

High-performance adhesives modified by demethylated lignin for extreme environment

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Table S1. Detailed reaction condition and name of obtained samples.

Demethylated lignin	LiBr (g)	HBr (mL)	Time (min)	Temperature (°C)
DL-a-1	0	5	30	120
DL-a-2	15	5	30	120
DL-a-3	30	5	30	120
DL-a-4	45	5	30	120
DL-b-1	30	5	30	110
DL-b-2	30	5	30	130
DL-b-3	30	5	30	140
DL-c-1	30	5	30	120
DL-c-2	30	5	60	120
DL-c-3	30	5	75	120
DL-d-1	30	3	60	120
DL-d-2	30	7	60	120
DL-d-3	30	9	60	120

Table S2. Mass ratio of lignin epoxy resin adhesive composition and name of each adhesive

Samples	W _{RLER} (g)	W _{DLER} (g)	W _{E-44} (g)
ERA	0.0	0.0	10.0
RLERA-1	1.0	0.0	9.0
RLERA-2	2.0	0.0	8.0
RLERA-3	3.0	0.0	7.0
RLERA-4	3.5	0.0	6.5
DLERA-1	0.0	1.0	9.0
DLERA-2	0.0	2.0	8.0
DLERA-3	0.0	3.0	7.0
DLERA-4	0.0	3.5	6.5

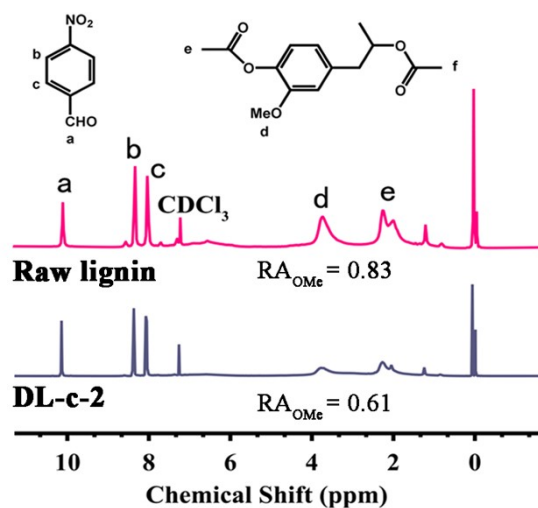


Figure S1. The quantitative ^1H NMR spectra of raw lignin and DL-c-2. The illustrated structure of p-nitrobenzaldehyde and acetylated lignin unit (G type) was given, and the peaks corresponded to the ^1H signal in the spectrum was marked

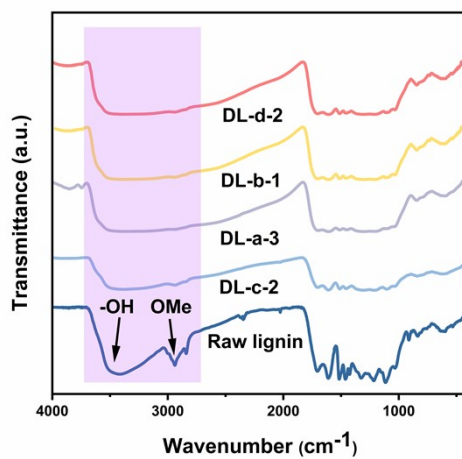


Figure S2. The FTIR spectra of raw lignin and demethylated lignin.

Table S3. The epoxy value of RLER and DLER.

Samples	RLER	DLER
Epoxy values	0.363	0.454

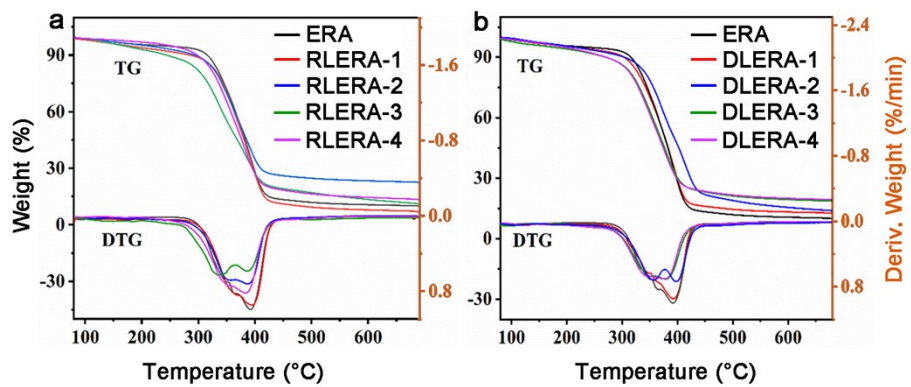


Figure S3. TG and DTG curves of ERA, RLERA and DLERA.

