Supplementary Information

S1. Complete database search strategies

Complete database search strategies used for the literature audit. Query line breaks are for readability; the recorded search terms and Boolean operators are preserved. Search dates, search fields, applied limits, and retrieved counts are reported for each database-specific search.

S1a Main Scopus search

Field	Recorded information
Search audit date	15 August 2026, as confirmed by the author
Search field	TITLE-ABS-KEY
Publication years	Lower limit: PUBYEAR > 2009; no upper-year clause in the recorded Scopus query. Results retrieved during the 15 August 2026 search spanned 2010–2026.
Document types	Article and Review, applied as interface filters
Language and subject restrictions	None at the database-search stage
Records	154 initial results; 147 after filters, comprising 141 articles and 6 reviews
Export identified by the author	scopus_export_Aug 15-2026_agnes(1).csv

```
TITLE-ABS-KEY(
  ("deep eutectic solvent"
   OR "natural deep eutectic solvent"
   OR NADES OR "eutectic mixture")
  AND
  ("polyethylene glycol"
   OR "poly(ethylene glycol)"
   OR PEG OR "polyvinyl alcohol"
   OR PVA OR "polyvinylpyrrolidone"
   OR PVP OR poloxamer OR pluronic
   OR "polypropylene glycol"
   OR PPG OR "polymer additive"
   OR "polymeric additive")
  AND
  (lignin OR lignocellulos*
   OR delignification OR fractionation
   OR pretreatment OR biorefin*
   OR cellulose OR hemicellulose)
)
AND PUBYEAR > 2009
```

The recorded query does not encode an upper-year clause or document-type limits. Those limits are documented separately above rather than added retrospectively to the original query. The timestamp in the initial screenshot filename is 14 August; 15 August is reported here as the completed search-audit date, consistent with the author's recap.

S1b ScienceDirect searches

Search date: 15 August 2026. Search field: Title, abstract or author-specified keywords. Publication-year range: 2010–2026. No additional document-type, language, subject-area, or access-status filters were applied. The three query texts below are reproduced from the author's saved search record; screenshots corroborate the result counts, although the displayed query text is horizontally cropped in the interface.

Query	Polymer group	Results
A	PEG	26
B	PVA and PVP	32
C	PPG and poloxamer	0

Query A

("deep eutectic solvent" OR NADES)
AND
("polyethylene glycol" OR PEG)
AND
(lignin OR lignocellulose OR fractionation OR pretreatment)

Query B

("deep eutectic solvent" OR NADES)
AND
("polyvinyl alcohol" OR PVA OR "polyvinylpyrrolidone" OR PVP)
AND
(lignin OR lignocellulose)

Query C

("deep eutectic solvent" OR NADES)
AND
("polypropylene glycol" OR PPG OR poloxamer OR pluronic)
AND
(lignin OR lignocellulose)

Zero results for Query C means that no records were retrieved using this particular query and its recorded limits. It does not establish an absence of research involving PPG or poloxamers.

The four main search executions yielded 205 raw record occurrences (147 Scopus + 26 PEG + 32 PVA/PVP + 0 PPG/poloxamer) before deduplication. The literature-audit workbook records 46 duplicate removals, leaving 159 unique records for title-and-abstract screening. Overlap occurred between Scopus and the ScienceDirect searches and was resolved using normalized DOI and then normalized title.

S1c Targeted Scopus sensitivity search

This targeted recall check was conducted in Scopus on 17 August 2026 using the recorded query below. No database-level filters were applied at the retrieval stage. Eight records were exported and reconciled against the main Scopus export by normalized DOI. The predefined 2010–2026 eligibility period was applied after export; the single 1975 record was excluded, and all seven in-window records matched the main dataset. No additional unique record was identified.

Field	Verified record and limitations
Date	17 August 2026; confirmed by author
Field	TITLE-ABS-KEY, as encoded in the supplied query
Results	8 raw exported records (all labelled Article); 7 within 2010–2026; 1 dated 1975; 0 additional unique records
Other filters	No database-level publication-year, document-type, language, subject-area, or access-status filters were applied at retrieval.
Overlap check	7 of 7 in-window DOI identifiers matched the 15 August 2026 Scopus export (normalized exact DOI match); see the record-level audit below.

TITLE-ABS-KEY(("deep eutectic solvent*" OR DES OR NADES)
AND ("polyethylene glycol" OR PEG OR "polymer additive*")
AND ("molecular weight" OR "different molecular weight*"
OR "average molecular weight" OR "chain length"
OR PEG200 OR PEG400 OR PEG600 OR PEG800
OR PEG1000 OR PEG2000 OR PEG4000)
AND (lignocellulos* OR biomass OR lignin OR cellulose)
AND (fractionation OR pretreatment OR delignification
OR dissolution))

S1c.1. Record-level DOI audit of the targeted sensitivity search

Year	DOI	Decision / overlap
2020	10.1016/j.ijbiomac.2020.07.153	Present in main Scopus by DOI
1975	10.1016/S0338-4535(75)80013-4	Outside year window (1975)
2026	10.1016/j.biombioe.2026.109655	Present in main Scopus by DOI
2024	10.1016/j.indcrop.2024.118297	Present in main Scopus by DOI
2025	10.1016/j.ijbiomac.2025.139922	Present in main Scopus by DOI
2025	10.1016/j.ijbiomac.2025.142231	Present in main Scopus by DOI
2022	10.1016/j.biortech.2022.128186	Present in main Scopus by DOI
2025	10.1016/j.cej.2025.164829	Present in main Scopus by DOI

Audit provenance: “scopus_export_Aug 17-spesisifik agnes(1).csv” (8 records) was compared by exact normalized DOI against “scopus_export_Aug 15-2026_agnes(1).csv” (main corpus). The main CSV contains a malformed continuation line within one reference field; this is not treated as an additional bibliographic record. The unmodified raw exports are retained.

