

Supporting Information

Multi-dynamic bond reinforced polyurethane elastomer with outstanding damping characteristics and mechanical properties

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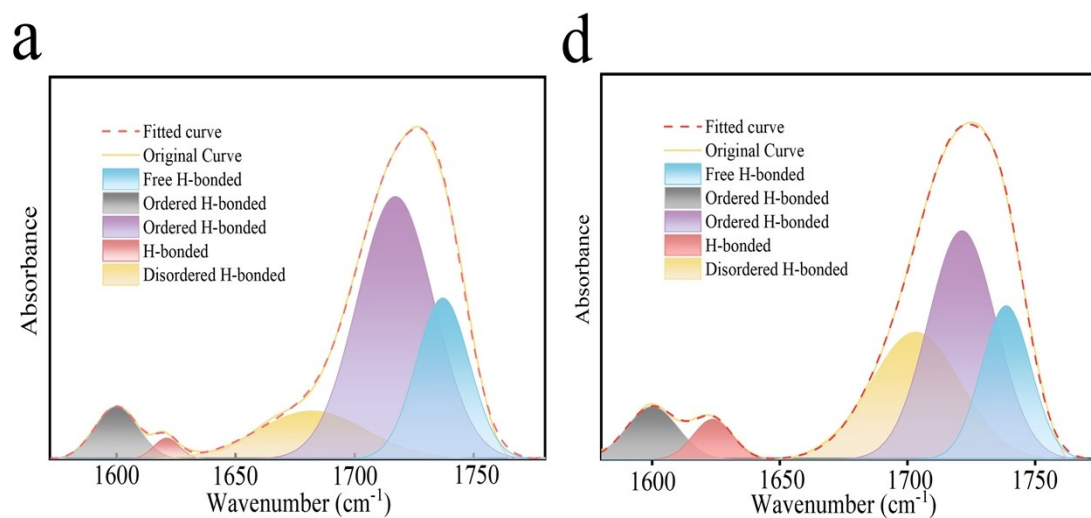


