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Supplementary material

Electrorheological elastomer for simultaneous enhancements in durability and micro-vibration suppression

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Mechanical analysis

Harmonic excitation with variable displacement frequency and amplitude was used. The top of the counterweights and the vibration exciter were each connected to a load cell respectively, which recorded the response and excitation force signals. The transmission function is defined as follows:

$$\mathrm{T} = \log_{10}\left[\frac{\mathrm{Z}_2}{\mathrm{Z}_1}\right]^2$$

where T is the transmission amplitude, Z_2 is the response signal, and Z_1 is the excitation signal.

Since the dynamic mechanical properties of ERE are independent of the excitation amplitude and frequency, the vibration differential equation of the ERE vibration isolation system is derived as follows:

$$m\ddot{x}_p + (c_0 + \Delta c)(\dot{x}_p - \dot{x}_e) + (k_0 + \Delta k)(x_p - x_e) = 0$$

c_0 and Δc are the zero-field damping and field damping (damping change due to applied electric field) of the ERE isolation; k_0 and Δk are the zero-field stiffness and field damping (stiffness change due to applied electric field) of the ERE isolation; x_p and x_e are the base excitation and response displacements of the primary system, respectively. The vibration transfer function of the system is obtained by the Laplace transformation:

$$H(s) = \frac{X_p(s)}{X_e(s)} = \frac{(c_0 + \Delta c)s + (k_0 + \Delta k)}{ms^2 + (c_0 + \Delta c)s + (k_0 + \Delta k)}$$

At the same time, the Laplace transform is converted to a Fourier transform to obtain the frequency response function of the system.

$$H(s) = \frac{X_p(s)}{X_e(s)} = \frac{j\omega c + k}{-m\omega^2 + j\omega c + k}$$

The transfer function in the real number domain is given as a function of the excitation frequency, the natural frequency of the system, the ERE stiffness, the ERE damping and the primary mass.

$$H(s)=\frac{|X_p(j\omega)|}{|X_e(j\omega)|}=\sqrt{\frac{1+4\xi^2\eta^2}{(1-\eta^2)^2+4\xi^2\eta^2}}$$

In order to evaluate the damping force under different electric field, the effective damping coefficient (C_{eff}) calculated as follows:

$$C_{eff}=H/2\pi^2 fX^2$$

The parameter *H*, is the energy dissipated by the ER damper in one cycle, corresponding to the area enclosed within the hysteresis loop of stress-strain curve. Where, *f* is the excitation frequency, and *X* is the excitation amplitude.

Table S1. The tabular data of EREs including relaxation stress, zero-field modulus (E_0), electro-induced modulus (△E), storage modulus (E’), and loss modulus (E’’) at 10Hz.

sample	relaxation stress (MPa)	E_0 (MPa)	△E (MPa)	E’ (MPa)	E’’ (MPa)
TiO_2:HCs=2:1	0.03	0.68	0.06	0.58	0.06
TiO_2:HCs=1:1	0.05	1.15	0.25	1.45	0.19
TiO_2:HCs=1:1.5	0.04	0.94	0.15	1.41	0.19
TiO_2:HCs=1:2	0.04	0.77	0.14	0.82	0.12
TiO_2:HCs=1:4	0.03	0.63	0.07	0.88	0.12