S1d Lower-date sensitivity check

A lower-date sensitivity check was conducted on 13 October 2026 to test whether the predefined 2010 lower publication-year boundary excluded eligible earlier evidence. The main Scopus and ScienceDirect search concepts and fields were rerun without a lower publication-year cutoff while retaining 2026 as the upper publication-year boundary. Because this check was performed after the 15 August 2026 main audit, total database counts could have changed

through subsequent indexing. Therefore, the effect of the cutoff was assessed from records published before 2010 rather than from the difference between August and October total counts.

Database / query	Search date	Current total	Records <2010	Eligible <2010	Effect on evidence base
Scopus main query	13 Oct 2026	156	4	0	No change
ScienceDirect Query A — PEG	13 Oct 2026	26	0	0	No change
ScienceDirect Query B — PVA/PVP	13 Oct 2026	33	0	0	No change
ScienceDirect Query C — PPG/poloxamer	13 Oct 2026	0	0	0	No change

The Scopus sensitivity rerun used the same main TITLE-ABS-KEY concept groups as S1a, with the lower-year restriction removed. Article and Review document types were retained; no language or subject-area restriction was applied. The ScienceDirect reruns used the same Queries A–C and the same Title, abstract or author-specified keywords field as S1b, without a lower-year limit.

S1d.1 Pre-2010 Scopus records and eligibility decisions

Year	Title	DOI	Reason for exclusion	Eligibility
1984	In vitro and invivo evaluation of some fast release dosage forms of hydrochlorothiazide	10.3109/03639048409039075	Pharmaceutical fast-release/solid-dispersion study; not DES-based lignocellulose processing or eligible transferable mechanistic evidence.	Excluded
2000	Improving drug solubility for oral delivery using solid dispersions	10.1016/S0939-6411(00)00076-X	Pharmaceutical solid-dispersion review; not DES-based lignocellulose processing or eligible transferable mechanistic evidence.	Excluded
2004	Enhancing the bioavailability of ABT-963 using solid dispersion containing Pluronic F-68	10.1016/j.ijpharm.2004.08.009	Pharmaceutical bioavailability/solid-dispersion study; eutectic behavior is drug-formulation context, not the review target.	Excluded
2009	Fabrication and design of transdermal fluconazole spray Transdermal fluconazole spray	10.1080/10837450802498936	Transdermal drug-delivery formulation; the eutectic mixture is pharmaceutical and outside the review eligibility criteria.	Excluded

Interpretation: removing the lower publication-year cutoff identified no additional eligible pre-2010 study. The retained corpus and review conclusions therefore did not change. The increase of ScienceDirect Query B from 32 records in the 15 August audit to 33 records in the 13 October rerun is not attributed to the cutoff, because no Query B record in the rerun was published before 2010.

S2. Evidence-reliability assessment of the three E1 within-study PEG-grade series

Purpose. This audit addresses replication, controls, statistical testing, completeness of grade-resolved measurements, major confounding variables, and numerical traceability for the three lignocellulose studies that compared more than one nominal PEG grade. Judgments are domain-specific; no total quality score is calculated.

Judgment terminology. Documented = explicitly supported by the inspected source; Partly documented = some relevant information is available but the requested domain is not fully established; Not reported after source inspection = the inspected main article/supporting information did not provide the required information. These judgments assess reporting and causal interpretability, not overall scientific merit.

S2a. Summary reliability matrix

Study	Replication	Controls	Statistical testing	Grade-resolved completeness	Major confounding	Numerical traceability	Interpretive consequence
Liu et al. 2024 [14]	Partly documented	Documented	Not reported for grade screen	Partly documented	High	Partly documented	Supports a within-formulation grade response; does not isolate PEG molecular size.
Zhou et al. 2025 [16]	Partly documented	Documented	Not traceable for grade-screen claim	Partly documented	High	Partly documented	Supports a controlled grade screen with cautious interpretation of "not significant".
Huang et al. 2022 [18]	Partly documented	Documented	Partly documented (RSM ANOVA)	Relatively complete, but not fully tabulated for all outcomes	High	Documented for composition; partial for GC/GY screen	Strongest quantitative grade screen, but fixed-molar formulation confounds grade with composition.

S2b. Source-linked domain audit

Study	Domain	Judgment	Source evidence / locator	Reliability implication
Liu et al. 2024 [14]	Replication	Partly documented	Supporting information, Note S2.1: component/lignin-content tests were repeated three times and the average was used. The source inspected does not explicitly state that the complete PEG-grade pretreatment series itself was independently repeated.	Replicated analytical determination is documented, but independent pretreatment replication for the grade series cannot be assumed.

