

TRIAL / PARTIAL-WINDOW ISSUE — covers 1 Sep – 14 Oct 2026 only. Draft for technical review (reviewer: OPEN); not for circulation.

WHAT CHANGED THIS QUARTER

Four laboratory papers moved formaldehyde-free binders closer to panel conditions: a cysteine-lignin plywood glue, a starch-citric acid MDF binder, a lignin-tannin NIPU curing at 130 °C and a veneer-faced spent-grain particleboard. None ran a UF control. No verified industrial bio-binder or bio-acrylic milestone appeared before the cutoff.

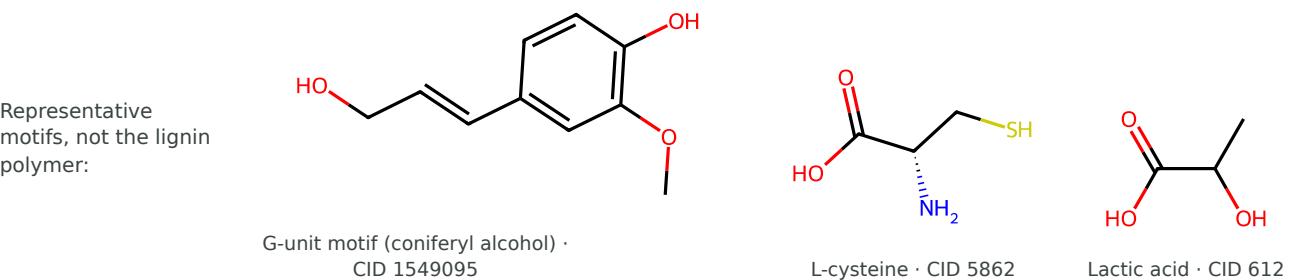
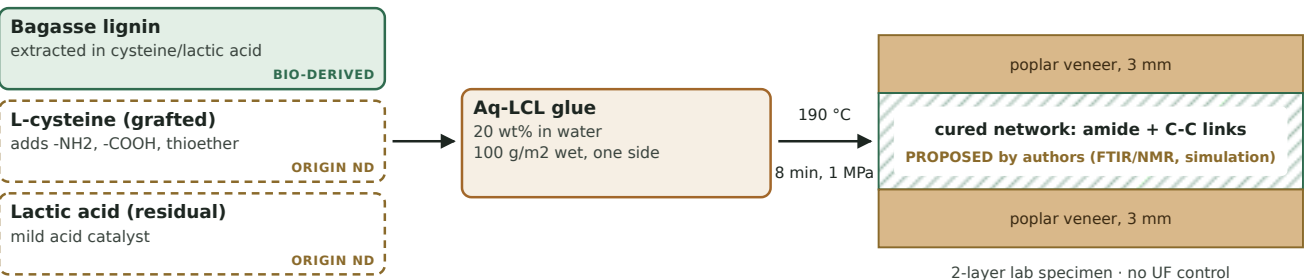
Tags: **BIO-DERIVED** **FOSSIL-TYPICAL** **ORIGIN ND** **INORGANIC** · Strategy **A** = renewable version of the same chemistry, **B** = different chemistry · ND = not disclosed

1 Cysteine-grafted lignin bonds plywood without formaldehyde

Change. Bagasse lignin grafted with cysteine self-cures in the press as a 20 wt% aqueous glue. Two-layer poplar plywood reached 4.0 MPa dry [1].

Implication. At 1.96 mPa·s it can be sprayed. Its ‘beats commercial resin’ claim uses PF diluted to 20 % solids, not UF or PF as supplied [1].

Gap. Stable wet strength needed hotter pressing (190 °C, 8 min). Cysteine recovery and cost remain unresolved [1].



Cysteine-grafted lignin glue cures between veneers; bond chemistry shown as the authors propose it.

APPLICATION 2-ply poplar plywood (lab)	CHEMISTRY Claimed fully bio-based; cysteine and lactic-acid origin ND · B	GEOGRAPHY China	SCALE / TRL Lab · TRL not reported
CAPACITY ND	COST BASIS ND	CO₂E ND	HCHO / VOC 0.05 mg/L, dryer method GB 17657 · VOC ND

2 Citric acid and urea upgrade starch binder for MDF

Change. Starch with sorbitol, glycerol, citric acid and urea bonded 10 mm lab MDF at 10 % dry resin: IB 0.59–0.86 MPa, 2 h swelling 22.74–24.54 % [2].