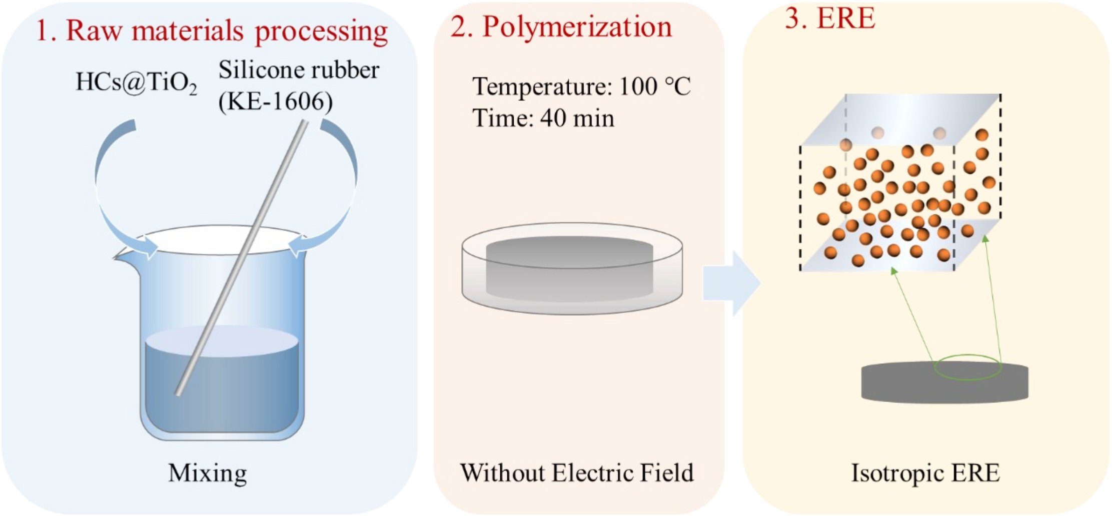

Diagram S1. Schematic illustration for the preparation of EREs.

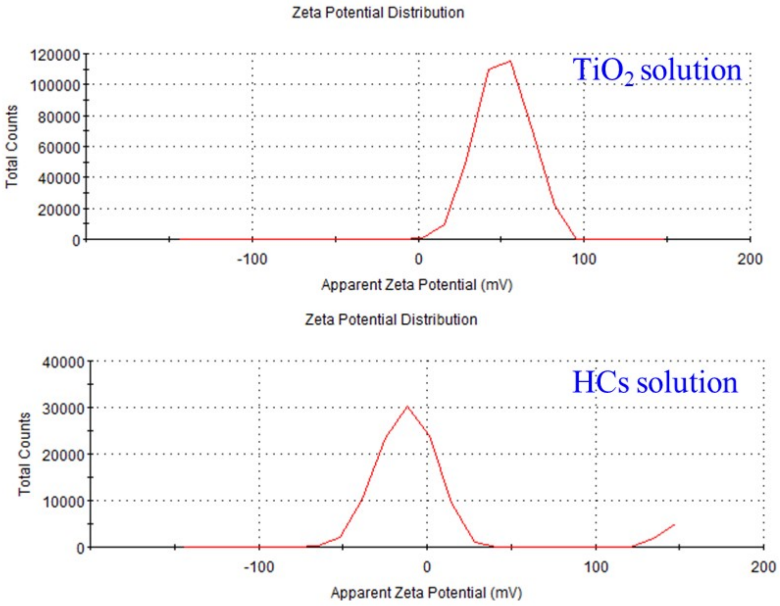

Figure S1. Zeta potential of TiO_2 and HCs ethanol solution.

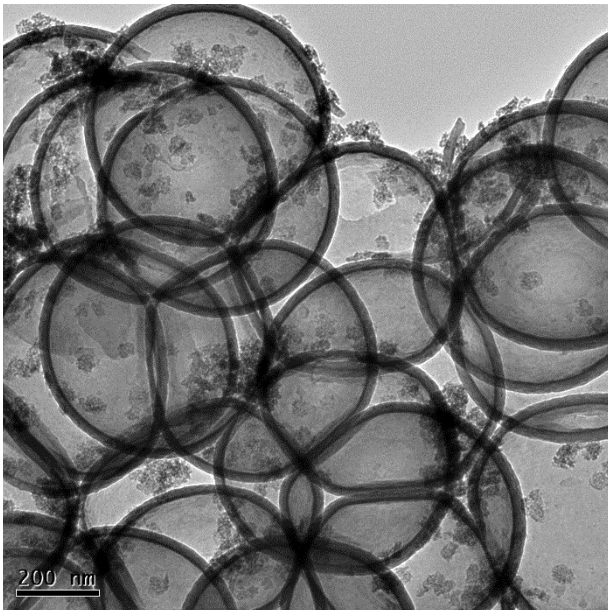

Figure S2. TEM image of TiO_2: HCs particles with the ratio of 1: 1.

