Supporting information

Recyclable Non-Isocyanate Polyurethanes Containing Dynamic Covalent Network Derived from Epoxy Soybean Oil and CO_2

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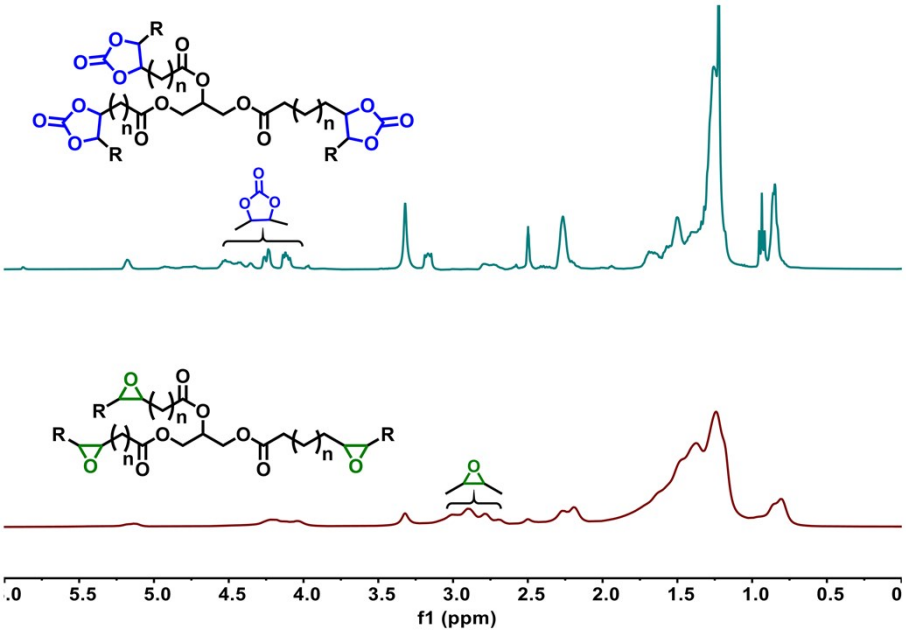

Figure S1. ^{1}H NMR spectra of ESO and CSBO.

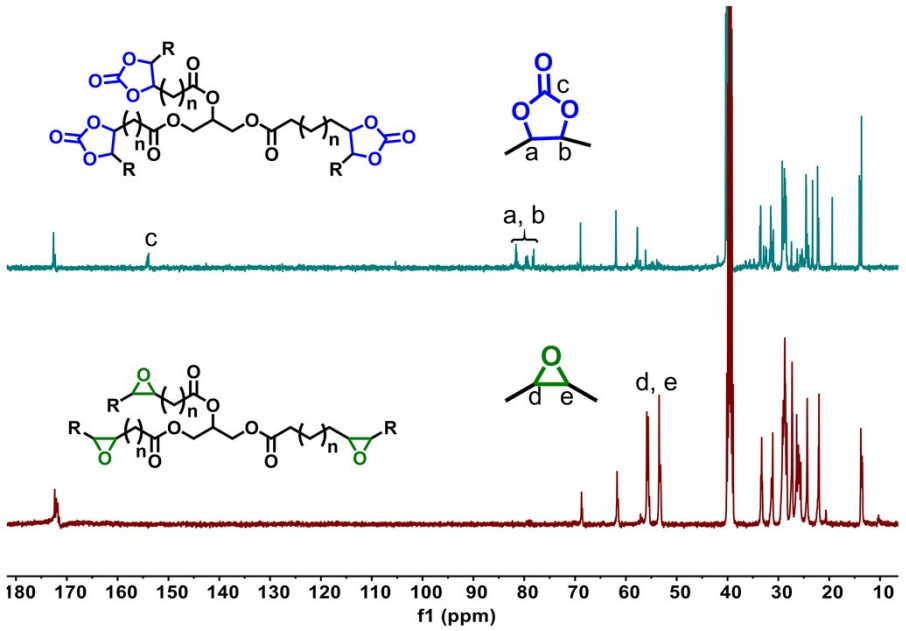

Figure S2. ^{13}C NMR spectra of ESO and CSBO.