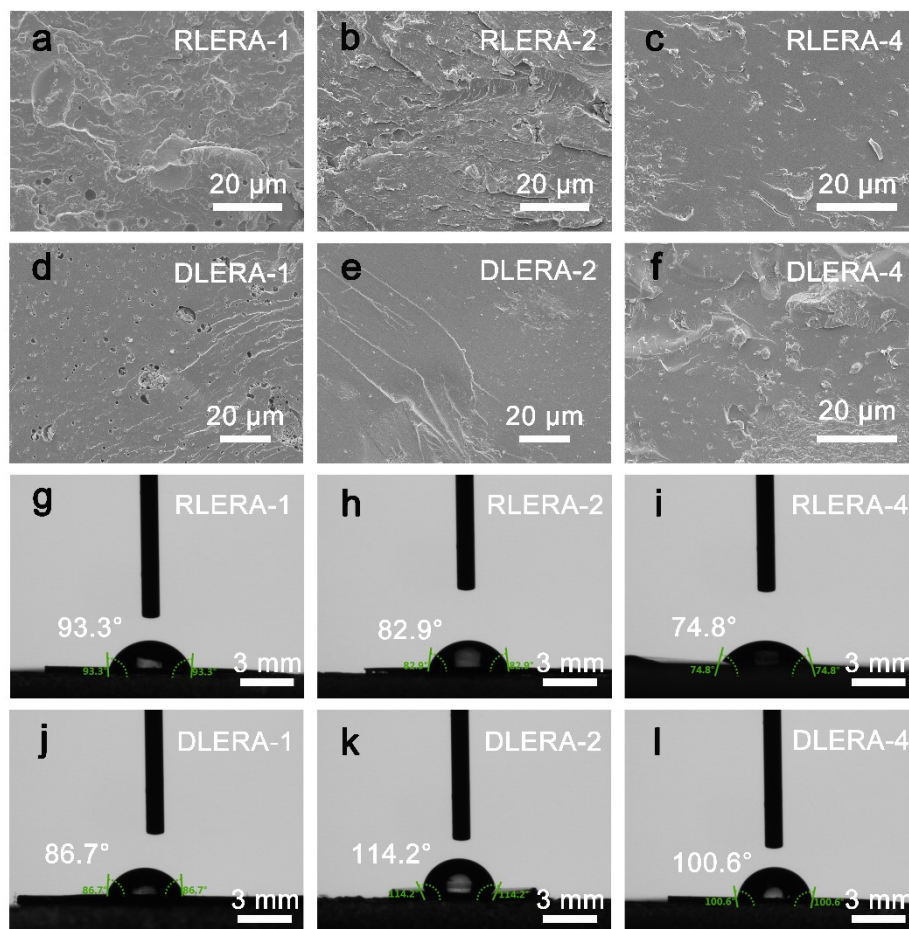


Figure S4. The SEM images of flexural fracture surfaces and the contact angle water on these prepared adhesives.

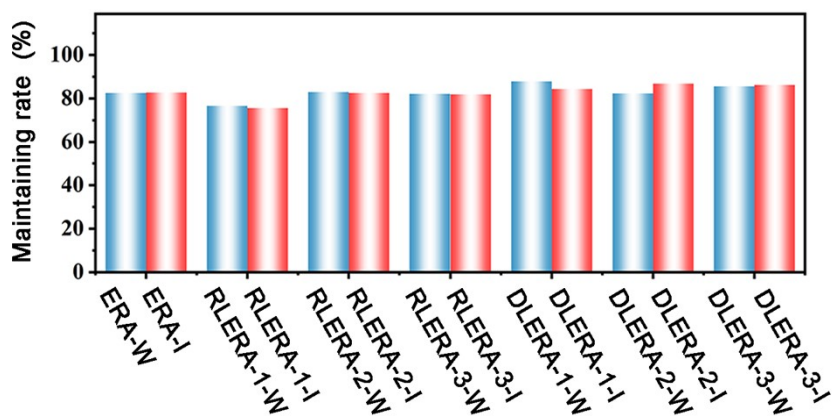


Figure S5. The maintaining property rate of ERA, RLERAs and DLERAs after bathed in the water and frozen. In addition, the sample name of X-n-W meant which was bathed in water, and the sample name of X-n-I meant which was frozen (where X is ERA, RLERAs or DLERAs; n is 1 or 2). The maintain rate was calculated by the percentage ratio of tensile shear strength under extreme conditions to tensile shear strength under mild conditions of the corresponding adhesive.

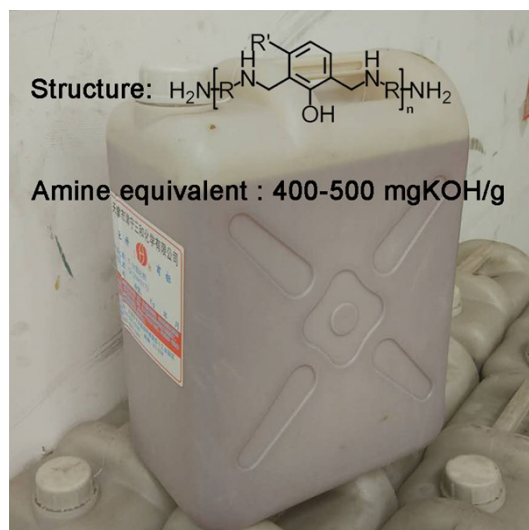


Figure S6. The possible structure schematic diagram and the amine equivalent of the used commercial curing agent (T-31).