SUPPLEMENTARY INFORMATION

Table S1 Assignment of FTIR peaks for lignin extracted from holm oak.

Assignment	Vibration	Wavenumber / cm^{-1}
Phenolic + alcoholic OH	O-H stretching	3550-3100
CH_2 + CH_3	C-H stretching	2940-2935/2896-2840
Unconjugated + Acetyl Carbonyls	C=O stretching	1730
Aromatic backbone vibrations (S > G)	C-C stretching	1595
Aromatic backbone vibrations (G > S)	C-C stretching	1514
S ring breathing	C-C breathing	1326-1324
G ring breathing	C-C breathing	1257
Aryl + alkyl ether bonds	C-O stretching	1219
Aromatic in plane deformation (S)	In plane C-H deformation	1110
Aromatic in plane deformation (G)	In plane C-H deformation	1031

Table S2 Number-average, weight-average molecular weights and polydispersity of holm oak extracted lignin compared with other GVL extracted lignin found in the literature.

Biomass	Solvent System	Reaction Conditions	M_n (g mol^{-1})	M_w (g mol^{-1})	PDI	Reference
Holm Oak	GVL:H_2O [50:50 (w:w)]	170° C, 2h	835	2156	2.6	This work
Eucalyptus Globulus	GVL:H_2O [50:50 (w:w)]	180° c, 2.5 h	915	2437	2.7	[1]
Cotton Stalk	GVL:H_2O [60:40 (w:w)] 10 mM H_2SO_4	170° C, 1h	220	610	2.8	[2]
Masson pine	GVL:H_2O [80:20 (w:w)] 75 Mm H_2SO_4	150° C, 1h	1172	5980	5.1	[3]

Hybrid Poplar	GVL:H_2O [90:10 (w:w)] 85 mM H_2SO_4	120 °C 1h	841	2883	3.4	[4]
Eucalyptus Camaldulensis Dehnh	GVL:H_2O [80:20 (w:w)] 20 Mm H_2SO_4	120° C, 1h	1320	1900	1.4	[5]
Hybrid Pennisetum	GVL 5 mM H_2SO_4	100° C, 2h	5310	6350	1.2	[6]

Figure S1 Electrochemical characterization of LHC-LGN composite electrode in Na half-cells: (a) Cyclic voltammetry curves at different scan rates between 0.1 mV s^{-1} and 1.0 mV s^{-1}; (b) Relationship between log *i* and log *v*;(c) Percentage of capacitive and diffusive contributions during sodiation as a function of the potential at scan rates of 0.1 mV s^{-1}.

