

Supporting Information

Highly sensitive and stretchable double-layer conductive network structure CB/TPU/CB/MXene strain sensor for Human-Machine interaction

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Table S1. The list of Materials

Materials	Type specification	Source
TPU	1185A	BASF., Ltd
Dimethyl Formamide (DMF)	-	Kemiou Chemical Co., Ltd
Tetrahydrofuran (THF)	-	Chendu Kelon Chemical Co., Ltd
Carbon Black	Average grading 60nm	Cabot Corp., Ltd
Ethyl alcohol	Alcohol concentration >99%	Tianjin Fuyu Fine Chemical Co., Ltd
MXene/NMP suspension	XFK-04	Nanjing/Jiangsu XFNANO Materials Tech Co., Ltd

Formula S1. Gauge Factor calculation

The GF is frequently used to evaluate the responsivity of a strain sensor, is estimated by following formula:

$$GF = \frac{\Delta R}{\Delta \varepsilon} \quad (1)$$

Here, ΔR , R_0 and $\Delta \varepsilon$ represent the change in resistance ($R - R_0$), the initial resistance and the applied strain, respectively.

Formula S2. Conductivity calculation

The Conductivity is estimated by following formula:

$$\sigma = \frac{1}{\rho} \quad (1)$$

$$G = \frac{\sigma \times A}{L} = \frac{1}{R} \quad (2)$$

It can be obtained by equations (2),

$$\sigma = \frac{L}{A \times R}$$

Here, σ - Conductivity, R- Resistance, A- Cross sectional area, L- Material length.

Definition S1.

Resolution detection: Apply a larger stimulus signal first to generate the signal. Then, fine signal stimulation is carried out until another signal is generated on the basis of the previous signal. It aims to measure whether it has the function of detecting trace stimuli at a high measurement range.

Low detection limit: When no stimulus signal is received (no signal fluctuation, relative change is 0), when a tiny stimulus is applied until a signal is generated, the minimum stimulus signal applied at this time is the lowest detection limit.

