus RICHTER[1]
orcid.org/0000-0002-6583-0254 (richter@hfm.tum.de)

Antoni SANCHEZ-FERRER[1,*]
orcid.org/0000-0002-1041-0324 (sanchez@hfm.tum.de)

[1] Chair of Wood Science, TUM School of Life Sciences, Technical University of Munich

[2] Department of Civil Geo and Environmental Engineering, TUM School of Engineering and Design, Technical University of Munich

Figures

Tables

Experimental Section

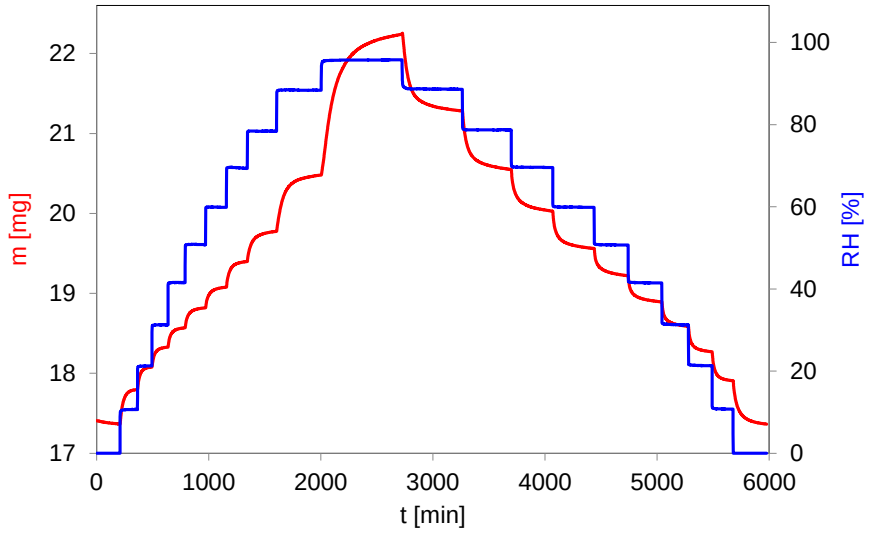

Figure SI–1: Exemplary sequence of a DVS experiment with measured RH in blue and specimen mass in red.

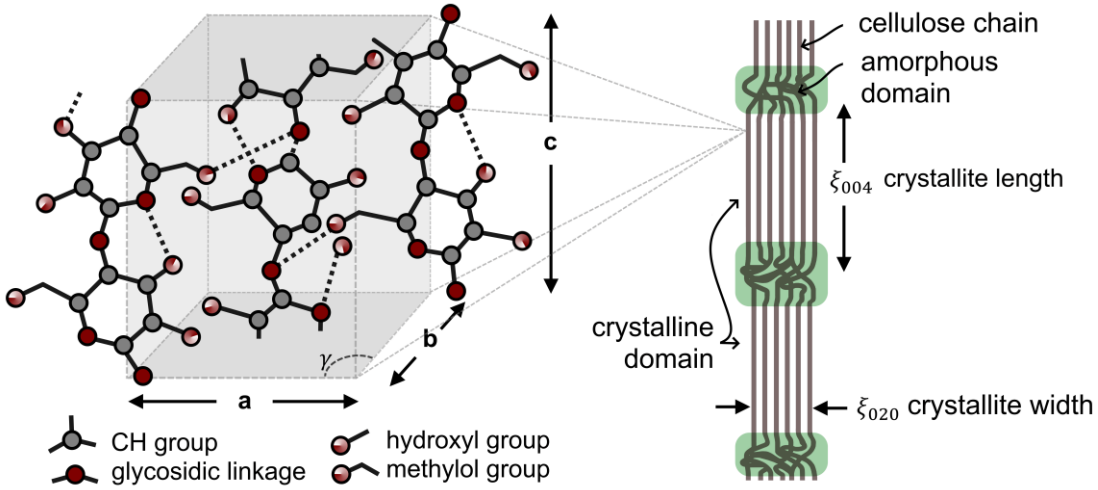

Figure SI–2: Schematic of crystallite unit cell and crystallite lengths of crystalline cellulose domains (artwork based on Zabler *et al.* (2010)).