Implication. An aldehyde-free MDF route on commodity inputs; urea (8.2 % of solids, computed) makes it hybrid. Press: 180 °C, 7 min (≈ 42 s/mm, computed) [2].

Gap. No UF control, rheology, pot life or emission test [2].

Dry solids of best binder (SSGUC), computed from Table 1

Corn starch 81.6 %

Sorbitol 3.1 %
Glycerol 3.1 %

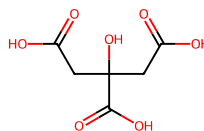
Citric acid 4.1 %
Urea 8.2 %

Plant-derived

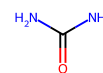
BIO-DERIVED

Origin not disclosed

ORIGIN ND



Citric acid (ester crosslinker) ·
CID 311



Urea (co-reactant) · CID 1176

Dry solids of the best binder; only starch is stated as plant-derived.

APPLICATION

Lab MDF, 10 mm, hardwood fibre

CAPACITY

ND

CHEMISTRY

Hybrid (urea, origin ND) · B

COST BASIS

ND

GEOGRAPHY

Iran (with Bulgaria)

CO₂E

ND

SCALE / TRL

Lab · TRL not reported

HCHO / VOC

Not measured

3 Lignin-tannin NIPU cures birch plywood at 130 °C

Change. Diamine-grafted lignin and oxidised, methoxycarbonylated tannin form urethane links without isocyanate. At 130 °C, 10 min: 1.89 MPa dry, 0.85 MPa wet (EN 314-1) [3].

Implication. Brings NIPU cure into plywood press range; the authors' control NIPUs peaked near 180–200 °C [3].

Gap. Wet strength is below 1.0 MPa and passes only via the ≥ 40 % wood-failure rule. HMDA is fossil-typical; spread 300 g/m² [3].

Hardwood lignin

Lignova Pure, Fibenol

BIO-DERIVED

Condensed tannin

species ND

BIO-DERIVED

Hexamethylenediamine

amination

FOSSIL-TYPICAL

NaIO₄

oxidant: quinones

INORGANIC

Aminated lignin

major prepolymer

Dimethyl carbonate

methoxycarbonylation

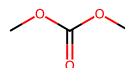
ORIGIN ND

LT-NIPU + 30 % MCC (bio)

urethane links, no isocyanate
3-ply birch: 130 °C, 1 MPa, 10 min



Hexamethylenediamine · CID
16402



Dimethyl carbonate · CID 12021

Two prepolymers combine in alkaline water; tags show the origin of each input.

APPLICATION

3-ply birch plywood (lab)

CAPACITY

ND

CHEMISTRY

Hybrid (HMDA; DMC origin ND) · B, isocyanate-free

COST BASIS

ND

GEOGRAPHY

Sweden / Spain; lignin from Estonia

CO₂E

ND

SCALE / TRL

Lab · TRL not reported

HCHO / VOC

Not measured

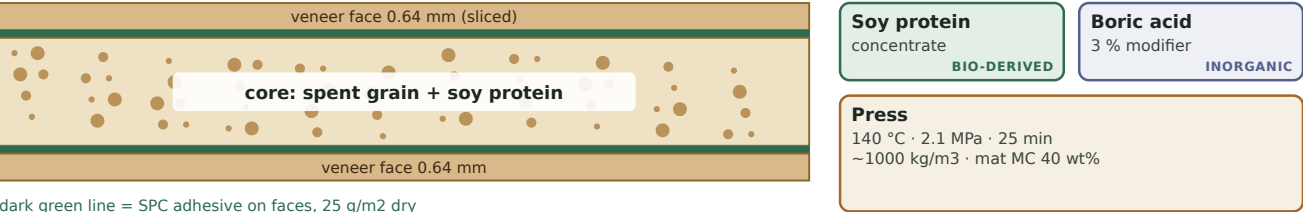
4 Veneer faces lift spent-grain board to P2 bending

Change. Spent grain bonded with boric-acid-modified soy protein missed EN 312 bending minimums. With 0.64 mm veneer faces, boards met P2 and ANSI H1 flexural minimums [4].

Implication. A residue board with no added formaldehyde, but at about 1000 kg/m³ and a 25 min press at 140 °C [4].

Gap. Internal bond untested on faced boards; no UF control or emission data [4].