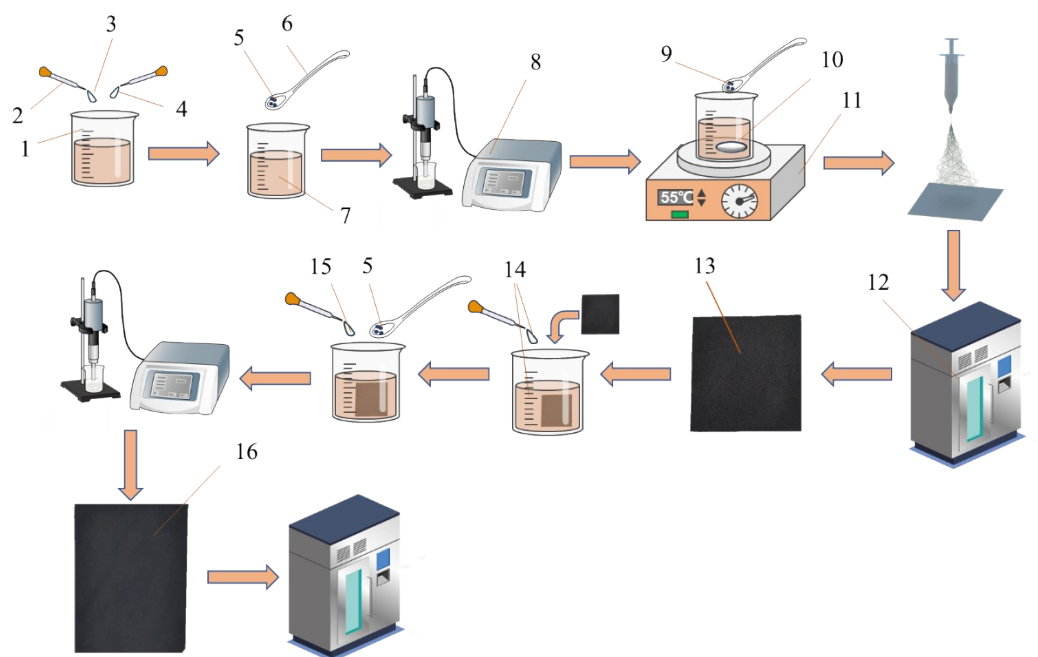


Figure S1. The schematic illustration of the fabrication process of CTCM

As show in Figure S1. The list of components represented by each label is as follows: 1-beaker, 2-pipettes, 3-DMF solution, 4-THF solution, 5-carbon black particles, 6-taking spoon, 7-DMF/THF mixed solution, 8-ultrasonic cell breaker, 9-thermoplastic polyurethane, 10-rotor, 11-magnetic mixer, 12-constant temperature and humidity box, 13-CT film, 14-anhydrous ethanol solution, 15-MXene dispersion, 16-CTCM film.