Moisture interaction

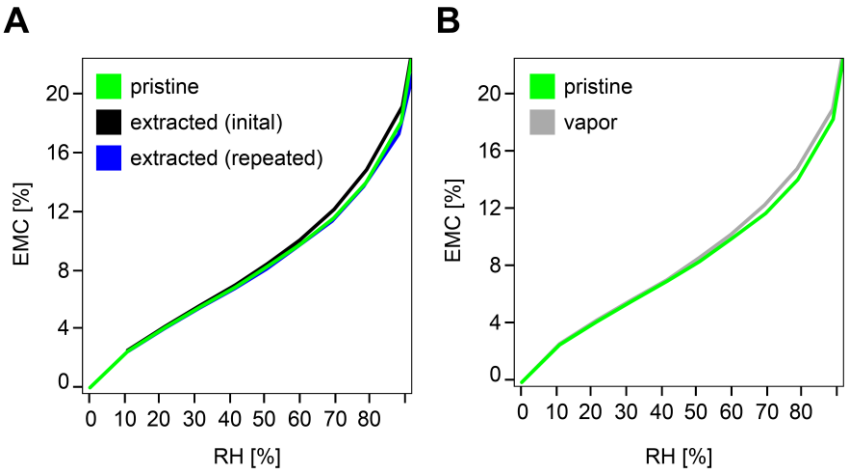

Figure SI–3: Moisture isotherms of birch wood in adsorption for (A) specimens before and after extraction treatments and (B) specimens before and after vapor treatment, EMC per dry specimen mass as a function of RH.

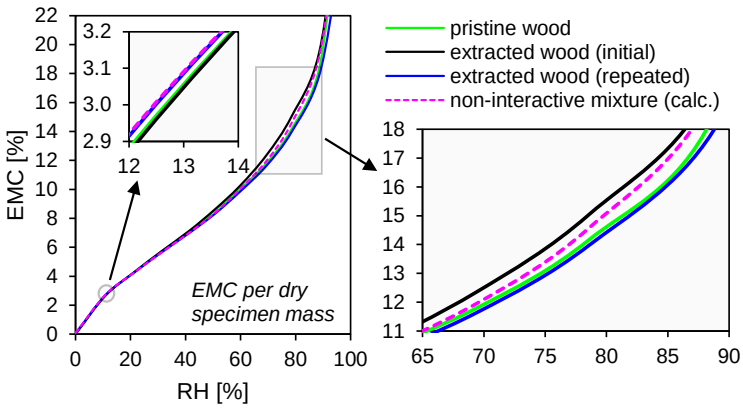

Figure SI–4: Moisture isotherms in adsorption of pristine birch wood and after extraction, EMC per dry specimen mass as a function of RH.

