Electronic Supplementary Material (ESI) for Green Chemistry.

Supporting Information

Environmentally Sustainable, High-Performance Lignin-Derived Universal Adhesive

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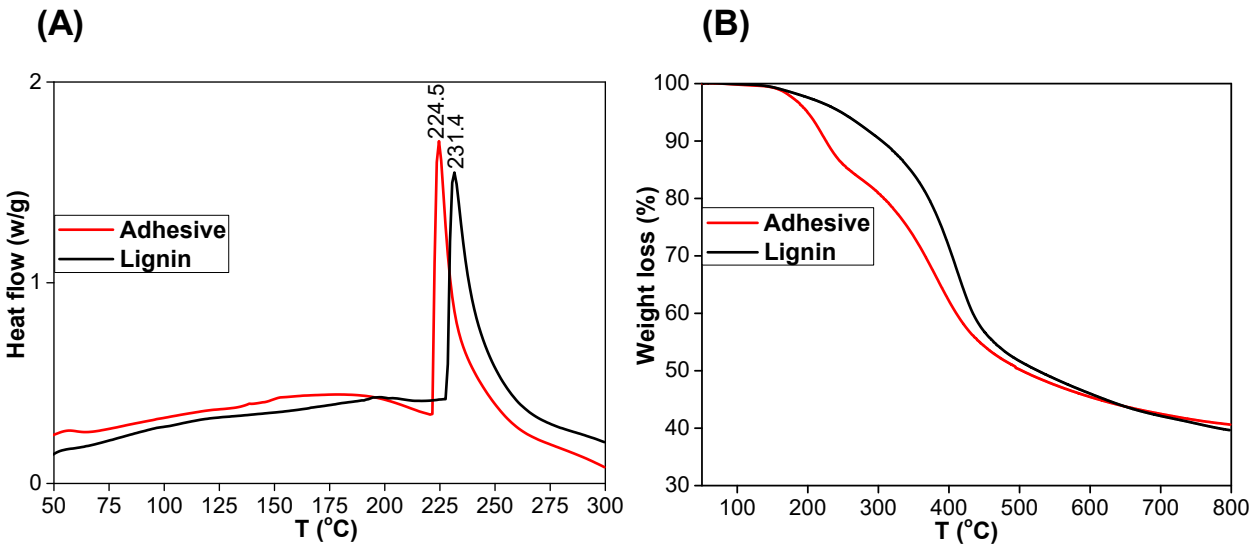

Fig. S1 Characterization of lignin-based universal adhesive. (A) DSC curves of lignin and adhesive, and (B) TGA curves of lignin and adhesive in N_2 atmosphere. The adhesive in A, and B refers to the recipe with lignin:acrylic acid of 1.0:1.0 wt/wt.

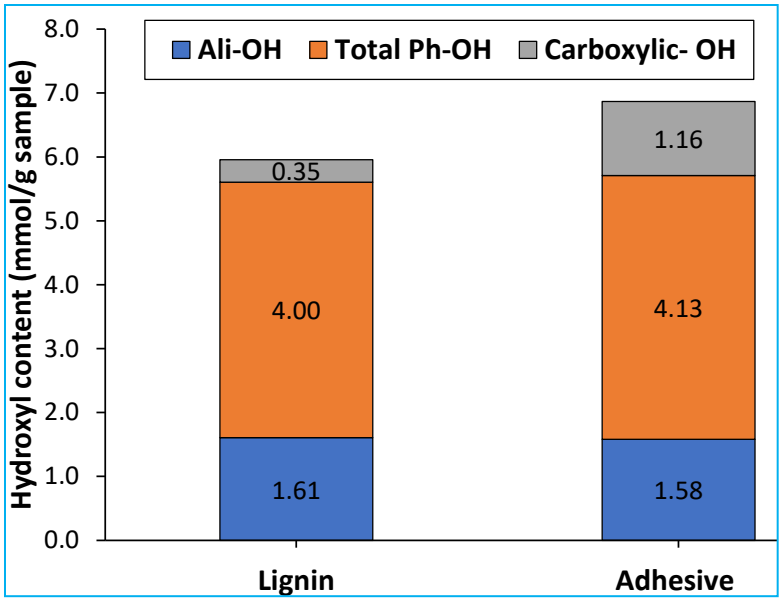

Fig. S2 Total hydroxyl contents in lignin and adhesive (lignin: AA, 1.0:1.0 wt/wt) as determine by using ^{31}P NMR spectroscopy.

