SUPPORTING INFORMATION

Self-Plied and Twist-stable Carbon Nanotube Fiber Artificial Muscles Driven by Organic Solvent Adsorption

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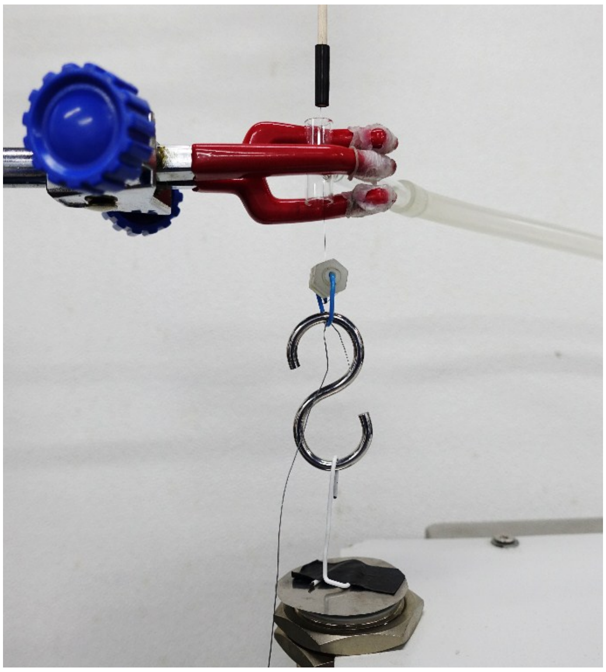

Fig. S1. Photograph of the experimental setup utilized for measuring the muscle actuations.

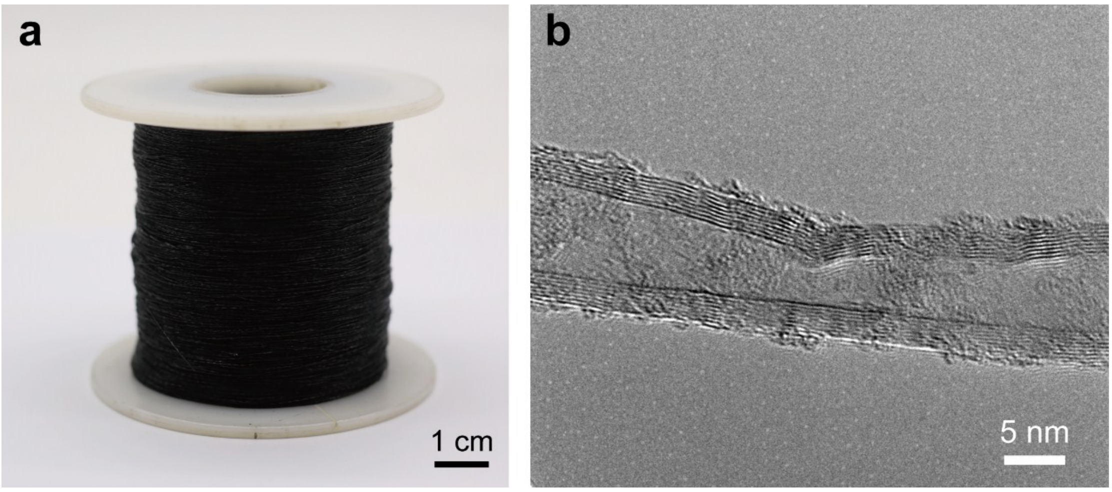

Fig. S2. (a) Photograph of carbon nanotube (CNT) ribbons, (b) TEM image of the CNTs in the ribbon. The outer diameter of multiwalled CNT is about 10 nm.