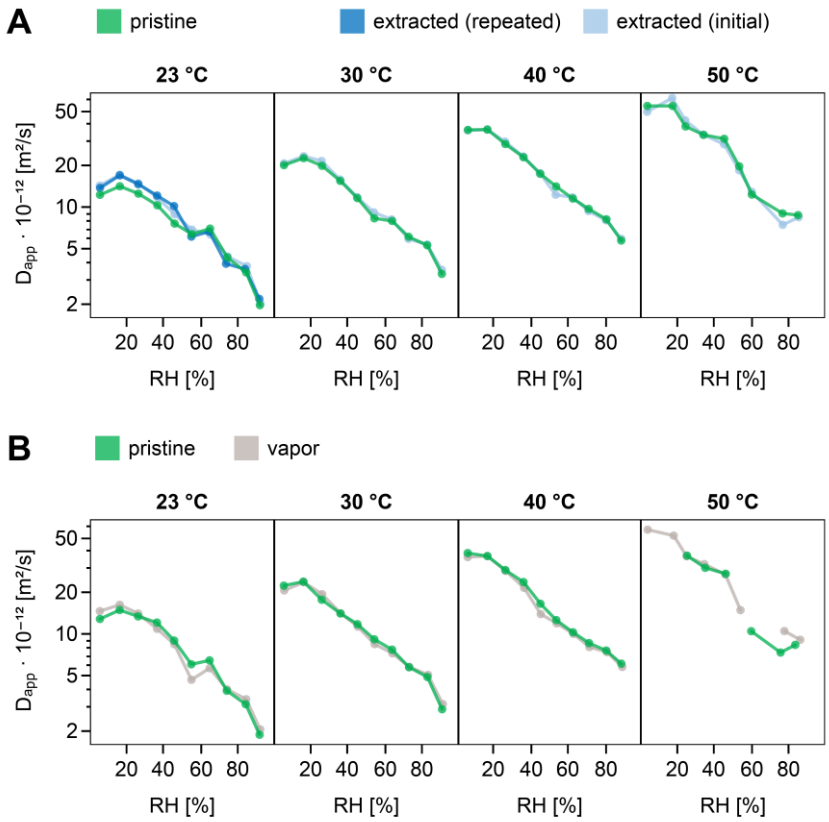

Figure SI–5: Apparent diffusivity D_{app} in adsorption (calculation following DSE model in Appendix 1 of Sánchez-Ferrer *et al.* 2023) of birch sapwood discs at ambient temperatures of 23 – 50 °C (A) before and after extraction treatment or (B) vapor treatment as a function of RH.

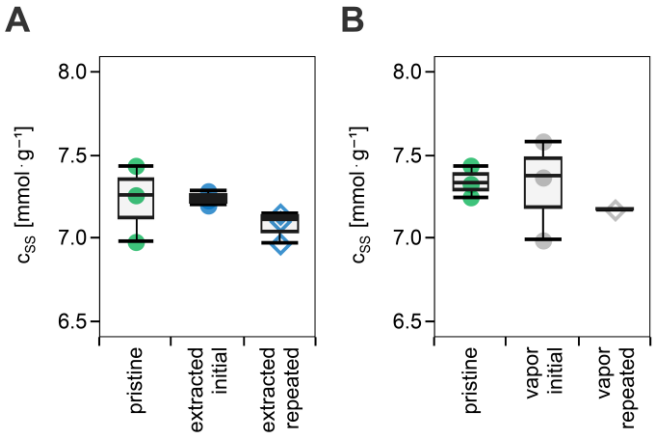

Figure SI–6: comparision of sorption isotherm analysis results of identical specimens (A) prior and after extraction treatment and (B) vaport treatment: soprtion site density c_{SS}, based on the SSO model.

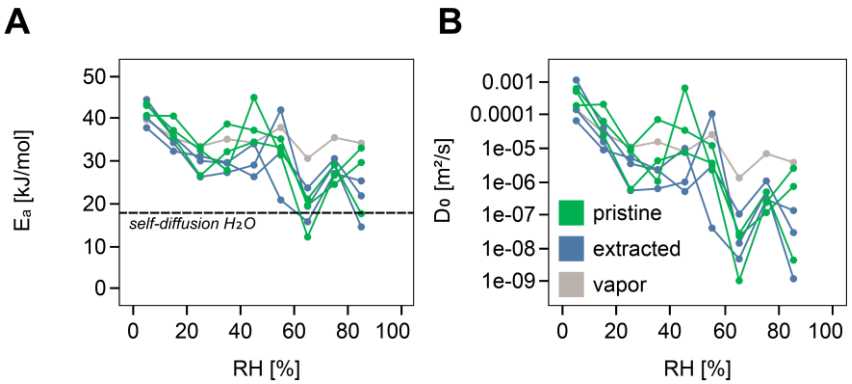

Figure SI–7: (A) Activation energy of diffusion E_a and (B) the corresponding pre-exponential factor of birch sapwood discs before (pristine) and after extraction treatment or vapor treatment as a function of RH. Each curve represents an individual specimen's evaluation result.