Fig. S1 Peak fitting of the carbonyl peak: (a) PUE-TMP and (b) PUE-T-20SS

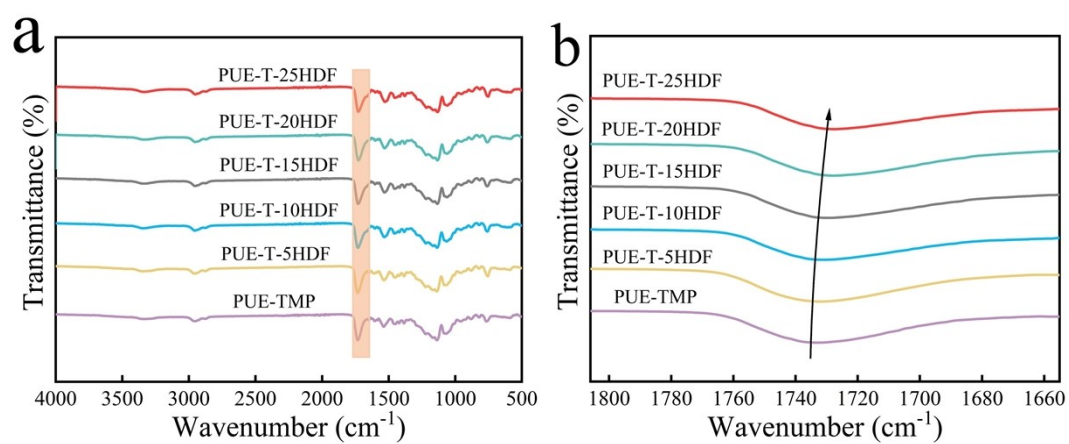


Fig. S2 FTIR spectra of PUE-T-xHDF

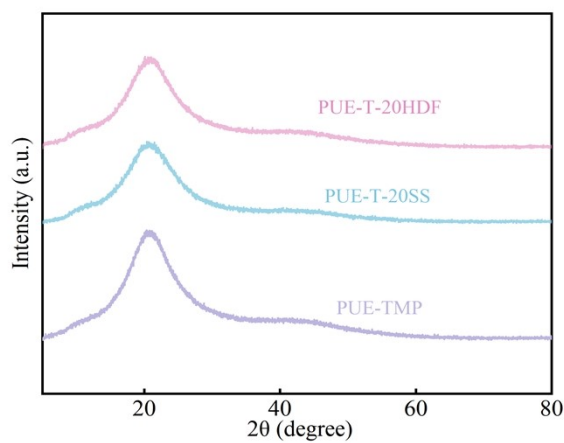


Fig. S3 XRD pattern of PUE material

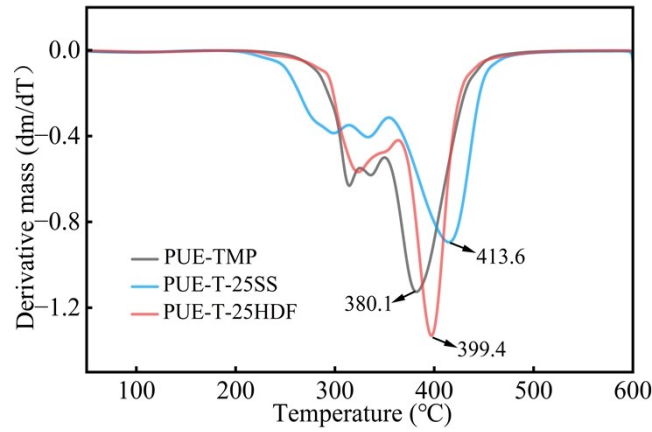


Fig. S4 DTG Curves for Three PUE

The calculation of $\tan \delta$ area (TA). The TA method can be used to comprehensively evaluate the damping performance of a material. The TA value refers to the area of the damping peak with a $\tan \delta \geq 0.3$, and The TA value is calculated as follows,

$$TA = \int_{T_2}^{T_1} \tan \delta dT$$

where $\tan \delta$ is the loss factor, T_1 and T_2 are initial and final temperature of damping temperature range where $\tan \delta$ is greater than or equal to 0.3.