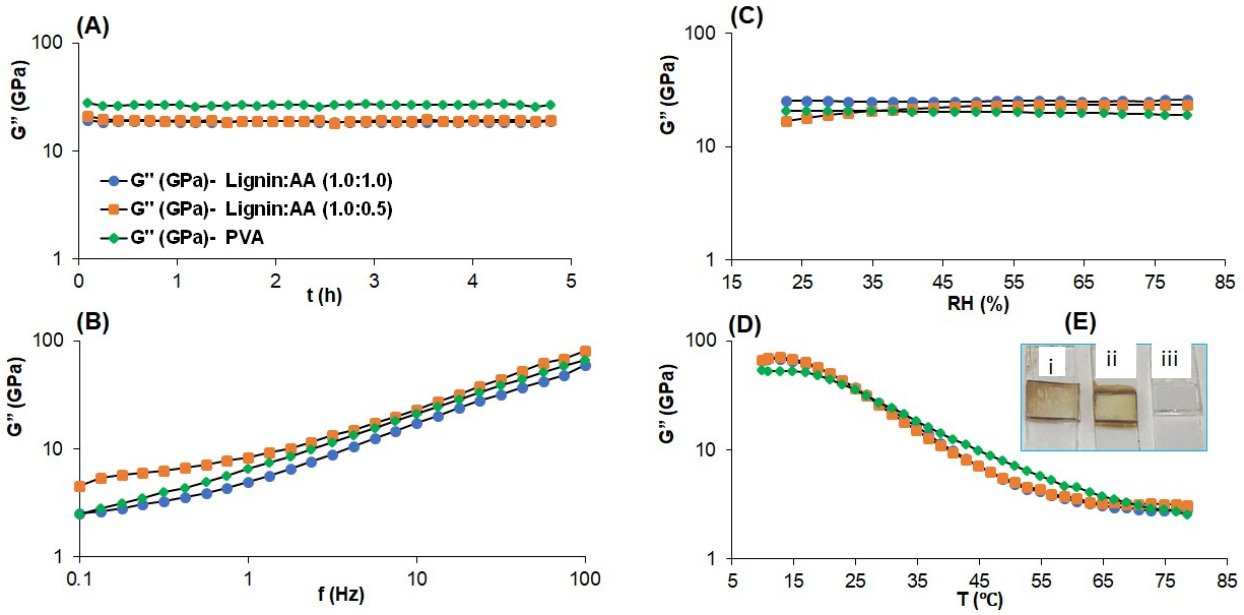

Fig. S3 DMTA of adhesives (lignin:acrylic acid (AA) of 1.0:1.0 and 1.0:0.5, wt/wt). (A) Time sweep at 25 °C and 30% RH with a frequency of 10 Hz, (B) Frequency sweep at 25 °C and 30% RH, (C) RH sweep at 25 °C, with a frequency of 10 Hz, (D) Temperature sweep at 30% RH with a frequency of 10 Hz and temperature increasing rate of 2 K/min, and (E) photocopy of glued samples for DMTA; i- adhesive (lignin: acrylic acid (AA), 1.0:1.0 wt/wt), ii- adhesive (lignin: acrylic acid (AA), 1.0:0.5 wt/wt), and iii- PVA.