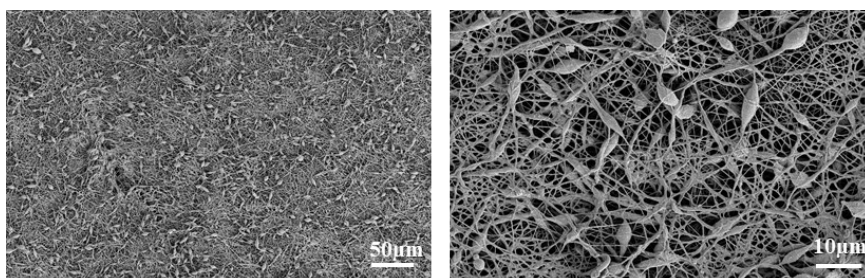


Figure S2. The SEM of CT film microstructure

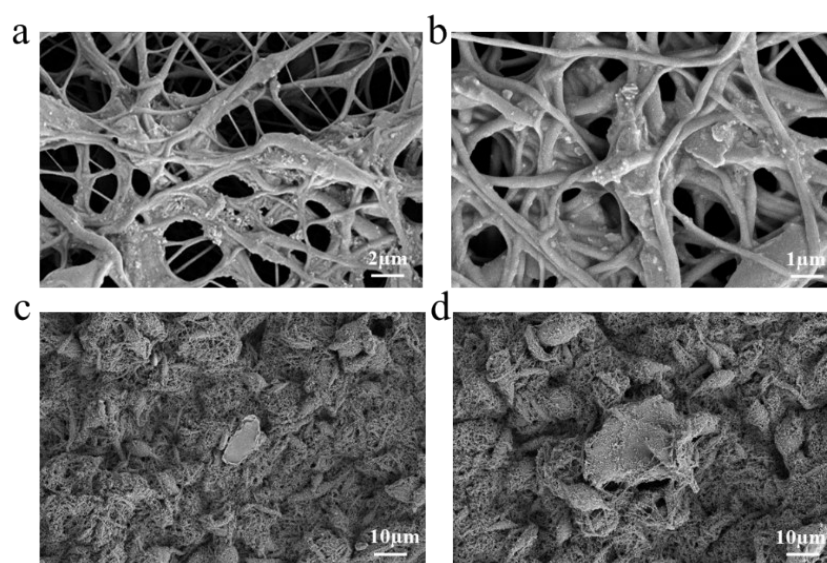


Figure S3. The SEM of CT and CTCM film

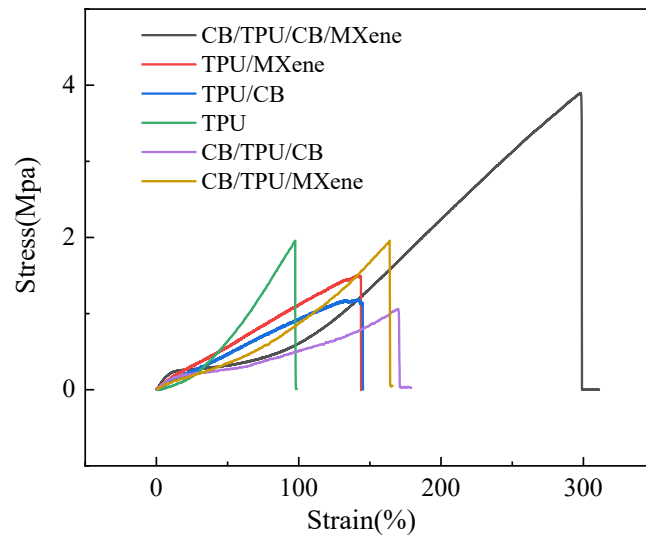


Figure S4. Stress-strain curves of each composite material

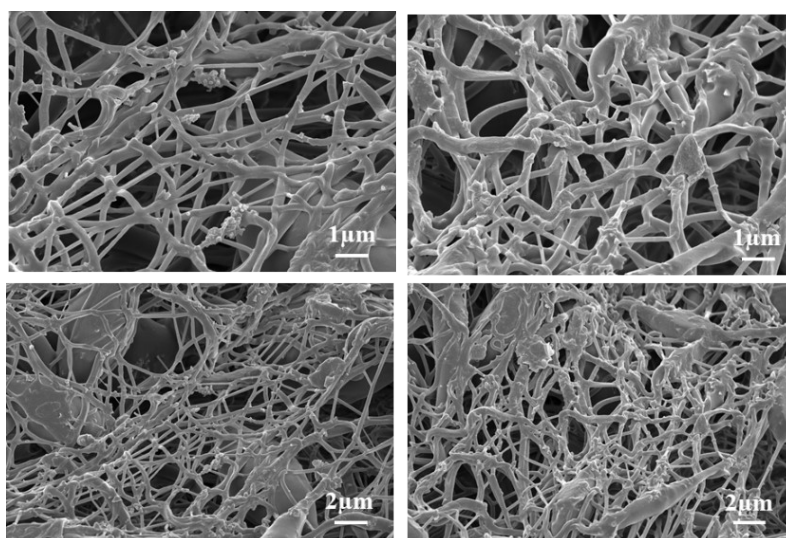


Figure S5. Network node structure of CT fibers

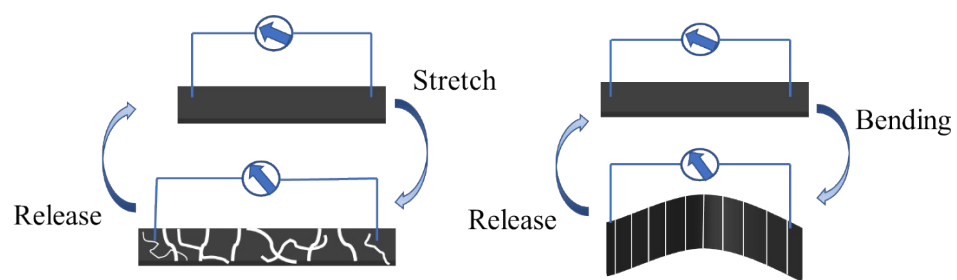


Figure S6. Change model of conductive network during strain process

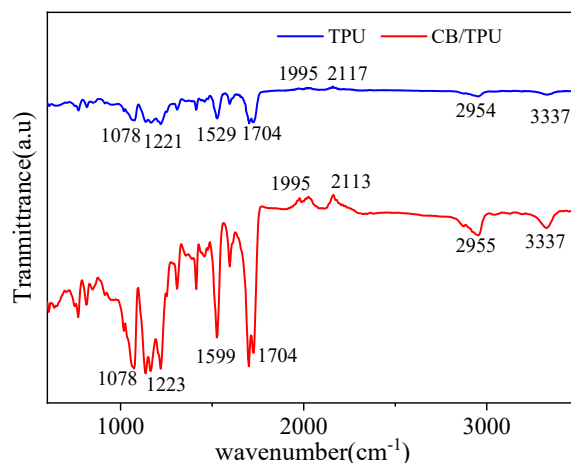


Figure S7. The FT-IR images of TPU and CT films clearly show the changes in the peak values of CT and pure TPU during electrospinning, which indicates that weak hydrogen bonding occurs during the spinning process, strengthening the interfacial interaction.