Study	Domain	Judgment	Source evidence / locator	Reliability implication
Liu et al. 2024 [14]	Controls	Documented	Original article, Section 3.1.6: glycol, PEG200, PEG400, and PEG4000 were compared under the same LA–ChCl system, 2.5 g third component, 140 °C, 30 min. Binary/acid controls are also reported elsewhere in the study.	The within-study grade comparison is interpretable at its reported formulation basis.
Liu et al. 2024 [14]	Statistical testing	Not reported after source inspection	Section 3.1.6 describes delignification as similar across PEG200/PEG400/PEG4000 and slightly higher for PEG400; no ANOVA, pairwise test, or grade-specific p-value was located for this comparison.	Descriptive differences should not be presented as statistically significant or equivalent.
Liu et al. 2024 [14]	Grade-resolved measurements	Partly documented	The original article provides grade-resolved process/component responses graphically and grade-resolved lignin Mw, Mn, and source PDI in its GPC results. Supporting Table S2 reports viscosity for PEG400 dosage levels rather than a complete grade series.	Useful grade-response information is available, but mediator measurements are incomplete across grades.
Liu et al. 2024 [14]	Major confounders	Documented limitation	The grade screen fixes third-component mass (2.5 g), not PEG chain molarity. Nominal PEG grade therefore changes chain number and terminal-OH concentration; measured PEG Mn/Mw/Đ, grade-resolved water, viscosity and diffusivity were not reported as a complete series.	The experiment tests formulation grade at fixed mass, not isolated molecular size.
Liu et al. 2024 [14]	Numerical traceability	Partly documented	Grade-specific lignin molar-mass values are tabulated in Table 3; several process outcomes are figure-based. The source-reported PDI values are retained separately from author-calculated Mw/Mn ratios in the review.	Traceable for several key values, but not all grade-response outcomes are available as tabulated numbers.
Zhou et al. 2025 [16]	Replication	Partly documented	Main article, Section 2.4.1 states that the analytical experiment was repeated three times to obtain the mean. Section 2.2 reports five viscosity measurements per sample. Independent repetition of the entire PEG-grade pretreatment series is not separately specified.	Analytical repeat measurements are documented; pretreatment-level replication remains incompletely described.
Zhou et al. 2025 [16]	Controls	Documented	Main article, Section 3.1 states that PEG addition, PEG molecular weight and temperature were investigated by a single-variable control approach. Fig. 1 includes the binary A0M0T130 reference and PEG200/400/600/800 grade series at the specified PEG addition.	Provides an internally controlled within-study grade comparison.
Zhou et al. 2025 [16]	Statistical testing	Not traceable for grade-screen claim	Section 3.1 states that PEG molecular weight “did not significantly affect” fractionation efficiency, but no grade-screen statistical method, p-value, confidence interval, or multiple-comparison result was located in the inspected main article/supporting information.	The review should not treat “not significantly” as a verified inferential result unless the original statistical basis is supplied.

Study	Domain	Judgment	Source evidence / locator	Reliability implication
Zhou et al. 2025 [16]	Grade-resolved measurements	Partly documented	Fig. 1 provides grade-resolved CRS/SR yields and CRS composition; Supporting Table S1 provides grade-resolved CrI values (PEG200/400/600/800). Detailed downstream cellulose/lignin characterization focuses primarily on the selected PEG400 condition.	The grade screen is visible, but not all outcomes/uncertainties are numerically tabulated for every grade.
Zhou et al. 2025 [16]	Major confounders	Documented limitation	PEG grade is changed at a fixed mass fraction. Chain concentration and terminal-OH concentration therefore change with grade; grade-dependent fluidity is itself discussed by the authors. Complete measured PEG molar-mass distributions, water content and diffusivity are not reported across the grade series.	The study tests nominal grade at fixed mass fraction, not molecular size in isolation.
Zhou et al. 2025 [16]	Numerical traceability	Partly documented	Selected PEG400 outcomes are numerically reported in the main text and supplementary tables; several grade-comparison outcomes are presented primarily in Fig. 1. Supporting Table S1 gives exact CrI values by grade.	Adequate for qualitative/selected quantitative comparison, but not a complete numeric grade-response table.
Huang et al. 2022 [18]	Replication	Partly documented	Main Table 2 reports grade-resolved values with ± uncertainty. The RSM ANOVA contains pure-error degrees of freedom from replicated design points. The inspected methods do not explicitly state the replicate number or uncertainty definition for the four-grade single-factor series.	Variability is reported, but the exact replication structure of the single-factor grade screen is not fully specified.
Huang et al. 2022 [18]	Controls	Documented	Section 2.3.1 fixes the grade-screen conditions at 1% HSA, 2 h and 170 °C with ChCl:PEG = 1:4; Table 2 includes untreated CK and PEG200/400/600/800 rows.	The grade screen has a clear within-study control structure.
Huang et al. 2022 [18]	Statistical testing	Partly documented	Section 3.2/Tables 4–5: RSM models for glucose concentration and yield were significant (p=0.0002); PEG molecular weight was significant for GC (p=0.0224) and GY (p=0.0031). However, the RSM PEG levels were 400/600/800, and these tests are factor-level model terms rather than pairwise comparisons of the full PEG200/400/600/800 single-factor screen.	Formal statistics support an MW-related factor in the multivariable RSM, but do not establish pairwise ranking of all four grades.
Huang et al. 2022 [18]	Grade-resolved measurements	Relatively complete	Table 2 reports solid recovery, cellulose/hemicellulose content and retention, lignin content and removal for PEG200/400/600/800 with uncertainty. Fig. 2 reports grade-dependent glucose concentration and yield; exact single-factor GC/GY numbers are not tabulated in Table 2.	Most complete of the three studies for direct grade-resolved biomass outcomes, although some hydrolysis outcomes remain figure-based.