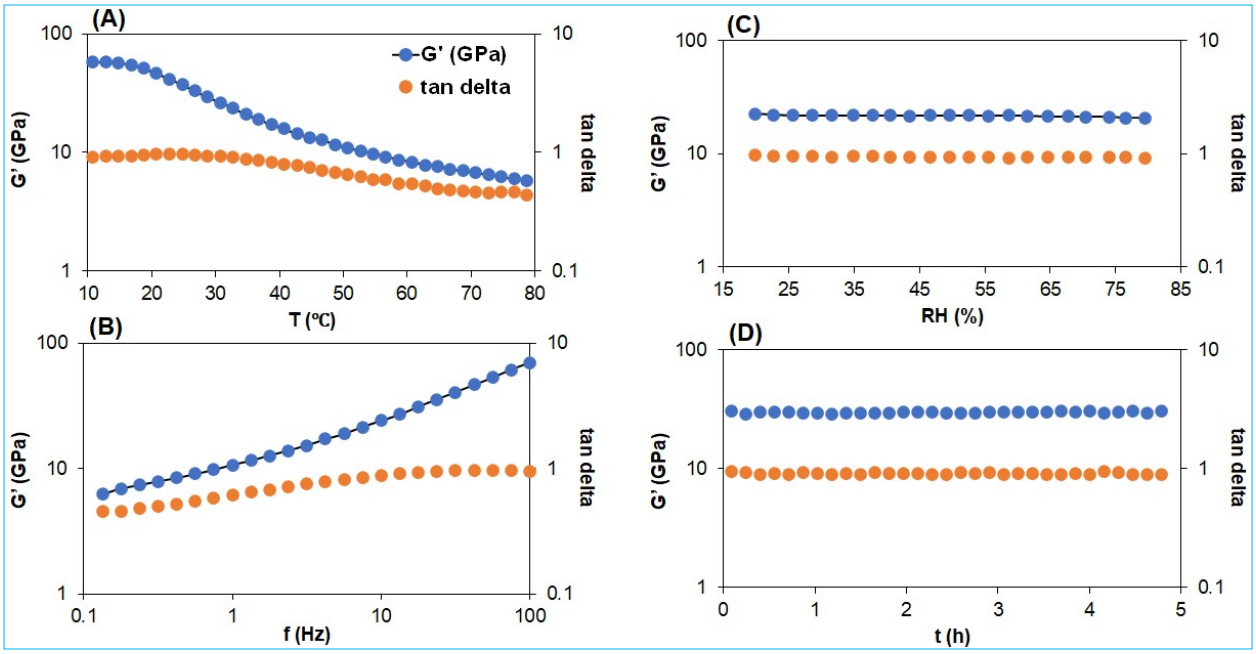

Fig. S4 DMTA of polyvinyl alcohol (PVA). (A) Temperature sweep at 30% RH with a frequency of 10 Hz and temperature increasing rate of 2 °C/min, (B) Frequency sweep at 25 °C and 30% RH, (C) Relative humidity sweep at 25 °C, with a frequency of 10 Hz and, (D) Time sweep at 25 °C and 30% RH with a frequency of 10 Hz.

Table S1: Dimension of the glued materials used for internal bond strength

Material	**Dimension (cm)**		
	l	b	h
Glass (G)	5	5	0.1
Stainless steel (SS)	5	5	0.2
Aluminum (Al)	5	5	-
Polycarbonate (PC)	5	5	0.4
Note: (-) direct sample holder used for analysis			

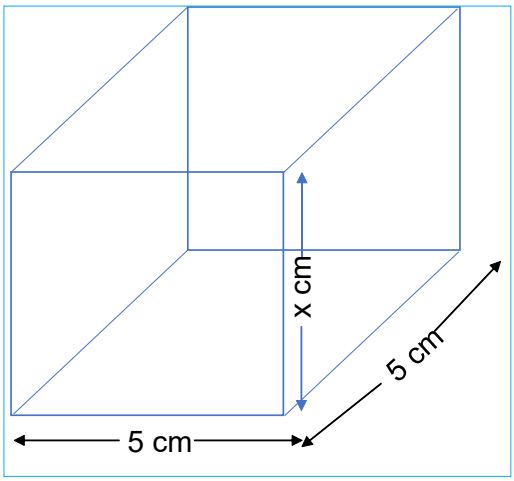

Fig. S5 A representative sketch dimension of the glued materials used for internal bond strength.