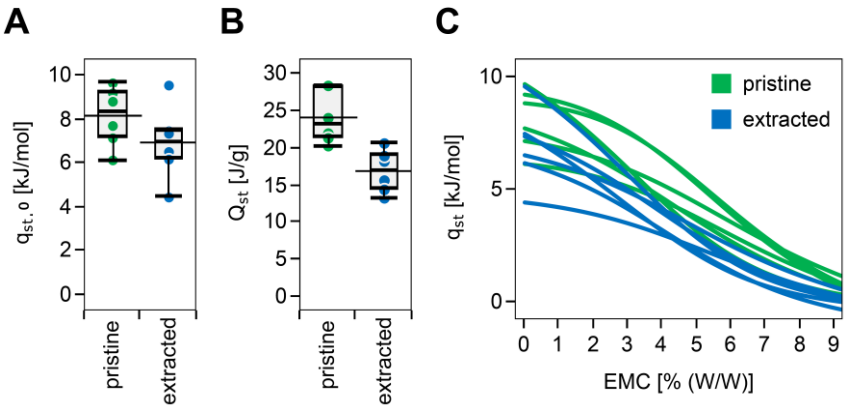

Figure SI–8: Evaluation results of net isosteric heat: (A) Distribution of $q_{st,0}$ and (B) Q_{st} for pristine and extracted wood specimens.(C) Progression of q_{st} in adsorption as a function of EMC.