As shown in Figure S7 of the support information the introduction of CB makes the characteristic peaks of the peak TPU (such as C=O at 1704 cm^{-1} and C-O-C at 1223 cm^{-1}) still exist, but the N-H peak at 1529 cm^{-1} is replaced or masked by the peak at 1599 cm^{-1} . These functional groups can have strong physical interactions with the polar groups on the TPU molecular chain (such as C=O, N-H). The introduction of CB brings about these interactions, which is equivalent to adding physical crosslinking points in the TPU matrix, thereby significantly enhancing the mechanical strength, hardness and electrical conductivity of the film.

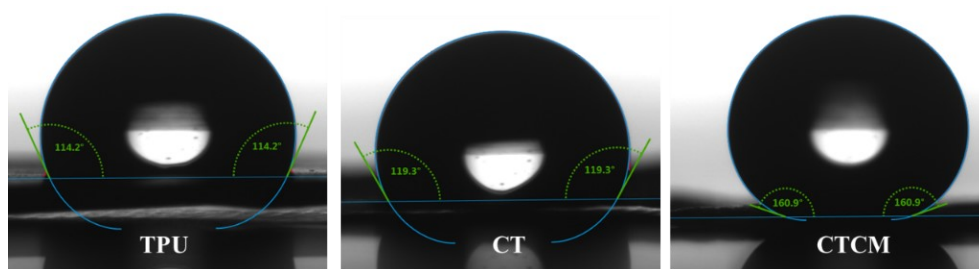


Figure S8. Contact angle of different film

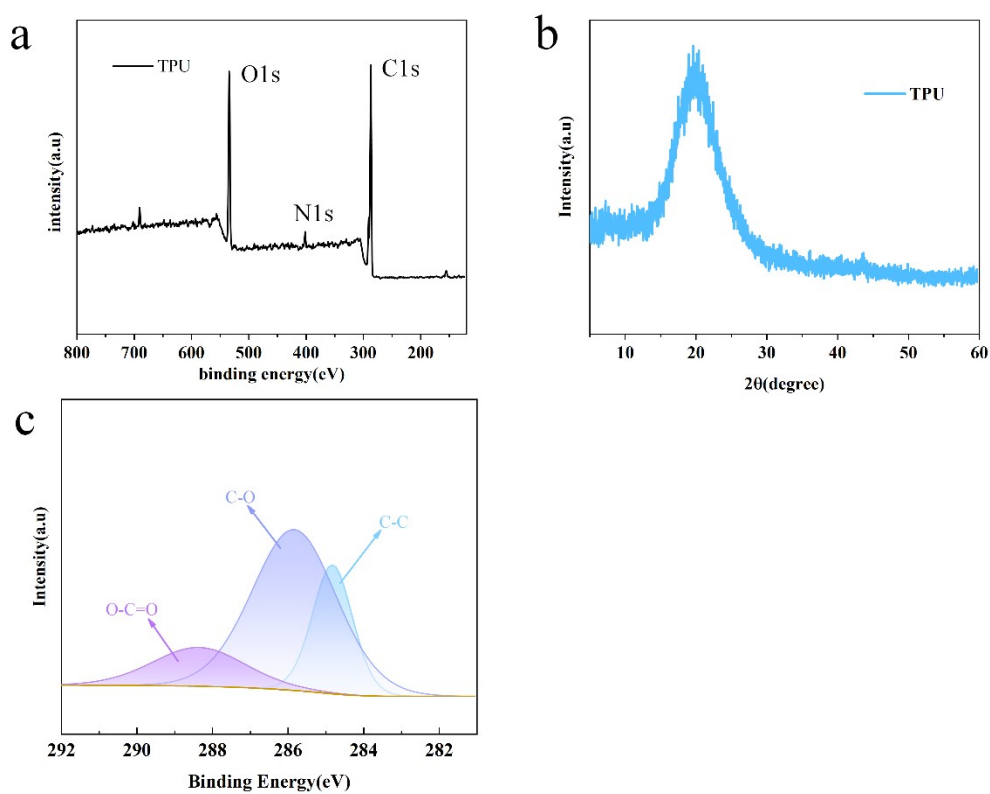


Figure S9. XPS and XRD images of TPU. (a)The XPS of TPU. (b)The XRD of TPU. (c)The Peak fitting of carbon element about TPU.