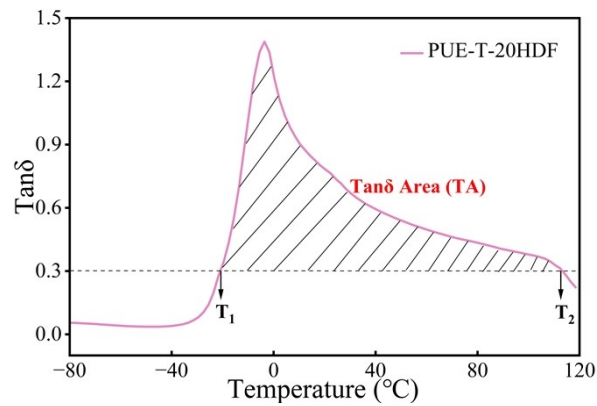


Fig. S5 TA value of PUE-T-20HDF

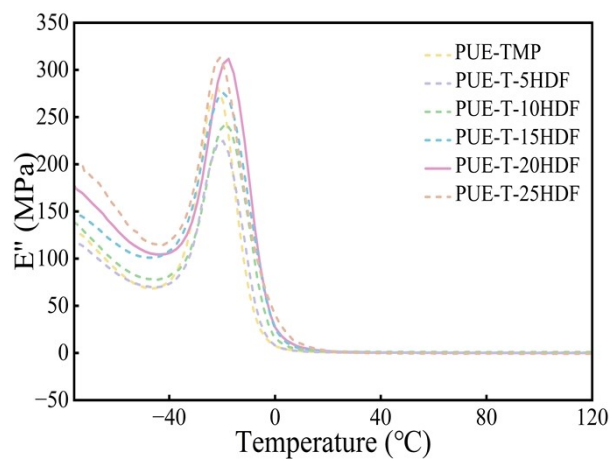


Fig. S6 loss modulus curves of PUE-T-XHDF

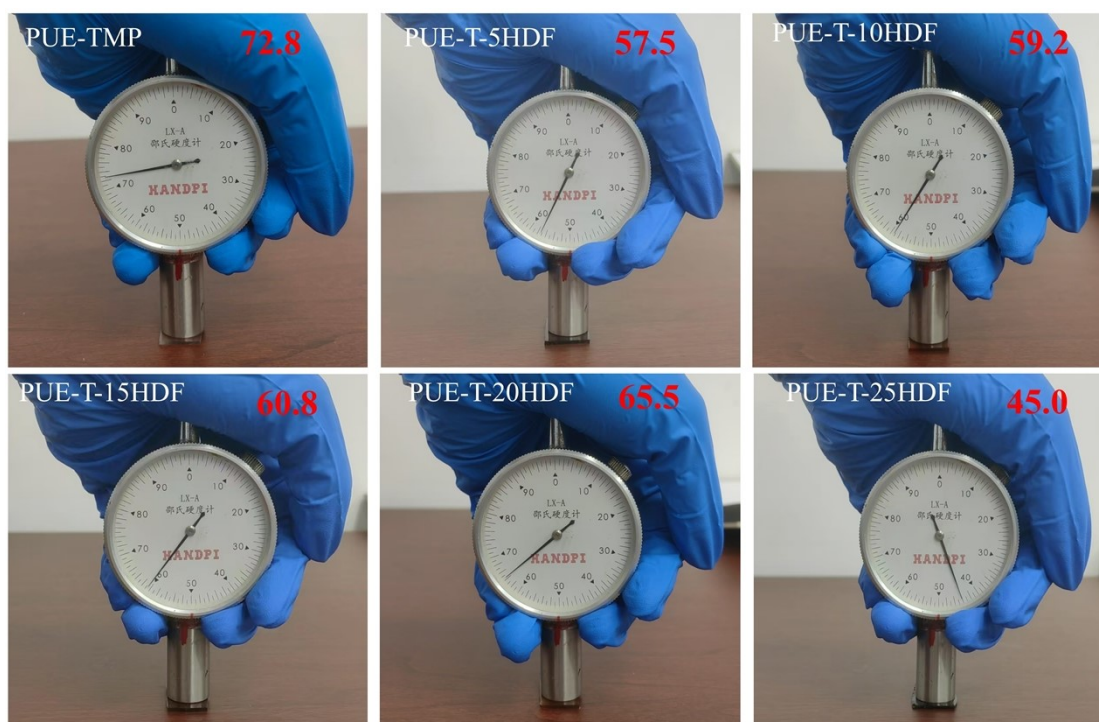


Fig. S7 Effect of HDF content on hardness of the PUE composites

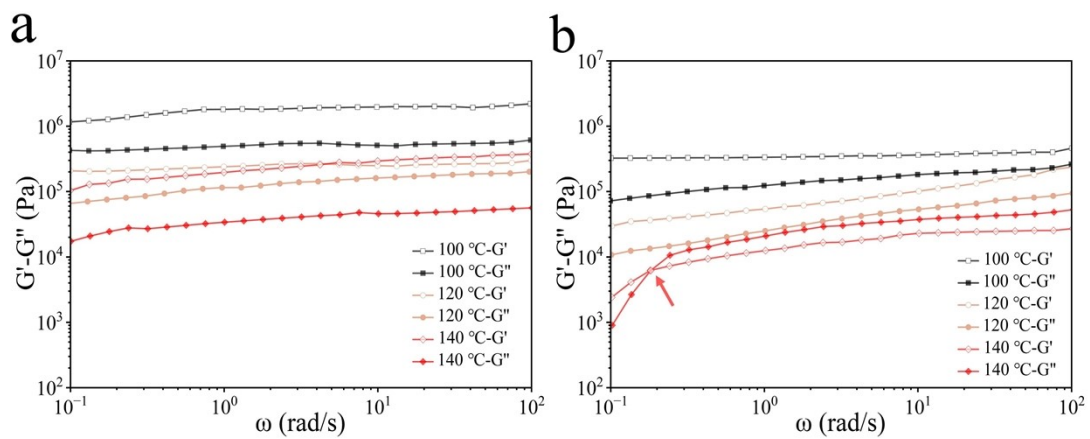


Fig. S8 Rheological Curves of (a)PUE-TMP and (b)PUE-T-20SS

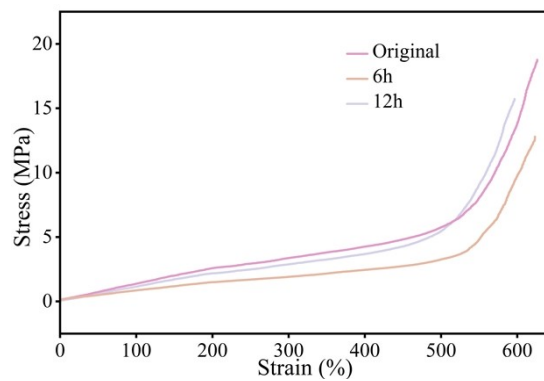


Fig. S9 Tensile strength recovery of PUE-T-20HDF after self-healing at 80 °C for 6 h and 12 h