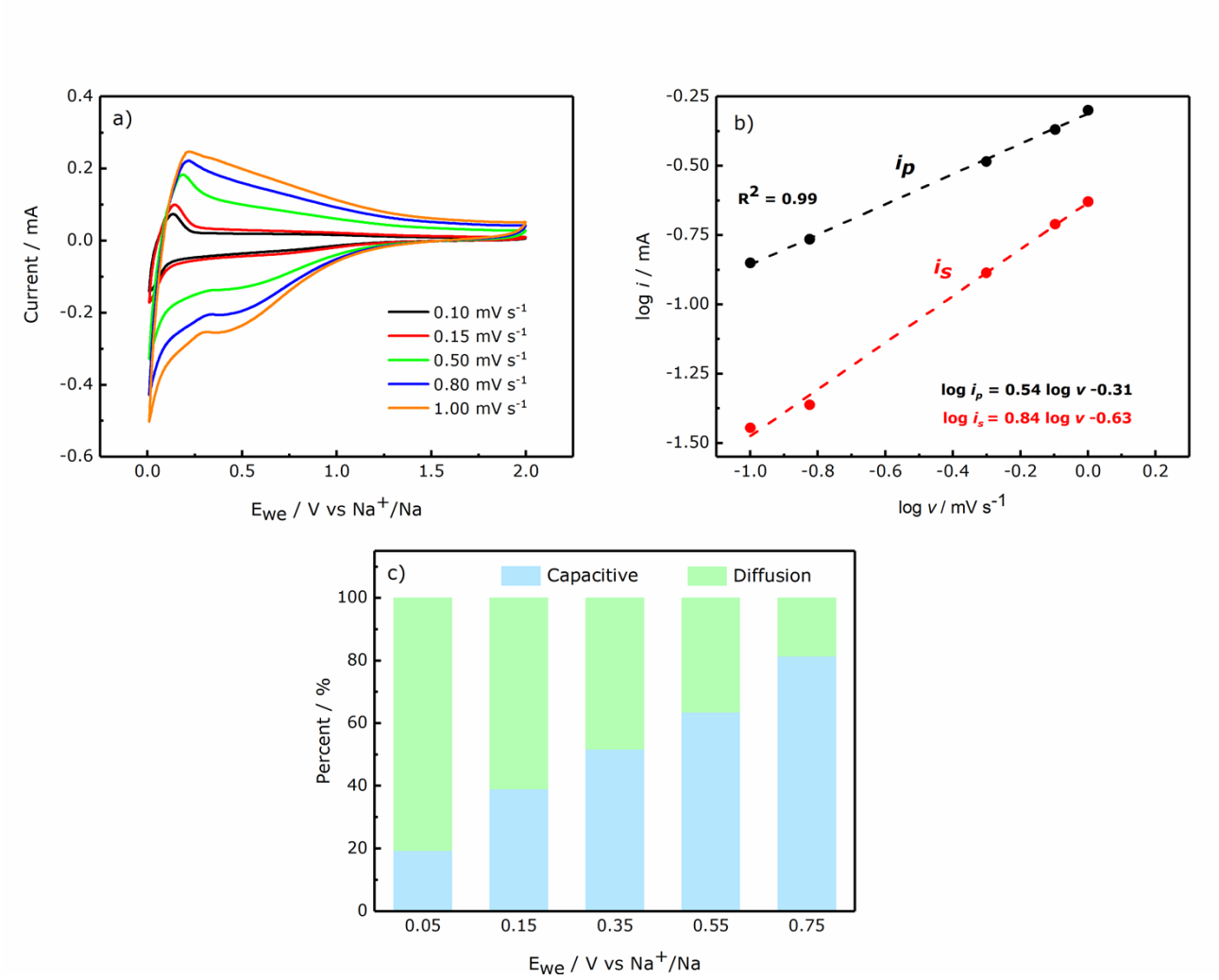

Figure S2 Charge/discharge comparison of LHC with different binders (lignin, PVDF and Na-CMC) in Na half-cells at 1C.

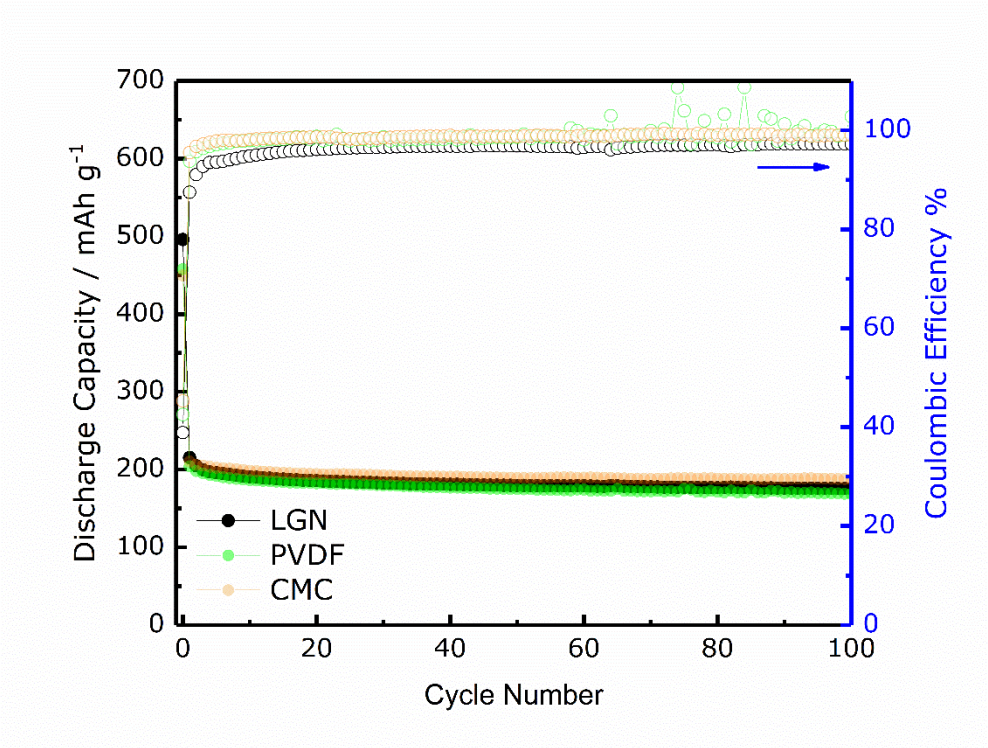

Table S3 First cycle discharge capacities, initial coulombic efficiencies %, second cycle discharge capacities and capacity retentions after 100 cycles of LHC electrodes with different binders at 1C.

Electrode	Discharge Capacity 1st cycle (mAh g^{-1})	ICE (%)	Discharge Capacity 2nd cycle (mAh g^{-1})	Capacity Retention after 100 cycles (%)
LGN	496.0	38.9	215.5	90.6
PVDF	458.0	42.6	204.4	90.6
CMC	449.8	45.3	210.5	92.5

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