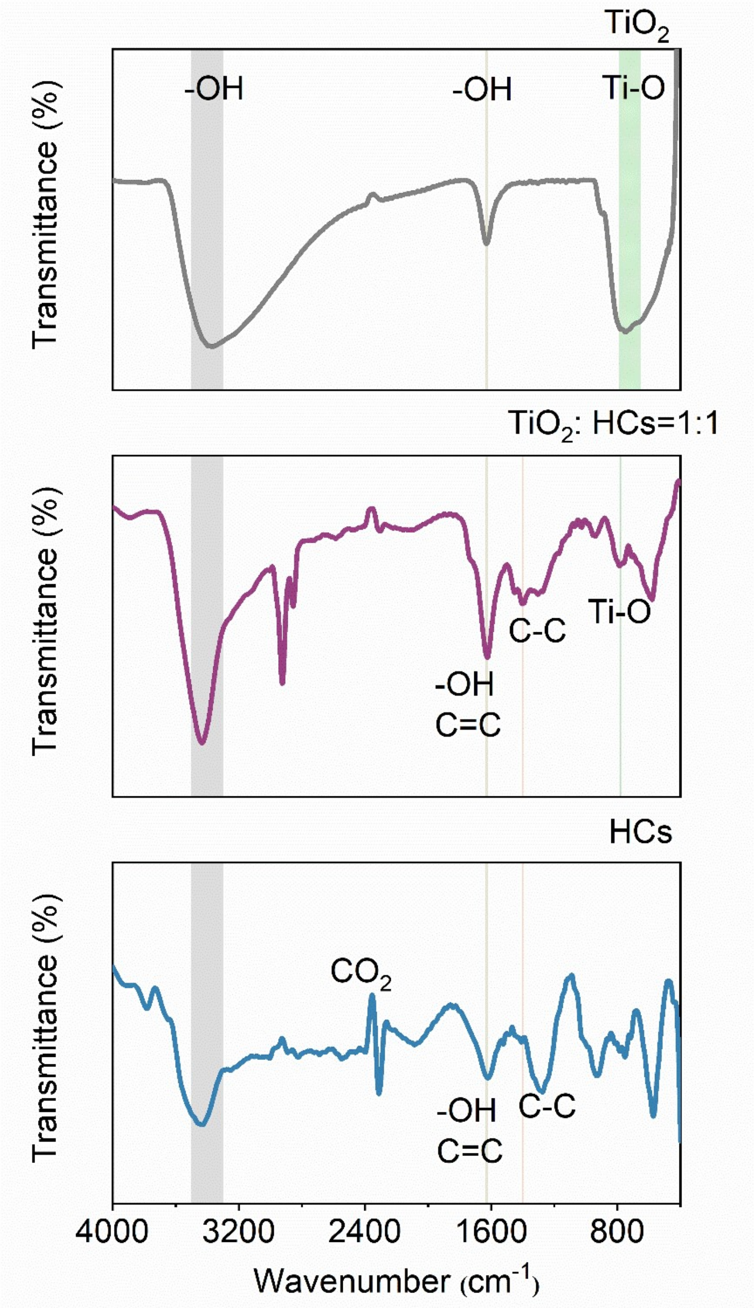

Figure S3. FTIR spectrum of TiO_2, TiO_2: HCs, and HCs samples.