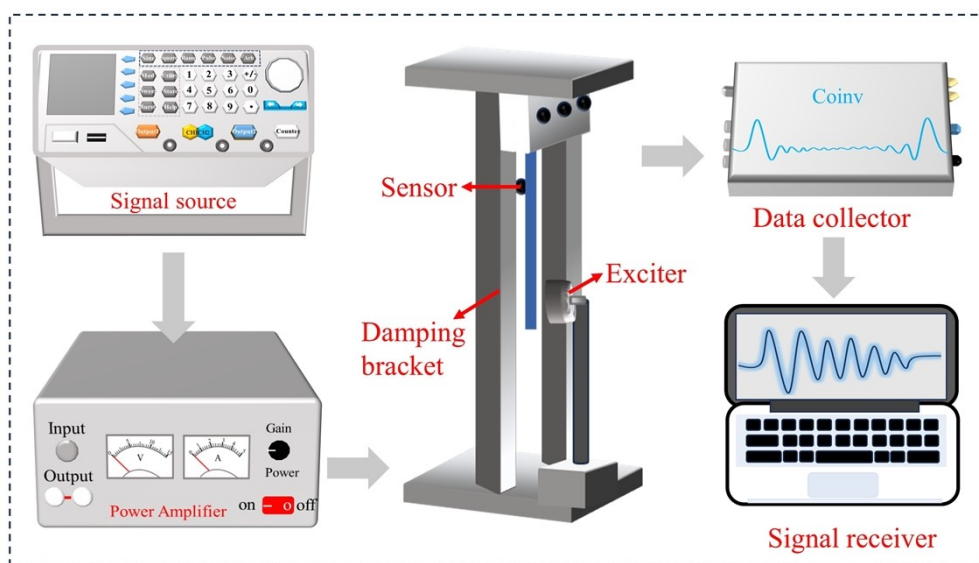


Fig. S10 Resonance Testing System

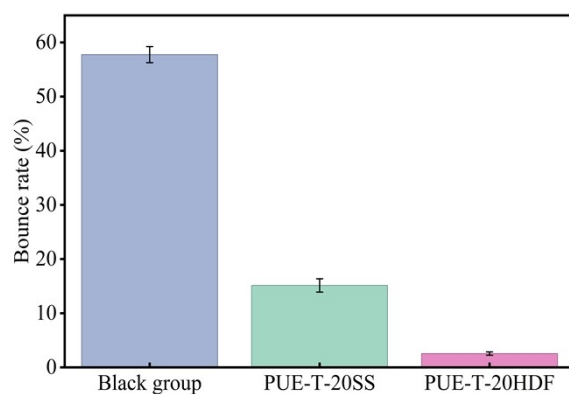


Fig. S11 Comparison of Rebound Rates Among the Black group, PUE-T-20SS, PUE-T-20HDF

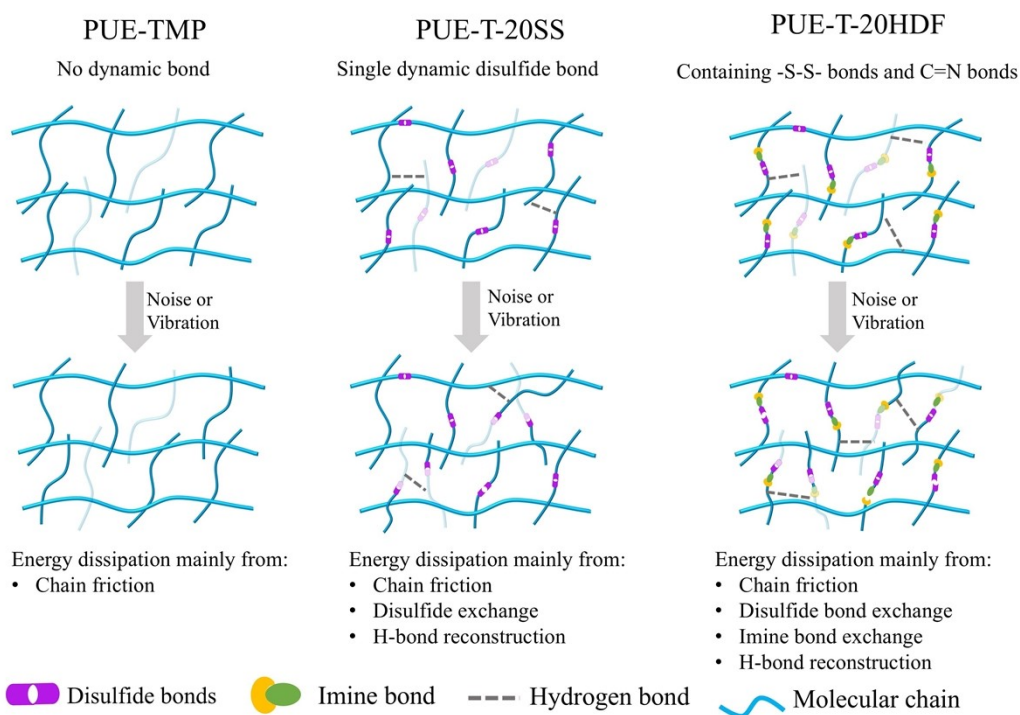


Fig. S12 Comparison of the energy dissipation mechanisms of PUE-TMP, PUE-T-20SS, and PUE-T-20HDF