Swelling behavior

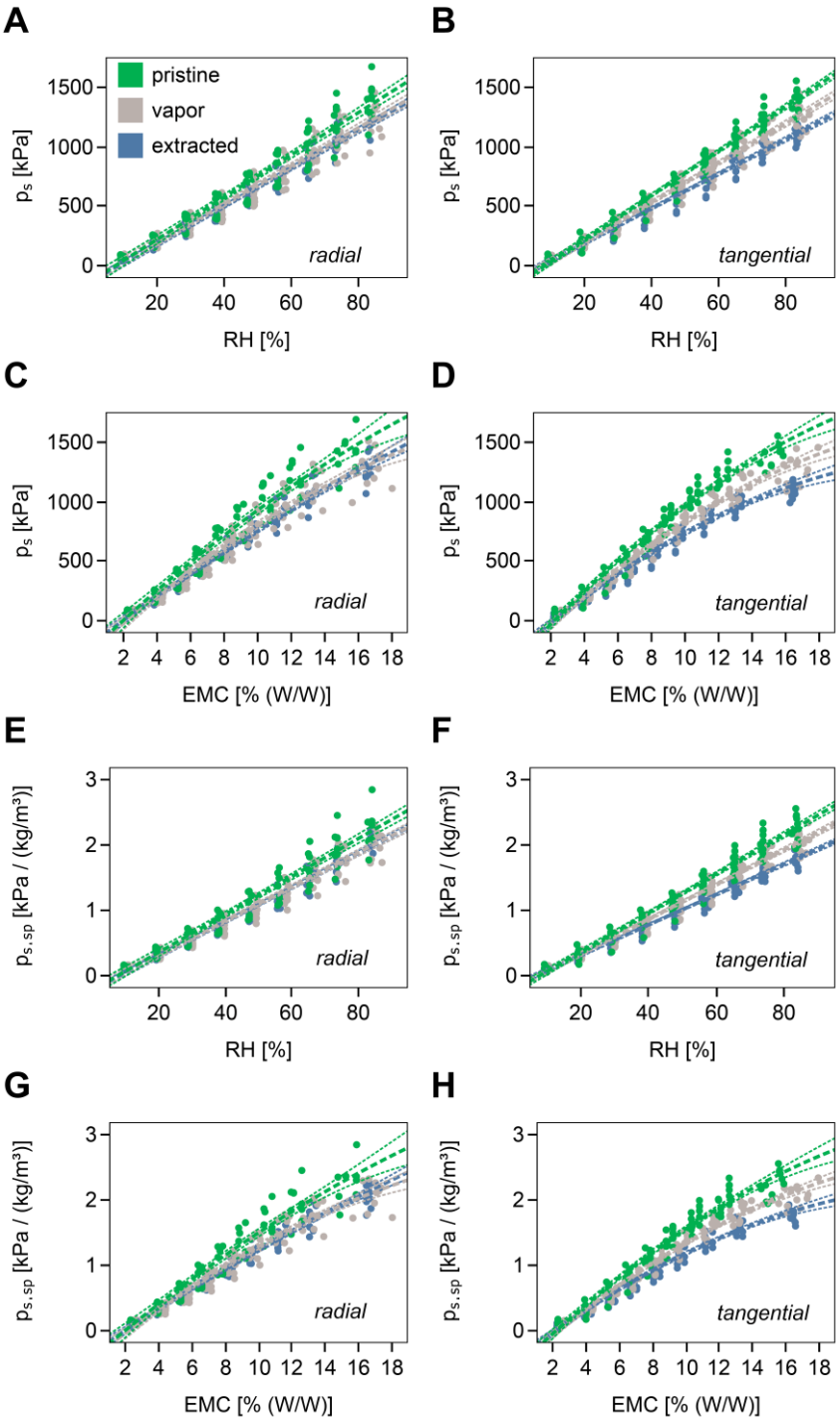

Figure SI–9: Swelling pressure experiments: Pressure and density-specific pressure as functions of RH and EMC.

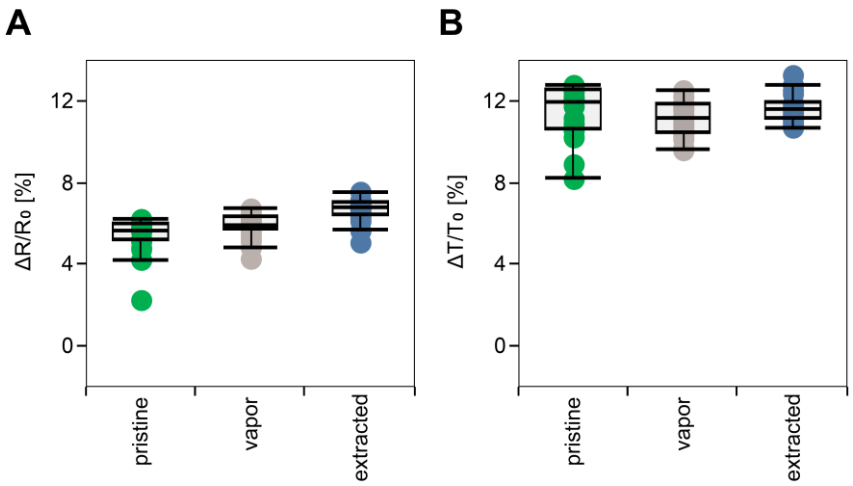

Figure SI–10: Distribution of swelling ratios from a dry state to fiber saturation point of cubic birch wood specimens in (A) radial, and (B) tangential direction.

Microstructural Analysis

Table SI–1: X-ray diffraction evaluations: average scattering peak position (q), distance (d), and correlation length (ξ) values for each peak after deconvolution for the pristine, vapor- and watertreated specimens.

peak	q [nm^{-1}]			d [nm]			ξ [nm]		
	pristine	**vapor**	**extracted**	**pristine**	**vapor**	**extracted**	**pristine**	**vapor**	**extracted**
$q_{1\bar{1}0}$	10.4	10.7	10.5	0.60	0.59	0.60	3.2	3.1	3.2
q_{110}	11.6	11.8	11.7	0.54	0.53	0.54	3.8	4.5	4.1
q_{020}	15.7	15.7	15.7	0.40	0.40	0.40	3.3	3.3	3.3
q_{004}	24.3	24.4	24.4	0.26	0.26	0.26	25.2	19.9	19.5
q_{A1}	13.9	13.7	13.7	0.45	0.46	0.46	0.80	0.76	0.77
q_{A2}	24.5	24.6	24.5	0.26	0.26	0.26	2.4	2.3	2.3

Table SI–2: X-ray diffraction evaluations: Monoclinic lattice parameters (a, b, c, and γ) and the degree of crystallinity χ for the pristine, vapor- and watertreated specimens.

	pristine	**vapor**	**extracted**
a [Å]	8.05	8.03	8.05
b [Å]	8.18	7.87	8.05
c [Å]	10.33	10.31	10.32
γ [°]	96.4	96.1	96.4
χ [%]	61.3	58.3	59.2

Surface Properties

Table SI–3: Dynamic wetting of adhesives on birch wood – Shi and Gardener model (Eq. 12) coefficients.