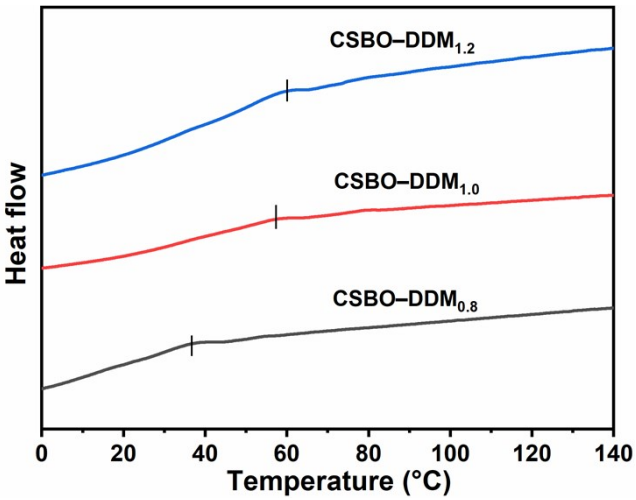

Figure S3. DSC curves of CSBO–DDM NIPUs.

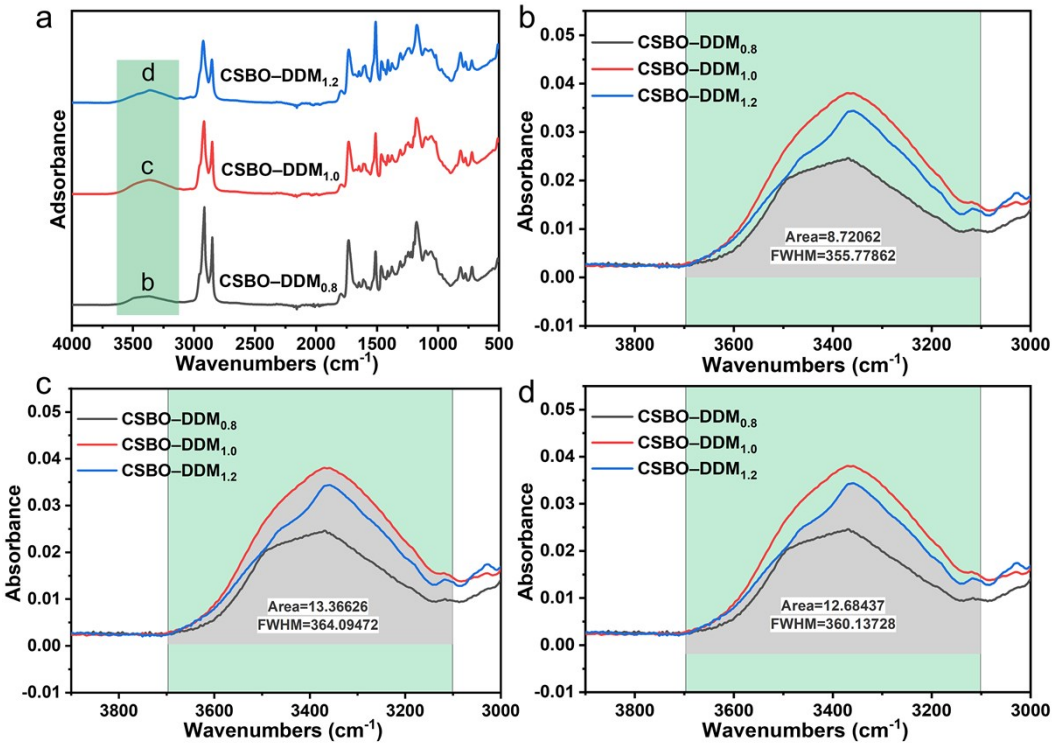

Figure S4. (a) FTIR spectra of CSBO–$DDM_{0.8}$, CSBO–$DDM_{1.0}$, and CSBO–$DDM_{1.2}$ from 4000 cm^{-1} to 500 cm^{-1}. (b) The integral of the activate groups (OH or NH_2) of CSBO–$DDM_{0.8}$. (c) The integral of the activate groups (OH or NH_2) of CSBO–$DDM_{1.0}$. (d) The integral of the activate groups (OH or NH_2) of CSBO–$DDM_{1.2}$.