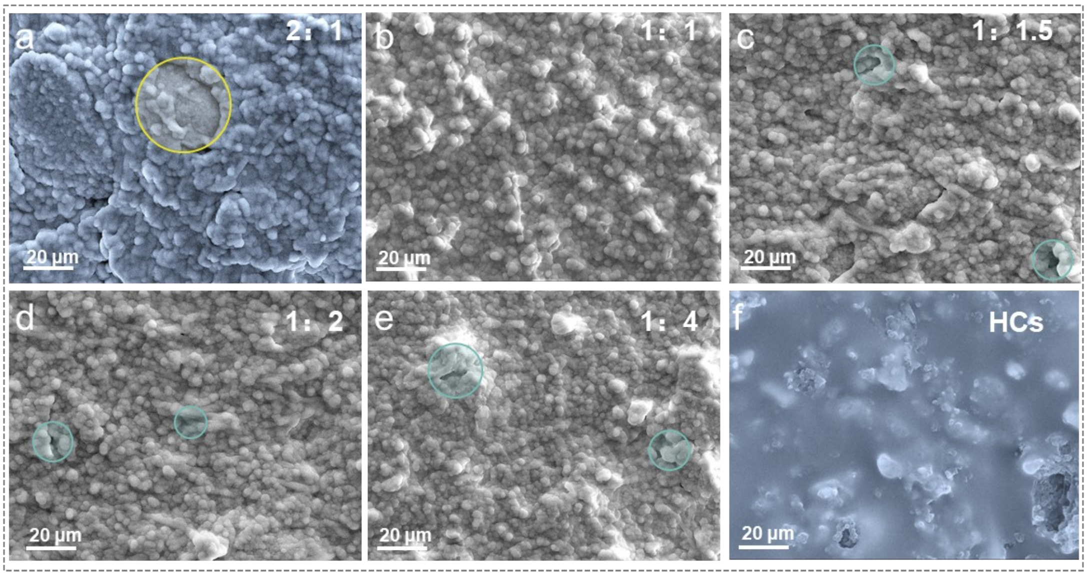

Figure S4. SEM images for cross-section of EREs with different TiO_2: HCs, (a) 2:1, (b) 1:1, (c) 1:1.5, (d) 1:2, (e) 1:4, (f) pure HCs.

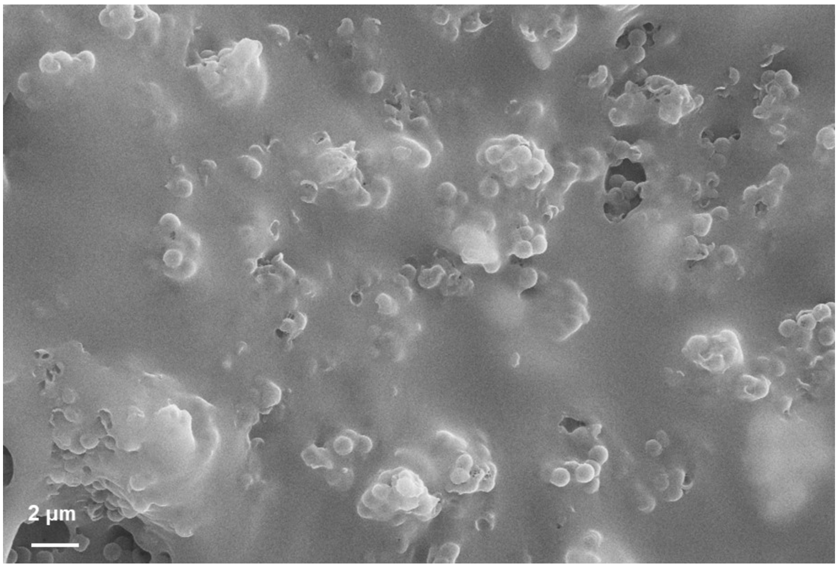

Figure S5. SEM images of the cross section of EREs following the compressive test.

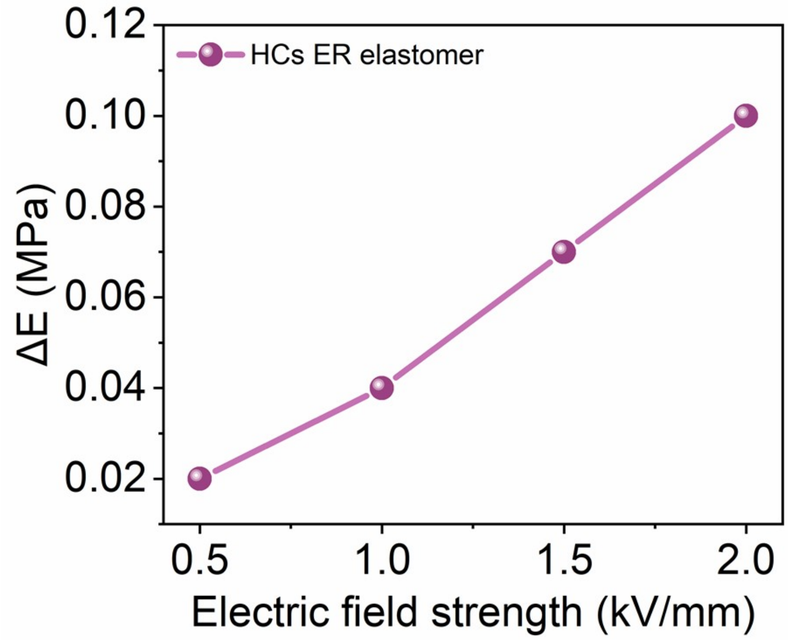

Figure S6. The relative elastic modulus (△E) of HCs ERE at different electric field strength.