Study	Domain	Judgment	Source evidence / locator	Reliability implication
Huang et al. 2022 [18]	Major confounders	Documented limitation	ChCl and PEG are fixed at a 1:4 molar ratio. Increasing nominal PEG grade therefore increases PEG mass contribution and changes overall solvent composition, repeat-unit contribution and end-group concentration. The later RSM also varies HSA concentration, time and temperature.	The observed response cannot be attributed to chain length alone; formulation composition changes simultaneously.
Huang et al. 2022 [18]	Numerical traceability	Documented / partial by outcome	Table 2 provides explicit grade-resolved means ± uncertainty for composition/retention/removal. RSM Tables 3–5 provide design points and ANOVA statistics. Single-factor GC/GY are shown in Fig. 2 rather than a numeric table.	Strong traceability for composition and RSM; partial traceability for the single-factor hydrolysis screen.

S2c. Overall interpretation

The reliability audit does not identify a single "high-quality" study that isolates PEG molecular size as an independent causal variable. All three E1 studies contain informative within-study comparisons, but each grade manipulation also changes chemical equivalents and/or solvent composition. Liu et al. and Zhou et al. provide controlled eucalyptus screens with incomplete grade-specific inferential statistics and mediator reporting. Huang et al. provides the most extensive grade-resolved quantitative table and formal RSM ANOVA, but its fixed ChCl:PEG molar ratio strongly couples nominal grade to PEG mass fraction and the RSM does not test PEG200. Consequently, the review uses these studies to identify context-dependent within-formulation grade responses and candidate mechanisms, not to claim a universal molecular-weight optimum or a causal chain-length effect.

Source locators

[14] Z. Liu et al., Industrial Crops & Products 212 (2024) 118297, DOI: 10.1016/j.indcrop.2024.118297. Main article: Sections 3.1.5–3.1.6 and the lignin GPC results; Supporting information: Note S2.1 and Table S2.

[16] S. Zhou et al., Chemical Engineering Journal 518 (2025) 164829, DOI: 10.1016/j.cej.2025.164829. Main article: Sections 2.2–2.4 and 3.1, Fig. 1; Supporting information: Table S1.

[18] Y. Huang et al., Bioresource Technology 366 (2022) 128186, DOI: 10.1016/j.biortech.2022.128186. Main article: Sections 2.3.1–2.3.2, 3.1.3 and 3.2; Tables 2–5; Fig. 2.

S3. Numerical reconciliation and grade-resolved extraction

S3a. Reconciliation of source-reported PDI with calculated Đ = Mw/Mn

Calculated Đ values are arithmetic checks using the Mw and Mn printed in the source tables. They are not proposed corrections to the source-reported PDI, because no unrounded or corrected values were located in the inspected supplementary files.

Study / sample	Source location	Mw	Mn	Source PDI	Mw/Mn exact	Đcalc (2 d.p.)	Interpretation
[16] TDESL, selected PEG400 A5M400T130	Zhou et al., Table 1, p. 7	4978	3434	1.44	1.4496	1.45	Small discrepancy; cause unresolved.
[14] PEG200	Liu et al., Table 3, p. 6, footnote d	5682	2683	2.17	2.1178	2.12	Source PDI exceeds displayed Mw/Mn ratio.
[14] PEG400	Liu et al., Table 3, p. 6, footnote d	5613	2730	2.14	2.0560	2.06	Source PDI exceeds displayed Mw/Mn ratio.
[14] PEG4000	Liu et al., Table 3, p. 6, footnote d	6365	3142	2.17	2.0258	2.03	Source PDI exceeds displayed Mw/Mn ratio.

S3b. Grade-resolved outcome extraction for the three E1 studies

Extraction rule. Exact source-tabulated or explicitly stated values are reproduced as reported. No numerical values were digitized from the grade-screen plots for Liu et al. [14] or Zhou et al. [16]. When a grade-resolved outcome was available only graphically, the record states 'graph-reported; exact numerical value not tabulated.' Exact supporting values available in tables, such as the Zhou et al. grade-resolved crystallinity index, are retained. Replicate counts or uncertainty definitions are never inferred from error bars. Source locators refer explicitly to the original article or supporting information.

Study / grade	Source-reported process outcome / availability	Second exact outcome / mediator availability	Replication	Uncertainty	Grade statistics	Source locator	Extraction note
[18] PEG200	Lignin removal 59.06 ± 0.51%	Cellulose retention 85.19 ± 0.75%	NR for single-factor screen	± reported; definition NR	No pairwise grade test located	Original article, composition table, p. 4	Exact source-tabulated values.
[18] PEG400	Lignin removal 59.23 ± 0.30%	Cellulose retention 85.43 ± 0.49%	NR for single-factor screen	± reported; definition NR	RSM factor B tested separately	Original article, composition table, p. 4; RSM/ANOVA section	Exact source-tabulated values.