Cross-section, not to scale



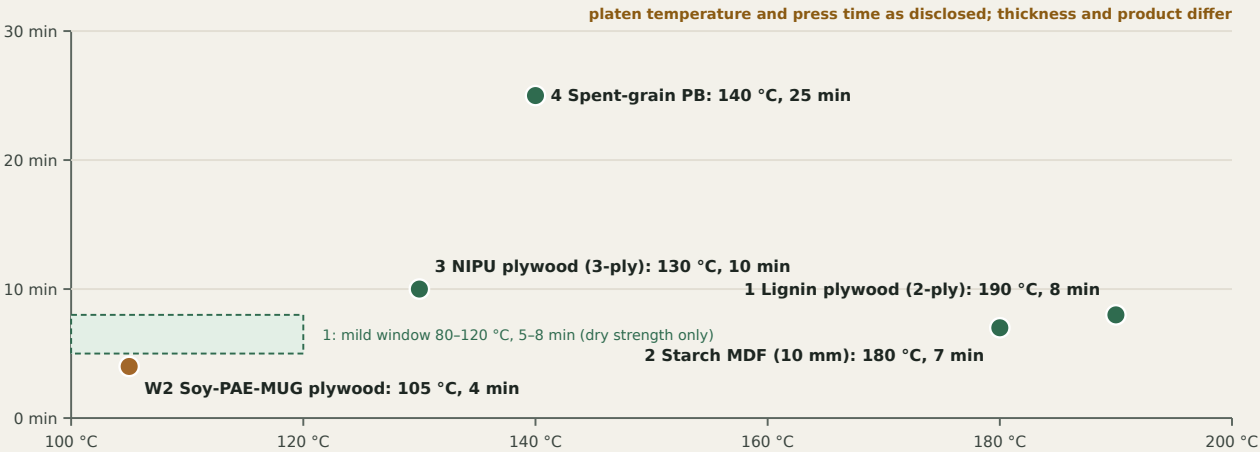
IB tested on unfaced boards only

Veneer faces carry the bending load; the core and its bond strength are unchanged.

APPLICATION Particleboard, high density (lab)	CHEMISTRY Bio-based organics + boric acid · no crosslinker	GEOGRAPHY Argentina	SCALE / TRL Lab · TRL not reported
CAPACITY ND	COST BASIS ND	CO₂E ND	HCHO / VOC Not measured

vs UF — what the four studies let us compare

1 · Lignin plywood Press: 80–190 °C, 2–8 min Comparator: PF diluted to 20 % UF control: none	2 · Starch MDF Press: ≈42 s/mm at 180 °C (computed) Comparator: other starch mixes UF control: none	3 · NIPU plywood Press: 130 °C, 10 min Comparator: internal NIPU controls UF control: none	4 · Spent-grain PB Press: 140 °C, 25 min Comparator: EN 312 P2 minimums UF control: none
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Disclosed press cycles of this issue's studies; not a like-for-like comparison and not a UF benchmark.

No UF baselines are imported from other sources. A like-for-like UF comparison needs a matched trial: same furnish, resin load, density and press cycle.

WATCHLIST

CROSSLINKER A hyperbranched imine adhesive gave a wood-particle composite (pressed at 120 °C) that kept 100 % of its properties over three reprocessing cycles. Abstract only; monomer origin ND [5].

CROSSLINKER Soybean meal with PAE, melamine-urea-glyoxal and blocked polyurethane pressed plywood at 105 °C in 4 min (wet shear 0.97 MPa). All three crosslinkers are fossil-typical, so it is hybrid. Abstract only [6].

ACRYLIC ACID No verified renewable acrylic-acid supply or scale milestone between 1 Sep and 14 Oct; earlier pilots are background only.

REGULATION Comments on US EPA's Section 610 review of the TSCA Title VI composite-wood formaldehyde rule closed on 13 Oct; outcome pending [7].

THREE FOLLOW-UP QUESTIONS

1. **MID** Does cysteine-grafted lignin keep its wet strength at ≤ 130 °C on 3-ply panels, against UF and undiluted PF at equal spread?
2. **MIM** What press factor does the starch-citric acid binder need on an MDF line, against UF at equal resin load and density?
3. **MTE** Can a bio-based diamine replace HMDA in the lignin-tannin NIPU and keep the 130 °C cure?