The internal bond strength (IBS) of polyvinyl alcohol-based adhesive was measured over Al york, and IBS 180.0 kPa was determined.

Table S2: Dimension of the glued materials used for vertical physical mechanical and weathering tests

Material	**Dimension (cm)**		
	l	b	h
PVC	38.3	2.5	0.5
PVC	39.2	2.5	0.5
PC	58.0	2.5	0.6

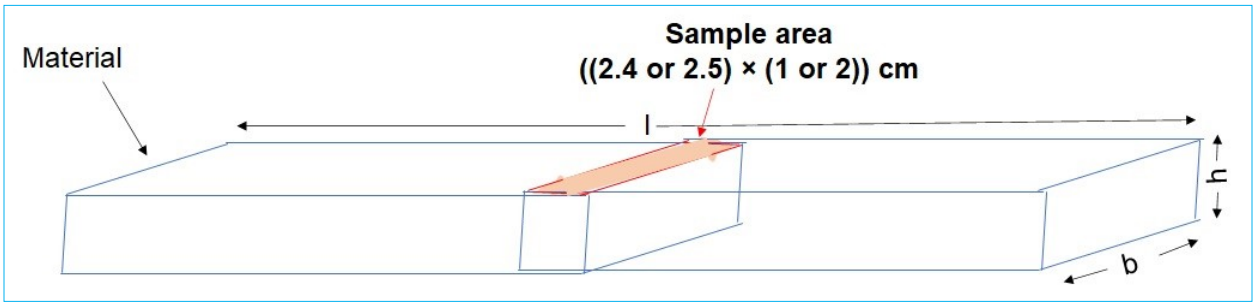

Fig. S6 A representative sketch dimension along with the glued area of materials for vertical physical mechanical test.

Table S3: Dimension of the glued materials used for horizontal physical mechanical testing

Material	**Dimension (cm)**		
	l	b	h
PVC	39.2	2.5	0.5
PC	58.0	2.5	0.6
PC	59.0	2.5	0.6
Pine wood	58.0	2.5	0.5
Glass	38.0	5.0	1.0
Glass	39.0	5.0	1.0

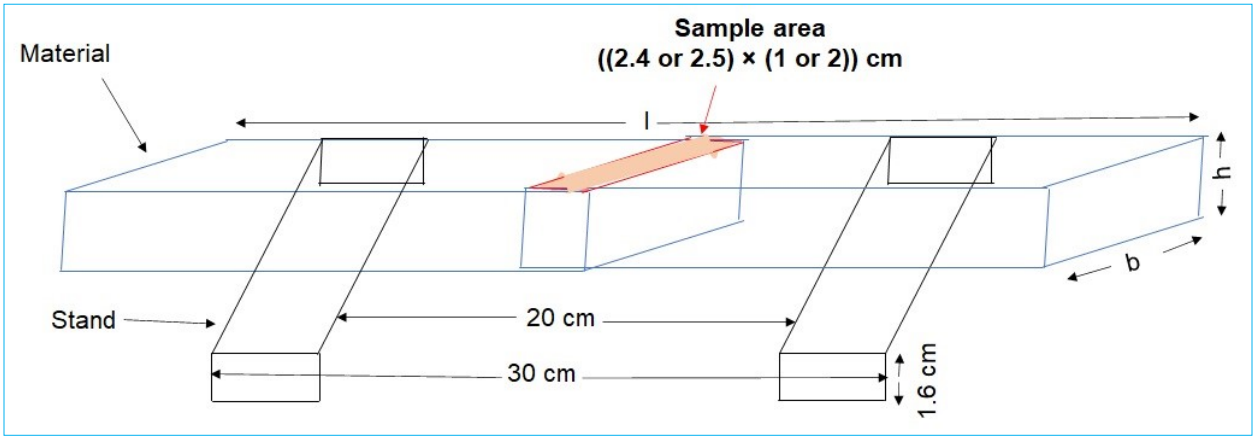

Fig. S7 A representative sketch dimension along with glued area of materials for horizontal physical mechanical test.