[18] PEG600	Lignin removal 83.23 ± 0.55%	Cellulose retention 73.63 ± 0.75%; GC and GY single-factor maxima	NR for single-factor screen	± reported; definition NR	RSM B: GC p=0.0224; GY p=0.0031	Original article, composition table, p. 4; enzymatic-hydrolysis grade-screen text; RSM/ANOVA section	Exact fractionation values; GC/GY maximum stated in the original article text. No plot digitization used.
[18] PEG800	Lignin removal 59.95 ± 0.73%	Cellulose retention 50.50 ± 0.53%	NR for single-factor screen	± reported; definition NR	No pairwise grade test located	Original article, composition table, p. 4	Exact source-tabulated values.
[14] PEG200	Delignification: graph-reported; exact numerical value not tabulated	Cellulose recovery: graph-reported; exact numerical value not tabulated	Component analysis repeated 3× in SI	Original-source grade-screen plot includes error bars; numeric definition NR	No grade-wise test located	Original article, Section 3.1.6 grade-screen plot; supporting information Note S2.1	No plot digitization; exact process value not tabulated.
[14] PEG400	Delignification: graph-reported; PEG400 described as slightly higher; exact numerical value not tabulated	Cellulose recovery: graph-reported; exact numerical value not tabulated	Component analysis repeated 3× in SI	Original-source grade-screen plot includes error bars; numeric definition NR	No grade-wise test located	Original article, Section 3.1.6 grade-screen plot; supporting information Note S2.1	No plot digitization; exact process value not tabulated.
[14] PEG4000	Delignification: graph-reported; exact numerical value not tabulated	Cellulose recovery: graph-reported; exact numerical value not tabulated	Component analysis repeated 3× in SI	Original-source grade-screen plot includes error bars; numeric definition NR	No grade-wise test located	Original article, Section 3.1.6 grade-screen plot; supporting information Note S2.1	No plot digitization; exact process value not tabulated.
[16] PEG200	CRS yield: graph-reported; exact numerical value not tabulated	CrI 70.36% (SI); viscosity graph-reported, exact numerical value not tabulated	Experiment reported repeated 3×; viscosity n=5/sample	Original-source grade-screen plot includes error bars; definition NR	No traceable grade-wise inferential test located	Original article, Section 3.1 grade-screen/rheology plots and methods; supporting information Table S1	No plot digitization; exact CRS/SR and viscosity values not tabulated.

[16] PEG400	CRS yield: graph-reported; PEG400 described as slightly higher; exact numerical value not tabulated	CrI 70.98% (SI); viscosity graph-reported, exact numerical value not tabulated	Experiment reported repeated 3×; viscosity n=5/sample	Original-source grade-screen plot includes error bars; definition NR	Source says “not significantly”; test method/p-value not located	Original article, Section 3.1 grade-screen/rheology plots and methods; supporting information Table S1	No plot digitization; exact CRS/SR and viscosity values not tabulated. Selected-product GPC is separate from the grade-screen comparison.
[16] PEG600	CRS yield: graph-reported; exact numerical value not tabulated	CrI 68.86% (SI); viscosity graph-reported, exact numerical value not tabulated	Experiment reported repeated 3×; viscosity n=5/sample	Original-source grade-screen plot includes error bars; definition NR	No traceable grade-wise inferential test located	Original article, Section 3.1 grade-screen/rheology plots and methods; supporting information Table S1	No plot digitization; exact CRS/SR and viscosity values not tabulated.
[16] PEG800	CRS yield: graph-reported; exact numerical value not tabulated	CrI 66.51% (SI); viscosity graph-reported, exact numerical value not tabulated	Experiment reported repeated 3×; viscosity n=5/sample	Original-source grade-screen plot includes error bars; definition NR	No traceable grade-wise inferential test located	Original article, Section 3.1 grade-screen/rheology plots and methods; supporting information Table S1	No plot digitization; exact CRS/SR and viscosity values not tabulated.

S4. Evidence classes and study-by-study pathway coding matrix

The 42 retained articles are counted once at article level using the hierarchy E1 > E2 > E3 > E4. Mechanistic pathway coding is separate from evidence distance. A pathway label can be mediator-supported, transferred, provisional, or hypothesis-only. A performance endpoint by itself is not treated as proof of a mechanism. E4 studies are secondary analogues and are not pooled with E1 for PEG-grade conclusions.

Class	Operational definition	n	Inference limit
E1	Within-study PEG-grade series in native lignocellulose	3	Within-study formulation response; not an isolated chain-length effect.
E2	PEG-containing native-lignocellulose study without a verified within-study grade series	8	Process/context evidence; cannot establish a grade ranking.
E3	PEG model or process-property study outside native lignocellulose, including purified substrates and non-biomass liquids	17	Transferable only through a measured mediator and stated boundary.
E4	Non-PEG mechanistic analogue	14	Secondary mechanistic context only; not PEG-grade evidence.

Study ID	Author-year	DOI	Class	System / classification basis	Pathway(s)	Measured mediator / coded observation	Verification status	Critical inference boundary
S001	Blokhina, Svetlana (2026)	10.1016/j.molliq.2026.129486	E3	PEG400-containing ChCl DES for ethionamide solubilization; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1	M1: Supports polymer–DES solvation and volumetric interactions.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Pharmaceutical system; fixed PEG grade.
S002	Yu S. (2026)	10.11949/0438-1157.20250691	E2	Choline-chloride DES screening for tobacco-stalk delignification including PEG400 as an HBD candidate; native-lignocellulose PEG process evidence without a verified grade series.	M1 (provisional)	M1: Provides provisional evidence that PEG400-containing DES was experimentally s…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Main full text unavailable; PEG400-specific quantitative outcome, exact formulation and controlled Mw comparison cannot be verified. Do not use for strict direct-evidence claims.