adhesive	**wood type**	**θ_i [deg]**		**θ_e [deg]**		**$K \cdot 10^3$**		***n***
		avg.	**± *cov***	**avg.**	**± *cov***	**avg.**	**± *cov***	
MUF	pristine	94	± *5%*	57	± *11%*	19	± *35%*	*10*
	extracted	96	± *6%*	62	± *6%*	27	± *45%*	*10*
PUR	pristine	112	± *5%*	60	± *5%*	26	± *34%*	*10*
	extracted	115	± *8%*	63	± *3%*	23	± *26%*	*10*

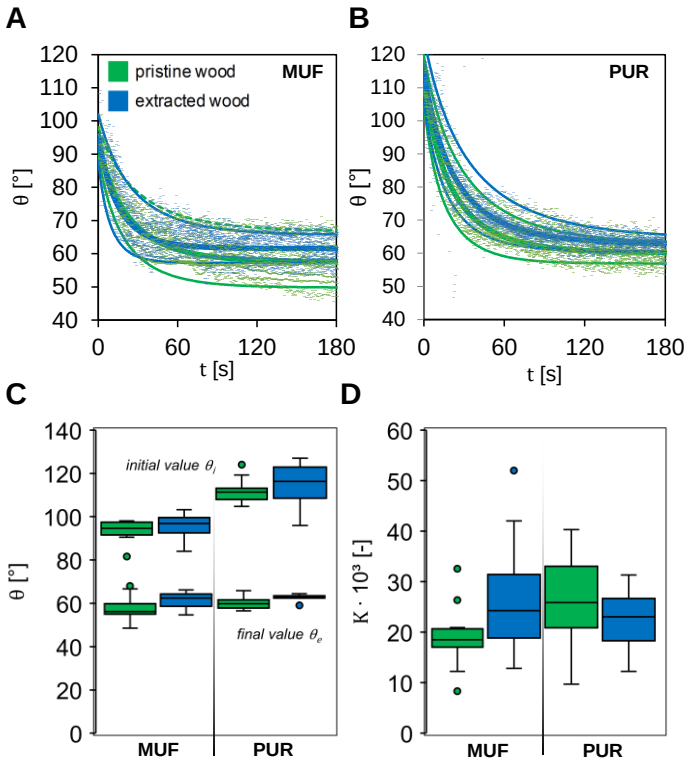

Figure SI–11: Contact angle development of MUF and PUR adhesive on pristine and extracted birch wood surfaces.

Table SI–4: Specific retention volumes V_G, free energies of adsorption ΔG_a and specific interaction parameters I_{sp} of probe gases in inverse gas chromatography experiments

Probes	**X_t**	**Pristine wood sample**			**Extracted wood sample**		
		V_G	**ΔG_a [kJ/mol]**	**I_{sp} [kJ/mol]**	**V_G**	**ΔG_a [kJ/mol]**	**I_{sp} [kJ/mol]**
Hexane	6	0.59	-1.326	–	0.82	-0.499	–
Heptane	7	1.75	1.386	–	2.33	2.101	–
Octane	8	5.19	4.082	–	6.78	4.744	–
Nonane	9	15.23	6.75	–	20.54	7.493	–
Isooctane	7.4	1.74	1.369	–	2.02	1.738	–
Cyclooctane	8.32	10.13	5.739	–	14.72	6.666	–
Chloroforme	3.21	2.93	2.664	11.5	4.52	3.74	11.7
Acetone	3.61	135.56	12.17	19.9	153.99	12.486	19.4
i-Propanol	3.78	16.48	6.946	14.2	33.56	8.709	15.2
Me-Acetate	4.47	84.52	10.999	16.4	115.82	11.78	16.4
Ether	4.77	0.86	-0.385	4.2	1.50	0.998	4.8
THF	4.85	8.30	5.247	9.7	12.53	6.267	9.9
benzene	4.88	2.49	2.264	6.6	4.02	3.447	7.0