Table S1 Thermal stability properties of CSBO–DDM NIPUs

sample	$T_{5\%}$ (°C)	$T_{10\%}$ (°C)	$T_{25\%}$ (°C)	$T_{50\%}$ (°C)
CSBO–$DDM_{0.8}$	273	302	345	380
CSBO–$DDM_{1.0}$	275	304	347	396
CSBO–$DDM_{1.2}$	274	303	348	397

Titration method for determining the epoxy content of ESO and CSBO

0.1% cresol red solution and 0.1% thymol solution was first mixed at a volume ratio of 1:3 to prepare a mixed indicator, which was adjusted to neutral using 0.01 M NaOH aqueous solution. Then, a certain amount (accurate to 0.0001 g) of ESO or CSBO was weighed and added into a conical flask containing 20 mL hydrochloric acid–acetone (volume ratio = 1:40) solution. Seal the conical flask and shake the mixture well. The mixed indicator (0.5 mL) was introduced after standing for 30 min in the dark. 0.1 M NaOH standard solution was used to titrate until the system turns blue-purple and does not fade within 30 seconds. A blank experiment in which no samples were dissolved in the hydrochloric acid–acetone solution was performed at the same time. The epoxide value (E, mol/100g) was calculated according to the following formula:

$$E = \frac{(V_1 - V_2) * C}{10m} \qquad (S1)$$

where V_1 is the volume (mL) of the NaOH standard aqueous solution consumed by the blank experiment, V_2 is the volume (mL) of the NaOH standard aqueous solution

consumed by the hydrochloric acid–acetone solution with the dissolved sample, C is the concentration (mol·L^{-1}) of the NaOH standard aqueous solution, m is the weight (g) of the sample.

The calculation process of epoxy equivalent weight (EEW)

The epoxy value measured by the titration method is 0.382 mol/100 g, which can be converted into 1 mol ESO containing 3.7 mol epoxy groups. Therefore, the epoxy group number of the ESO is 3.7. The EEW (epoxy equivalent weight) of ESO was calculated from the following equation (S2), and the EEW of ESO is about 263.24 (974/3.7) g·eq^{-1}.

$$EEW = \frac{Molecular\ weight\ of\ ESO}{Epoxy\ groups\ number\ of\ the\ ESO} \qquad (S2)$$

The calculation process of carbonate equivalent weight (CEW)

The epoxy values of ESO and CSBO measured by the titration method are 0.382 mol/100 g and 0.068 mol/100 g, respectively. It can be further calculated that 0.314 mol/100 g of epoxy groups is converted into cyclic carbonate. Therefore, the CSBO converted from ESO contains 3.0 mol of cyclic carbonate groups per molar, and the cyclic carbonate group number of the CSBO is 3.0. The CEW (carbonate equivalent weight) of CSBO was calculated from the following equation (S3), and the CEW of CSBO is about 355.16 (1065.48/3.0) g·eq^{-1}.

$$CEW = \frac{Molecular\ weight\ of\ CSBO}{Carbonate\ groups\ number\ of\ the\ CSBO} \qquad (S3)$$

The calculation process of active hydrogen atoms equivalent weight (AHEW)

Due to the purity of the purchased DDM is greater than 97%. The AHEW of DDM was calculated directly from the following equation (S4), and the AHEW of DDM is

about 49.56 (198.26/4) $g \cdot eq^{-1}$.

$$AHEW = \frac{Molecular\ weight\ of\ DDM}{Active\ hydrogen\ atoms\ number\ of\ the\ DDM} \quad (S4)$$

Calculations for stress relaxation derived activation energy

Equation obtained from Arrhenius law: $y = 10.723x - 18.393$ ($R^2 = 0.9853$)

Which corresponds to: $\ln(\tau) = 10.723 \times 1000/T - 18.393$

Identifying this to the experimental equation: $E_a/R = 10.723 \times 1000$

$E_a = 10.723 \times 1000 \times 8.314 = 89.15$ kJ mol^{-1}