S003	Zheng, Wenyu (2026)	10.1016/j.foodhyd.2025.111767	E3	PEG–sugar DES extraction of potato protein; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1	M1: Supports hydrogen-bond-network regulation by PEG-containing DES.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Protein extraction, not lignocellulose; exact PEG Mw NR in abstract.
S004	Wang X. (2026)	10.1021/acsami.5c26105	E4	PAA/PVA DES eutectogel network; non-PEG polymer/DES analogue used only for mechanistic context.	M1	M1: Supports polymer–DES network/H-bond concepts.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S005	Kang Y. (2026)	10.1016/j.cej.2026.173848	E4	Lignin/PVA dynamic eutectogel networks; non-PEG polymer/DES analogue used only for mechanistic context.	M1, M4	M1: Supports lignin–polymer–DES networking. | M4: Supports lignin–polymer–DES networking.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S006	Cheng X. (2025)	10.1016/j.ijbiomac.2024.138963	E4	Cellulose/HEC/PVA eutectogel ion transport; non-PEG polymer/DES analogue used only for mechanistic context.	M1, M2	M1: Supports polymer-network transport in DES. | M2: Supports polymer-network transport in DES.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S007	Wu G. (2025)	10.1039/d4gc05138f	E2	PEG-200 loading effects in alkaline ternary DES for wheat-straw deconstruction; native-lignocellulose PEG process evidence without a verified grade series.	M1, M2	M1: Direct support for PEG-loading control of viscosity–mass-transfer and lignin-… | M2: Direct support for PEG-loading control of viscosity–mass-transfer and lignin-…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Only one polymer molecular weight (PEG-200) was tested; 0/5/10/20 mL are loading points, not Mw points. Reported PEG loading is volumetric and should not be converted to wt% without density.

S008	Zhou P.-R. (2025)	10.1016/j.ijbiomac.2025.139922	E2	PEG200–oxalic-acid poly-DES pretreatment of tea stem; native-lignocellulose PEG process evidence without a verified grade series.	M1	M1: Direct support for polymer-containing PDES composition, hydrogen-bond environ…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Only one PEG molecular weight (PEG200) was tested. PEG200:OA ratio, temperature, time and water content varied, so these are composition/severity effects rather than Mw effects. HBA/HBD labels are internally inconsistent in the paper.
S009	Zhao D. (2025)	10.1021/acs.biomac.5c00737	E2	Lewis-acid-catalyzed DES with PEG stabilization for lignin-first fractionation; native-lignocellulose PEG process evidence without a verified grade series.	M1, M4	M1: Supports PEG-mediated stabilization/passivation of reactive lignin intermedia… | M4: Supports PEG-mediated stabilization/passivation of reactive lignin intermedia…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Main full text unavailable. Exact PEG Mw, PEG loading, full DES formulation and controlled Mw variation are not verifiable from abstract + SI; evidence class is therefore provisional.
S010	Zhou S. (2025)	10.1016/j.cej.2025.164829	E1	Eucalyptus lignocellulose fractionation; verified multi-grade native-lignocellulose comparison.	M2; M4	M2: grade-resolved solvent viscosity is reported for PEG200/400/600/800 alongside grade-resolved CRS/SR yield and composition; exact values are presented graphically rather than tabulated. M4: selected PEG400 TDESL shows PEG-associated β-O-4 α-substitution and reduced condensation by HSQC; this structural mediator is not grade-resolved.	Source-audited: original article methods and grade-screen/rheology results (pp. 2–4), plus selected-condition lignin characterization (pp. 6–7).	Fixed PEG mass changes chain count and terminal –OH equivalents across grades; exact grade-wise fractionation values are graph-only.

S011	Blokhina, Svetlana (2025)	10.1016/j.molliq.2025.127997	E3	PEG400 ternary ChCl DES for pyrazinamide solubilization; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1, M2	M1: Supports polymer–DES solvation and density–performance relationships. | M2: Supports polymer–DES solvation and density–performance relationships.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Pharmaceutical system; fixed Mw.
S012	Li Y. (2025)	10.1016/j.ijbiomac.2025.143914	E4	Viscosity/conductivity trade-offs in DES hydrogels; non-PEG polymer/DES analogue used only for mechanistic context.	M2	M2: Supports qualitative M2 transport/rheology concepts.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S013	Blokhina, Svetlana (2025)	10.1016/j.molliq.2025.127432	E3	ChCl/PEG300 DES for griseofulvin solubilization; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1, M2	M1: Supports PEG-DES solvation behavior. | M2: Supports PEG-DES solvation behavior.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Pharmaceutical system; single PEG300.
S014	Chen X. (2025)	10.1016/j.cej.2025.169501	E4	DES/water phase separation and lignin particle formation; non-PEG polymer/DES analogue used only for mechanistic context.	M1, M3	M1: Supports phase-separation/crowding concepts. | M3: Supports phase-separation/crowding concepts.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S015	Xu J. (2025)	10.1021/acs.jced.5c00446	E3	PEG400 ternary DES for multistage PAH isomer fractionation; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M2, M3	M2: Supports polymer-containing DES phase/separation behavior. | M3: Supports polymer-containing DES phase/separation behavior.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Non-biomass PAH separation; single Mw.