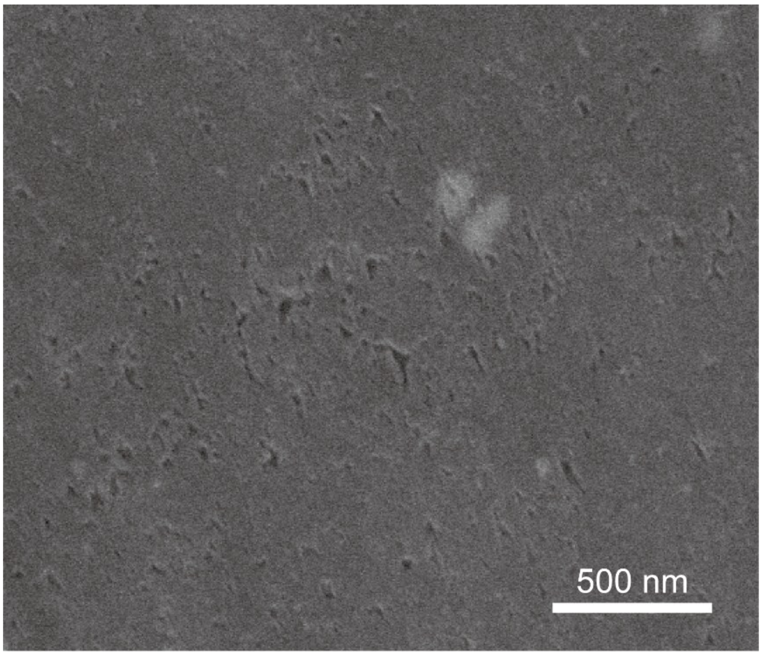

Fig. S3. Cross-sectional SEM image of the centre of a coiled CNT yarn, showing voids inside of the yarn.

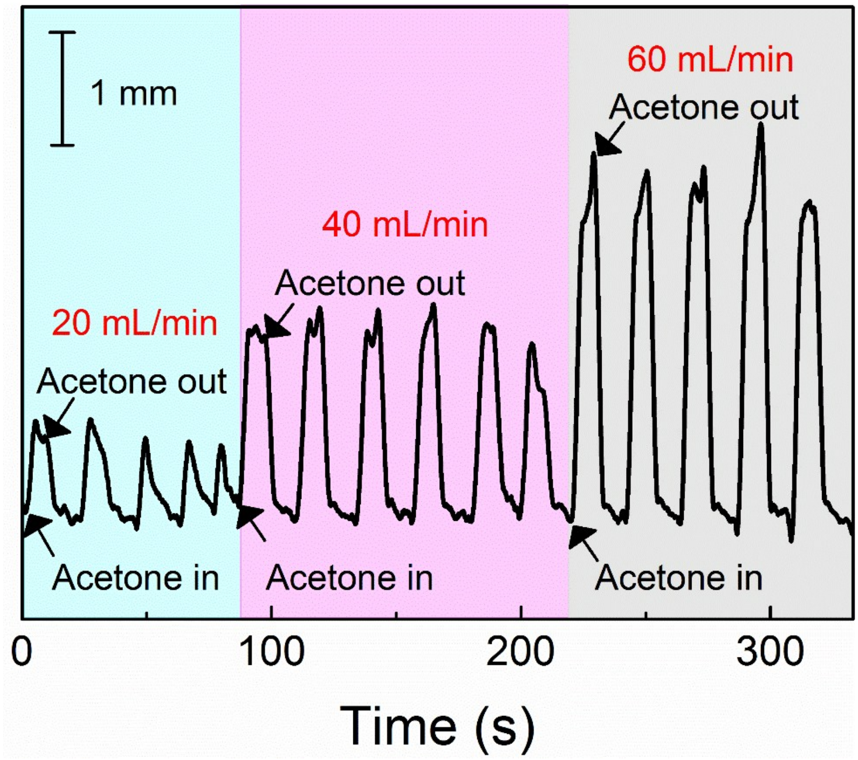

Fig. S4. The contraction of a 150-µm-thick single coiled CNT yarn muscle against a stress of 5.1 MPa. The muscle was driven by the adsorption and desorption of acetone vapor that was brought into the T-tube by nitrogen flow. The flow rates nitrogen passing through acetone were 20 mL/min, 40 mL/min, 60 mL/min, respectively. The contraction stroke at 60 mL/min was about 2.8 %.