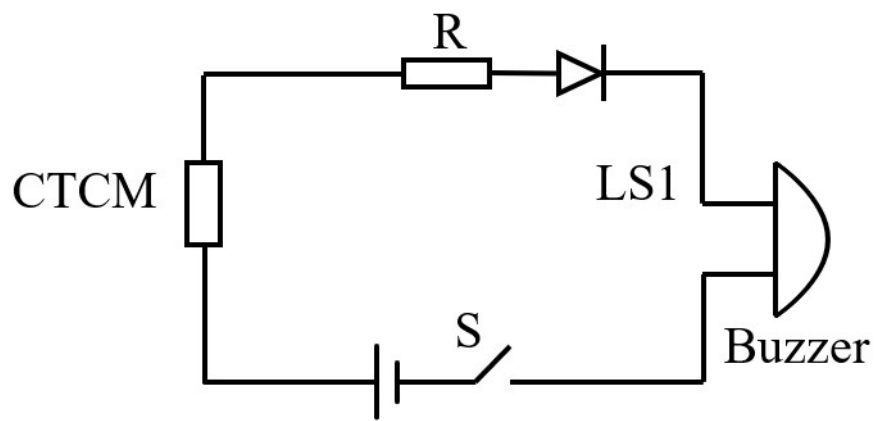


Figure S10. The schematic diagram of LED

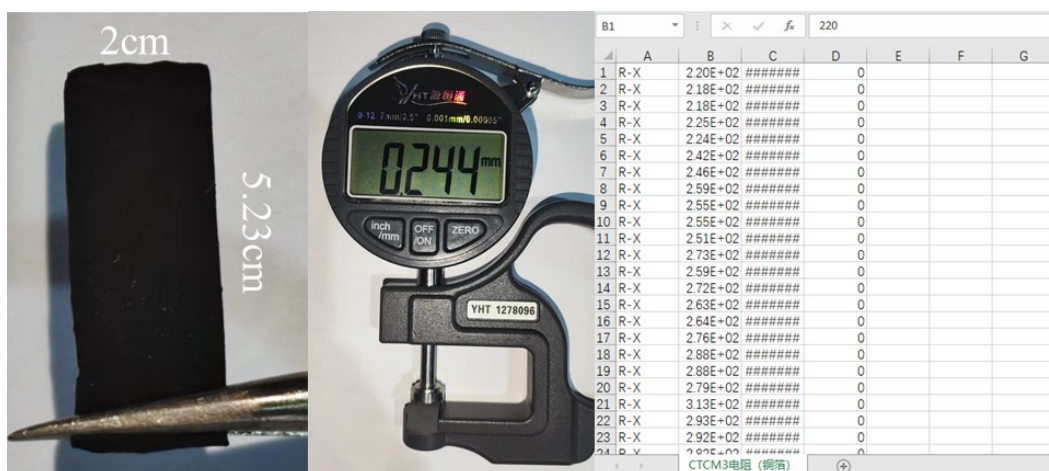


Figure S11. Data related to the conductivity of CTCM

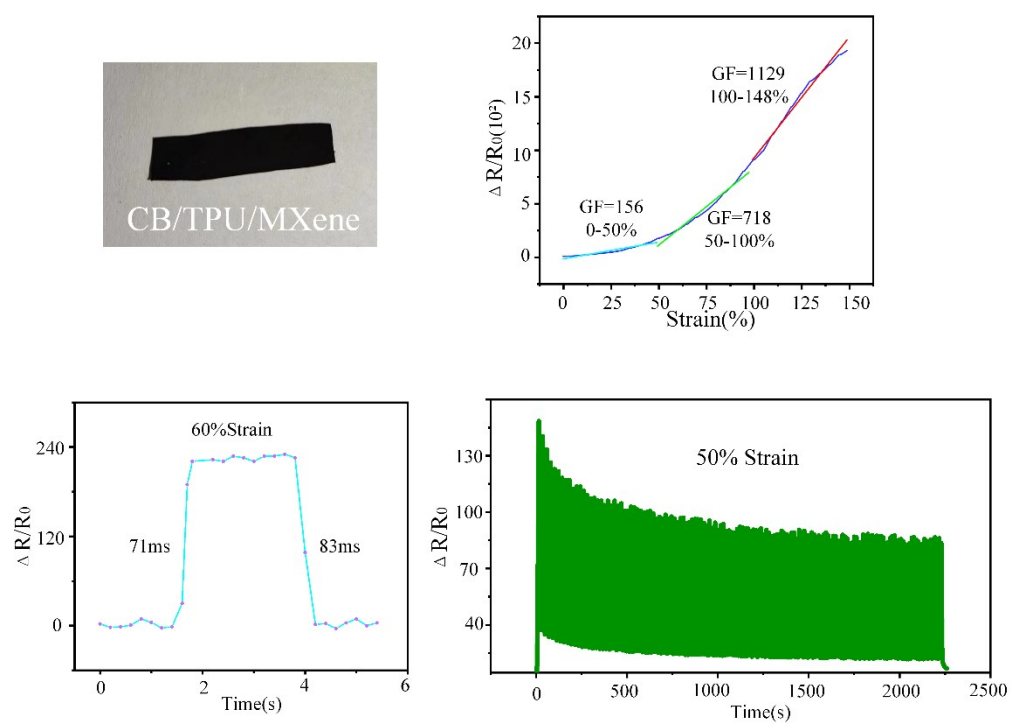


Figure S12. Electromechanical properties of CB/TPU/MXene