COVERAGE THIS ISSUE

LEAD	Proteins L4 · W2	LEAD	Lignin L1 · L3	LEAD	Starch L2
LEAD	Carboxylic acids L2 (citric)	LEAD	Tannins L3 (with lignin)	LEAD	Crosslinkers L3 (NIPU) · W1 · W2
SEEN	Sugars / polyols glycerol PB, not selected	SEEN	Phenolic LPF plywood, not selected	SEEN	Melamine-containing MUG in W2 only
NONE	Cellulose MCC filler only	NONE	Polylysine no in-window item	NONE	Polyketones no in-window item
NONE	Acrylic acid no verified milestone	NONE	Supply / capacity no verified milestone	WATCH	Regulation W3 (US EPA)

Chemistry lanes searched; LEAD = lead story, WATCH = watchlist, SEEN = in-window item not selected, NONE = no qualified update.

Searched against particleboard, MDF/HDF, plywood, LVL, glulam and moulded veneer (Crossref and OpenAlex by date; web and local-language search). No LVL, glulam or moulded-veneer result qualified.

Next issue: March 2027 (window 1 Dec 2026 – 28 Feb 2027). This trial issue will be refreshed after 30 Nov to cover the full September–November window.

REFERENCES

1. Zhou X., Wang Y., Hu S., ... Ou R. Aqueous lignin adhesive for high-performance wood bonding. *Science Advances* (2026), published 23 Sep 2026. CC BY-NC 4.0. [doi:10.1126/sciadv.aee5160](https://doi.org/10.1126/sciadv.aee5160). Accessed 14 Oct 2026.
2. Mehdinia M., Kamrani S., Ahmadi P., Nabipoor S., ... Citric acid-urea modification of dual-plasticized starch adhesives for medium-density fiberboard manufacturing. *Polymers* 18 (2026) 2400, published 1 Oct 2026. CC BY 4.0. [doi:10.3390/polym18192400](https://doi.org/10.3390/polym18192400). Accessed 14 Oct 2026.
3. Aladejana J.T., Olazabal I., Eceiza A., Hosseinpourpia R. Effective strategy for preparing low-curing-temperature lignin-based non-isocyanate polyurethane wood adhesives. *Int. J. Biol. Macromol.* 382 (2026) 154455, online 10 Sep 2026. CC BY 4.0. [doi:10.1016/j.ijbiomac.2026.154455](https://doi.org/10.1016/j.ijbiomac.2026.154455). Accessed 14 Oct 2026.
4. Rossi L., Rueda F., Ciannamea E.M., Stefani P.M. Bio-based brewer's spent grain particleboards: effect of rosin coating and wood veneer reinforcement on structure and properties. *Polymers* 18 (2026) 2303, published 20 Sep 2026. CC BY 4.0. [doi:10.3390/polym18182303](https://doi.org/10.3390/polym18182303). Accessed 14 Oct 2026.
5. Zhang X., Liu Z., Zhou Z., Lynch M., ... Strong fully reprocessable engineered wood composites. *Advanced Materials* (2026), online 7 Oct 2026. Abstract only inspected. [doi:10.1002/adma.75232](https://doi.org/10.1002/adma.75232). Accessed 14 Oct 2026.
6. Chang Z., Liu Y., Wei S., Han S., ... A soybean meal-based adhesive with improved hot-pressing efficiency and water resistance fabricated from PAE, low-cost melamine-urea-glyoxal and blocked polyurethane resins. *J. Agric. Food Chem.* (2026), online 17 Sep 2026. Abstract only inspected. [doi:10.1021/acs.jafc.6c12235](https://doi.org/10.1021/acs.jafc.6c12235). Accessed 14 Oct 2026.
7. US EPA. 2026 Unified Agenda of Regulatory and Deregulatory Actions — Section 610 Review of Formaldehyde Emission Standards for Composite Wood Products (RIN 2070-AL38). *Federal Register*, FR Doc. 2026-16608, 14 Aug 2026; docket EPA-HQ-OPPT-2025-2433 (comment period 14 Aug – 13 Oct 2026). [federalregister.gov](https://www.federalregister.gov). Accessed 14 Oct 2026.

Structures drawn with RDKit from PubChem SMILES (CIDs in captions); schematics drawn for this issue. No third-party figures or photographs are used. Numbers trace to verbatim passages in the issue's source files. Computed values are labelled.