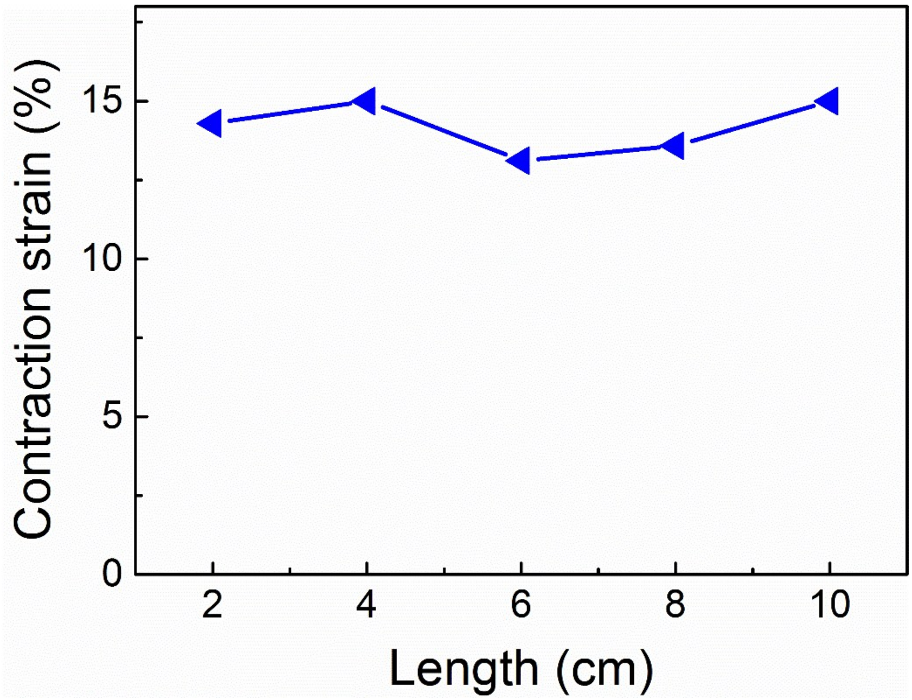

Fig. S5. Dependence of contraction strain on the length of CNT yarn muscles.

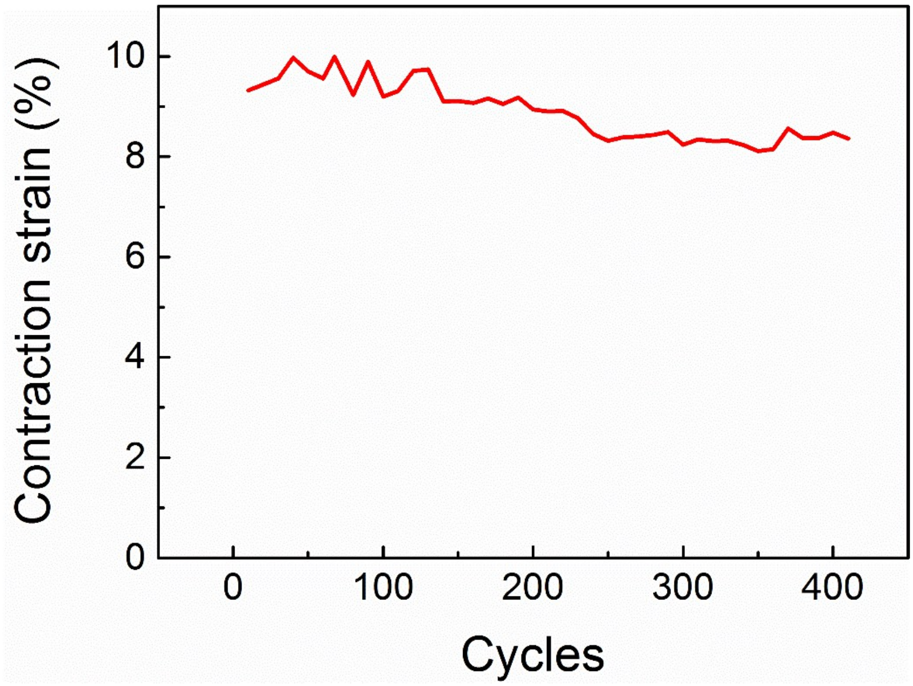

Fig. S6. Contraction strain as a function of actuation cycles for a self-plied CNT yarn muscle driven by acetone adsorption and desorption. A stress of 3.2 MPa was applied during the test.