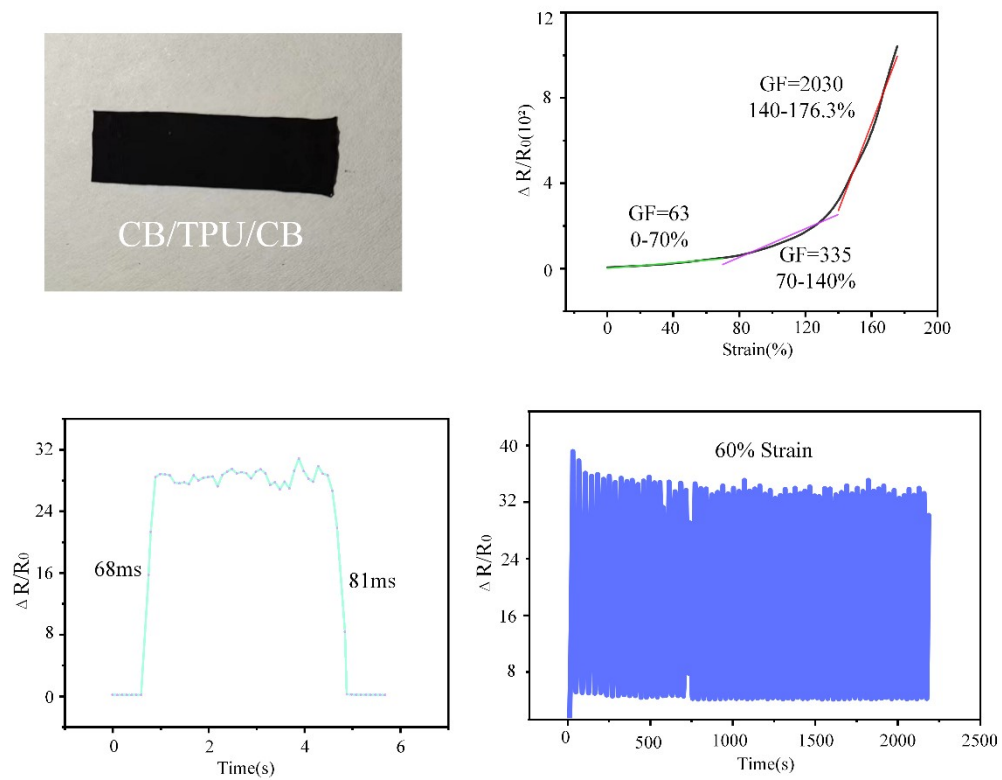


Figure S13. Electromechanical properties of CB/TPU/CB

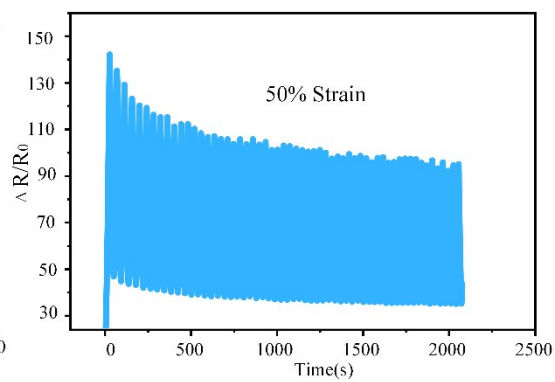
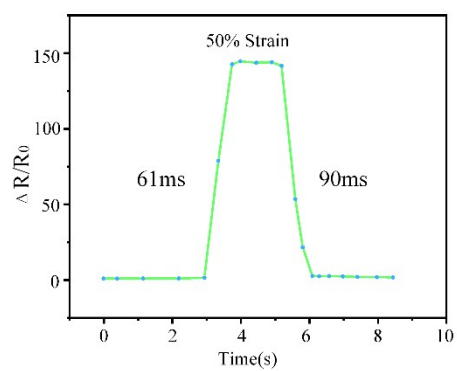
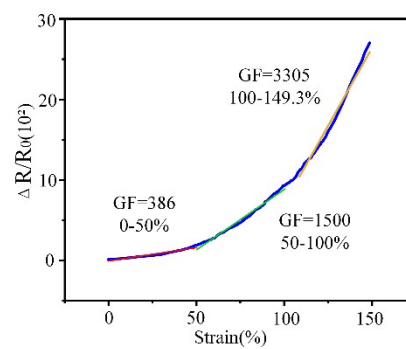


Figure S14. Electromechanical properties of CB/TPU