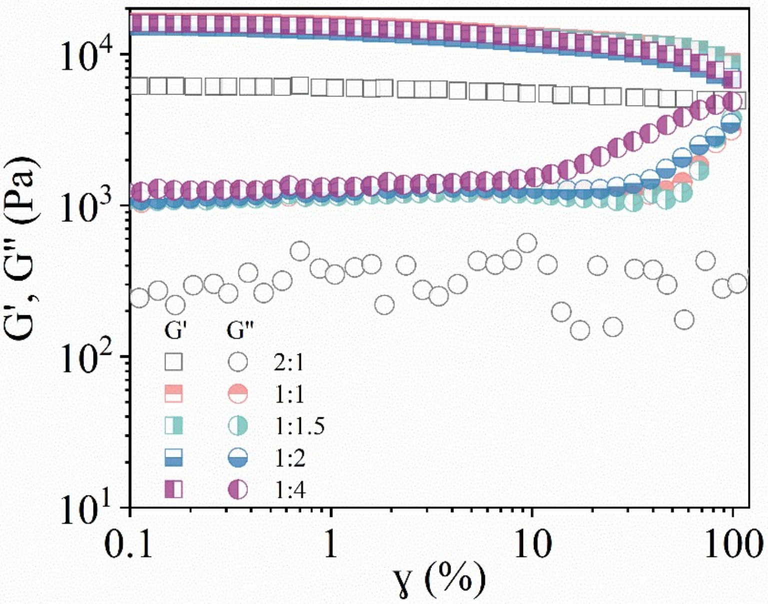

Figure S7. The strain dependence of the storage modulus (G’) and loss modulus (G’’) for ERE with different TiO_2: HCs at shear mode.

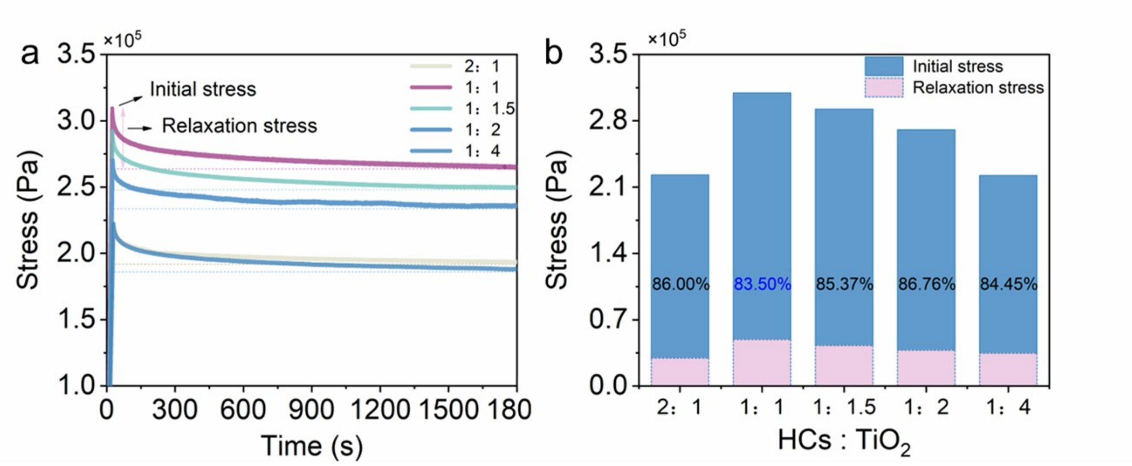

Figure S8. Stress relaxation data of TiO_2/HCs ERE with different TiO_2: HCs, (a) Stress relaxation vs time curve, (b) Initial stress and relaxation stress analysis vs different ratio.