S016	Xu C. (2025)	10.1016/j.ijbiomac.2025.142231	E2	Single-Mw PEG400 acidic ternary DES for bamboo fractionation with high recyclability; native-lignocellulose PEG process evidence without a verified grade series.	M1, M2, M4	M1: Supports PEG400 as a third-component modifier that improves lignin solubility… | M2: Supports PEG400 as a third-component modifier that improves lignin solubility… | M4: Supports PEG400 as a third-component modifier that improves lignin solubility…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Only PEG400 is used; DES ratio, solids loading, temperature and time are varied, so no Mw effect can be isolated.
S017	Zhang Q. (2025)	10.1016/j.colsurfa.2025.137514	E4	PVA/CMC DES gel electrolyte; non-PEG polymer/DES analogue used only for mechanistic context.	M1, M2	M1: Supports transport/network behavior. | M2: Supports transport/network behavior.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S018	Babapour, Roghayeh (2025)	10.1016/j.molliq.2025.127956	E3	PEG400–ethaline–water mixed-solvent CO2 solubility; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1, M2	M1: Supports PEG fraction effects on solvation and H-bond structure. | M2: Supports PEG fraction effects on solvation and H-bond structure.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Non-biomass; loading/composition effect, not Mw.
S019	Zhang, Wen-shuo (2025)	10.1016/j.jiec.2024.09.025	E3	Controlled PEG200/400/600/800 effects in TBAB/PEG DES for asphalt desulfurization; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1, M2	M1: Strong controlled-Mw evidence for a non-monotonic chain-length optimum and fo… | M2: Strong controlled-Mw evidence for a non-monotonic chain-length optimum and fo…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Non-lignocellulosic asphalt system. Text reports PEG400 DBT removal 44.95%, whereas Fig. 7a visually appears ~55%; retain this as a source inconsistency rather than reconciling.

S020	Liu L. (2024)	10.1039/d4gc02874k	E2	PEG400/OA DES–MIBK microextraction for switchgrass fractionation and furfural production; native-lignocellulose PEG process evidence without a verified grade series.	M1, M3, M4	M1: Supports PEG-mediated lignin stabilization, interfacial depletion/crowding be… | M3: Supports PEG-mediated lignin stabilization, interfacial depletion/crowding be… | M4: Supports PEG-mediated lignin stabilization, interfacial depletion/crowding be…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Only PEG400 is used; no controlled polymer-Mw comparison.
S021	Tong Z. (2024)	10.1016/j.carbpol.2023.121665	E3	Controlled PEG-Mw effects in ZnCl2–H3PO4 eutectic solvent for cellulose dissolution; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1	M1: Supports direct Mw-dependent coordination competition and solvent-property ef…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Controlled Mw series, but the substrate is purified cellulose rather than lignocellulosic biomass fractionation; therefore supporting-evidence under the strict protocol.
S022	Thombre A.V. (2024)	10.1016/j.est.2024.114060	E4	MD of PVA/lignin eutectogel; non-PEG polymer/DES analogue used only for mechanistic context.	M1, M2	M1: Atomistic support for M1/M2. | M2: Atomistic support for M1/M2.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.

S023	Liu Z. (2024)	10.1016/j.indcrop.2024.118297	E1	Eucalyptus lignocellulose fractionation; verified multi-grade native-lignocellulose comparison.	M1; M2	M1: solvent polarity/acidity descriptors and PEG400 addition effects are reported, but not across all PEG grades. M2: PEG200/400/4000 grade-screen delignification/cellulose-recovery responses are presented graphically; no grade-resolved viscosity/diffusivity mediator was located. Recovered-lignin Mw/Mn/PDI are grade-resolved in the original article's GPC results.	Source-audited: original article Section 3.1.6 grade screen and lignin GPC results; supporting information Note S2.1 and Table S2.	Fixed PEG mass changes chain count and terminal –OH equivalents; delignification values for PEG200/4000 are graph-only.
S024	Tsai H.-Y. (2023)	10.1038/s41428-023-00814-4	E4	DES-induced PVA crystallization during solvent exchange; non-PEG polymer/DES analogue used only for mechanistic context.	M2, M3	M2: Supports phase/crystallization response to DES. | M3: Supports phase/crystallization response to DES.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S025	Liang Q. (2023)	10.1039/d3tc03711h	E4	Ethylcellulose/polymerizable DES compatibility; non-PEG polymer/DES analogue used only for mechanistic context.	M1, M3	M1: Supports polymer–DES compatibility/phase behavior. | M3: Supports polymer–DES compatibility/phase behavior.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S026	Liu Q. (2023)	10.1039/d3gc00733b	E3	Controlled PEG/PEGDA molecular-weight effects in levulinic-acid poly-DESs for technical lignin dissolution; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1, M2	M1: Supports a non-monotonic Mw design window and coupling among viscosity, polar… | M2: Supports a non-monotonic Mw design window and coupling among viscosity, polar…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Uses isolated technical lignins rather than lignocellulosic biomass fractionation; highly transferable but not direct-evidence.

S027	Yang J. (2023)	10.1016/j.cej.2023.145544	E4	DES/water-induced PVA micro-phase separation and lignin self-assembly; non-PEG polymer/DES analogue used only for mechanistic context.	M1, M3	M1: Supports M1/M3 concepts. | M3: Supports M1/M3 concepts.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S028	Wang Y. (2022)	10.1016/j.compscitech.2022.109696	E4	Reversible PVA/gelatin/cellulose eutectogel network; non-PEG polymer/DES analogue used only for mechanistic context.	M1	M1: Supports polymer–DES H-bond-network concepts.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S029	Wang H. (2022)	10.1007/s10570-021-04321-8	E4	PVA/CNC hydrogel crosslinked by DES network; non-PEG polymer/DES analogue used only for mechanistic context.	M1	M1: Supports M1 only.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S030	Zhao, Zhechun (2022)	10.1016/j.molliq.2022.120542	E3	PEG400/PDA DES physicochemical properties and CO2 capture; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1, M2	M1: Strong physicochemical support for PEG-containing DES interactions. | M2: Strong physicochemical support for PEG-containing DES interactions.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Non-biomass; fixed PEG400.
S031	Wang J. (2022)	10.1021/acsapm.1c01899	E4	Metal-salt DES/PVA/lignin eutectogel; non-PEG polymer/DES analogue used only for mechanistic context.	M1, M2	M1: Supports polymer–DES–lignin interaction and transport concepts. | M2: Supports polymer–DES–lignin interaction and transport concepts.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.