Figure S15. (a) Physical picture of TPU/MXene composite film. (b) The composite film is non-conductive, and the multimeter shows 0. (c) Test conductive metals with a multimeter

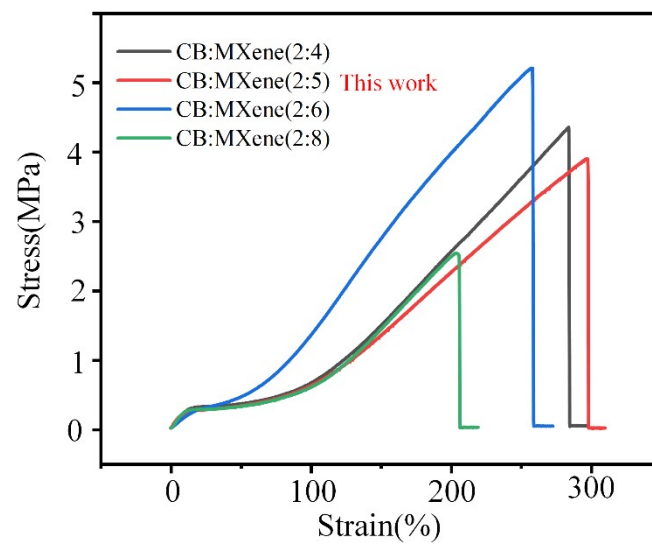


Figure S16. The ratio of CB to MXene in the ultrasonic suspension