In this study, we first synthesized a prepolymer using 2,4-toluene diisocyanate (TDI, with a NCO mass fraction of 48.2%) and PEPA2000, controlling the NCO content of the prepolymer at 6%. In addition, the R value is defined as 0.9. (The R value represents the ratio of the number of moles of -NCO in the prepolymer to the number of moles of -OH in the chain extender, indicated as mol(-NCO)/mol(-OH)). Isophorone diisocyanate (IPDI, with a mass fraction of NCO of 37.5%) was then added to increase the total mass fraction of NCO in the mixture of prepolymer and IPDI from 6% to 8%. The mixing ratio was calculated using the following formula:

$$\frac{0.06 \times m_T + 0.375 \times m_I}{m_T + m_I} = 0.08$$

where m_T is the mass of the prepolymer added, and m_I is the mass of the IPDI added.

Since the total NCO molarity has increased, to maintain $R = 0.9$, the -OH molarity of the chain extender (HDF+TMP) should be increased proportionally, i.e., recalculated based on the new total NCO molarity.

Under the above conditions, A series of PUE materials was synthesized by controlling the ratio of two chain extenders (HDF and TMP).

Table S1: Specific Experimental Formula Parameters for PUE Synthesis

Sample	Prepolymer/g	HDF/g	TMP/g	IPDI/g	2-DAPS/g
PUE-TMP	40	0	4.04	2.71	0
PUE-T-5HDF	40	1.05	3.84	2.71	0
PUE-T-10HDF	40	2.10	3.63	2.71	0
PUE-T-15HDF	40	3.15	3.43	2.71	0
PUE-T-20HDF	40	4.20	3.23	2.71	0
PUE-T-25HDF	40	5.25	3.03	2.71	0
PUE-T-20SS	40	0	3.23	2.71	2.25

Table S2: The assignment of the deconvoluted subpeaks in the FTIR C=O absorption bands

Peak position	peak position	Area percentage/%	Type	H-bonded content/%
PUE-TMP	1600	-5.00546	Ordered	70.7
	1621	-2.47449	Ordered	
	1682	-14.13859	Disordered	
	1717	-49.16733	Ordered	
	1740	-29.31414	Free	
PUE-T-20SS	1600	-7.02999	Ordered	80.8
	1623	-4.09519	Ordered	
	1703	-29.18221	Disordered	
	1725	-40.1031	Ordered	
	1738	-19.58952	Free	
PUE-T-20HDF	1600	-2.72135	Ordered	83.1
	1678	-39.63285	Disordered	
	1711	-40.67746	Ordered	
	1731	-16.96834	Free	

Table S3: Thermal Decomposition Parameters of PUE Materials

Sample	T ₅ (°C)	Residual Carbon Rate (%)	Maximum Thermal Degradation Rate Temperature (°C)
PUE-TMP	265	3.53	380.1
PUE-T-20SS	296	5.08	413.6
PUE-T-20HDF	301	4.38	399.4

T₅ (°C): Temperature at which the sample loses 5% of its weight

Table S4. Damping Performance Parameters of PUE

Sample	Effective Damping		TA(K)
	Temperature Range (°C)	Tan δ_{\max}	
PUE-TMP	38	1.05	15.9
PUE-T-5HDF	45	1.18	18.1
PUE-T-10HDF	60	1.15	20.8
PUE-T-15HDF	74	1.25	23.1
PUE-T-20HDF	134	1.38	44.2
PUE-T-25HDF	124	1.32	34.3

Table S5. Mechanical Performance Parameters of PUE

Sample	Stress (MPa)	Strain (%)
PUE-TMP	22.5	326
PUE-T-5HDF	18.8	396
PUE-T-10HDF	19.5	489
PUE-T-15HDF	20.3	554
PUE-T-20HDF	19.1	626
PUE-T-25HDF	12.4	680