S032	Huang Y. (2022)	10.1016/j.biortech.2022.128186	E1	Sugarcane-bagasse pretreatment; verified multi-grade native-lignocellulose comparison.	M2	M2 hypothesis only: PEG200/400/600/800 grade-resolved fractionation data are source-tabulated and glucose responses are described in the single-factor grade screen, but no grade-resolved rheology/diffusion mediator was measured. RSM tests PEG grade as a factor for GC/GY but does not establish transport mediation.	Source-audited: original article composition table, enzymatic-hydrolysis grade-screen section, and RSM/ANOVA results.	Not a clean single-variable chain-length test: PEG mass and repeat-unit content vary across nominal grades; primary outcome is glucose, not lignin removal.
S033	Wang H. (2021)	10.1016/j.carbpol.2020.117443	E4	PVA/CNC in ChCl/glucose DES; non-PEG polymer/DES analogue used only for mechanistic context.	M1	M1: Supports M1.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S034	Ma Z. (2021)	10.1021/acs.biomac.1c00706	E3	Lignin crosslinking with PEGDE in ternary DES; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1, M4	M1: Supports lignin–polymer stabilization/networking. | M4: Supports lignin–polymer stabilization/networking.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S035	Xue B. (2020)	10.1016/j.ijbiomac.2020.07.153	E3	PEG400 loading/composition effects in ChCl–glycerol ternary DES for isolated lignin dissolution; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1, M2	M1: Supports polymer-loading control of H-bond environment, viscosity, lignin sol… | M2: Supports polymer-loading control of H-bond environment, viscosity, lignin sol…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Only PEG400 is used and the substrate is isolated lignin rather than whole lignocellulose.

S036	Ci Y.-H. (2020)	10.1039/d0gc03240a	E2	PEG200–boric-acid near-neutral DES for wheat-straw deconstruction; native-lignocellulose PEG process evidence without a verified grade series.	M1	M1: Supports synergistic PEG200/BA H-bond-network disruption and near-neutral lig…	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Only PEG200 is used; BA ratio and process severity, not Mw, are varied.
S037	Bai Y. (2020)	10.15376/biores.15.3.6886-6901	E2	PEG200-based DES liquefaction for eucalyptus cellulose/lignin separation; native-lignocellulose PEG process evidence without a verified grade series.	M1, M2	M1: Supports lower-viscosity PEG200-containing DES for direct wood fractionation … | M2: Supports lower-viscosity PEG200-containing DES for direct wood fractionation …	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	PEG400 appears only in non-quantified preliminary trials; the main study is not a controlled PEG-Mw comparison.
S038	Aryafard, Meysam (2019)	10.1016/j.molliq.2019.03.149	E3	PEG400 mole-fraction effects on DES solvatochromic properties and ion solvation; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1, M2	M1: Strong solvent-property evidence for polymer loading/composition effects. | M2: Strong solvent-property evidence for polymer loading/composition effects.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Non-biomass; fixed PEG400.
S039	Zhang H. (2017)	10.1016/j.talanta.2017.04.018	E3	Controlled PEG200/400/600/1000/4000 effects in PEG-based DES aqueous biphasic systems; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M2, M3	M2: High-value controlled-Mw evidence that polymer chain length can drive opposin… | M3: High-value controlled-Mw evidence that polymer chain length can drive opposing phase-formation and solute-partition responses, supporting an optimum/trade-off framework.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Non-lignocellulosic RNA extraction. Fig. 4B extraction efficiencies are graph-read (~99/~97/~91/~88/~56% for PEG200/400/600/1000/4000), so treat as medium-confidence values.

S040	Mukherjee, Kallol (2017)	10.1016/j.fluid.2017.05.003	E3	Dynamics of PEG-based nonionic DES; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M2	M2: Supports M2 polymer-physics/dynamics.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Supporting mechanism only; do not use for direct lignocellulose Mw-effect claims.
S041	Al Ani, Zainab (2017)	10.1016/j.cherd.2017.01.003	E3	Continuous TBAB/PEG200 DES extraction in microchannels; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M2	M2: Supports transport/mass-transfer behavior of PEG-based DES.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Fuel system; fixed PEG200.
S042	Ren H. (2016)	10.15376/biores.11.2.5435-5451	E3	PEG400 co-solvent effect in ChCl–imidazole DES for cellulose dissolution; PEG-based purified-substrate, physicochemical, or non-biomass model/process system.	M1, M2	M1: Supports PEG-enabled accessibility/decrystallization through amphiphilicity, H-bond acceptance and solvent-property modification. | M2: Supports PEG-enabled accessibility/decrystallization through amphiphilicity, H-bond acceptance and solvent-property modification.	Audit-coded; exact page/table/figure locator not independently rechecked in this revision.	Only PEG400 is tested and the substrate is purified cotton-linter cellulose, not lignocellulosic fractionation.