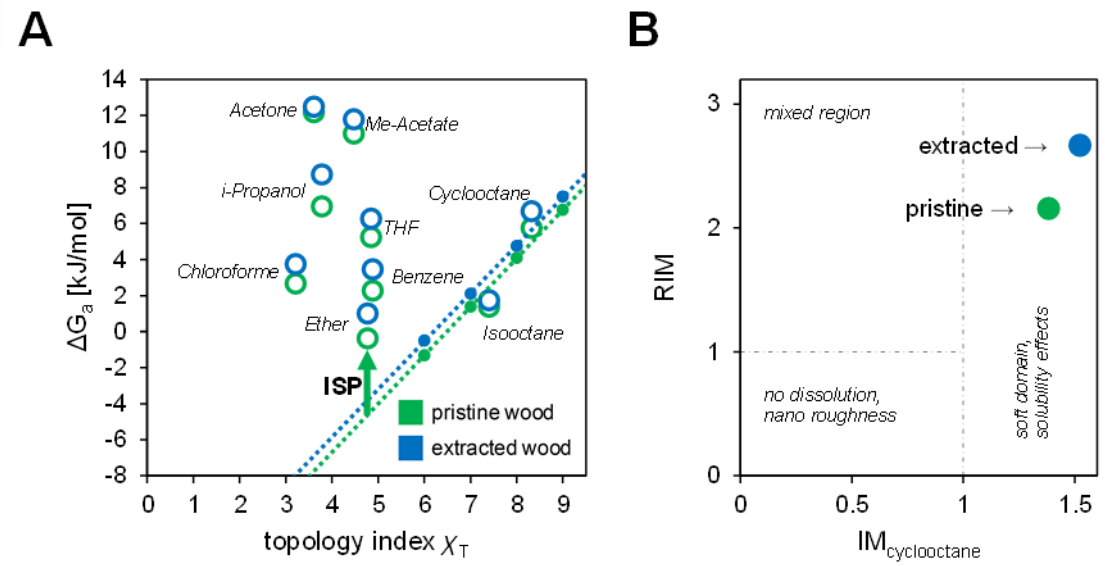

Figure SI–12: Results of inverse chromatography: (A) Free enthalpy of adsorption ΔG_a for various probe gases as a function of the topology index χ_T. Filled dots show results from the alkane series (hexane – nonane) for γ_s^d calculation. The vertical distance of polar probe gases to the linear regression lines is the specific interaction ISP (indicated exemplary for diethyl ether with an arrow); (B) Relative Morphology Index (RIM) plotted over Morphology Index ($IM_{cyclooctance}$).

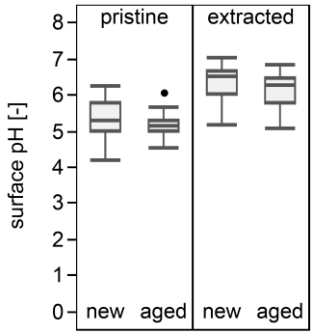

Figure SI–13: Distribution of pH measurements on pristine and extracted surfaces after aging (20–30 d) or new surfaces (cut with microtome).

Mechanical Properties

Table SI–5: Compression measurements: results of modulus of elasticity E

loading direction	**specimen ID#**	**E [GPa]**		
		pristine	**vapor**	**extracted**
longitudinal	017	19.3	22.1	18.1
	021	19.9	16.5	16.4
	041	14.3	13.3	16.3
	046	19.1	17.7	18.5
	048	15.4	15.8	12.7
	061	24.6	24.0	20.5
	076	25.5	22.3	18.5
	085	16.2	13.8	16.6
radial	011	1.23	1.15	1.11
	016	1.16	1.09	1.17
	020	1.22	1.11	1.06
	039	1.42	1.33	1.46
	044	1.27	1.17	1.25
	049	1.19	1.14	0.97
	063	1.13	1.06	0.68
	073	1.36	1.30	1.19
	074	1.38	1.25	1.17
	081	1.05	0.99	0.89
tangential	132	0.53	0.49	0.60
	141	0.59	0.54	0.48
	158	0.79	0.77	0.64
	168	0.67	0.60	0.70
	179	0.60	0.57	0.44
	188	0.64	0.57	0.57
	191	0.64	0.61	0.59