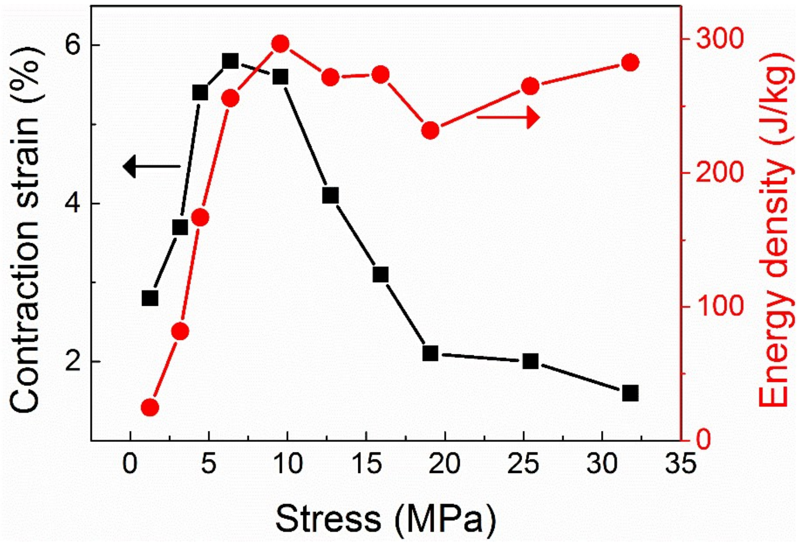

Fig. S7. Stress dependence of contraction strain and energy density for a 150-μm-thick single coiled CNT yarn muscle that was driven by acetone adsorption and desorption.

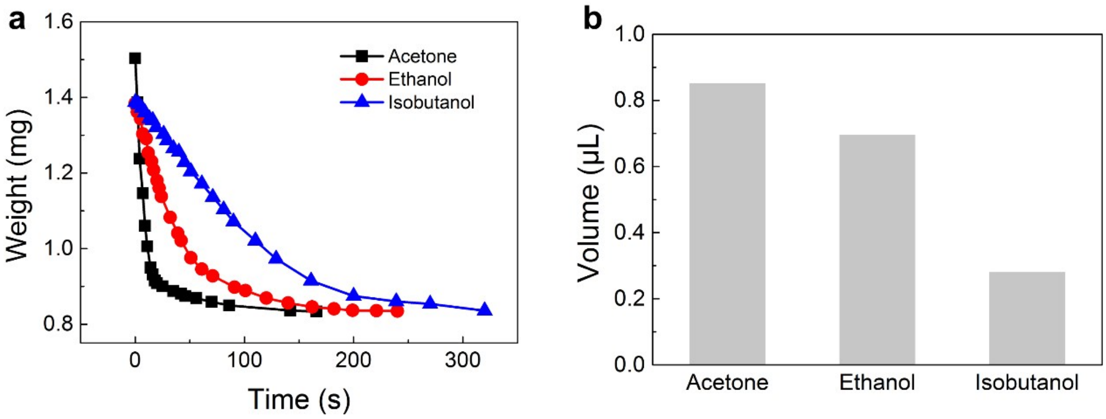

Fig. S8. (a) The weights of the self-plied CNT yarns that were infiltrated by acetone, ethanol and isobutanol as a function of time. Due to solvent desorption, the weight of an infiltrated yarn was gradually decreased and finally stabilized. (b) The volumes of adsorbed acetone, ethanol and isobutanol inside of the yarns.

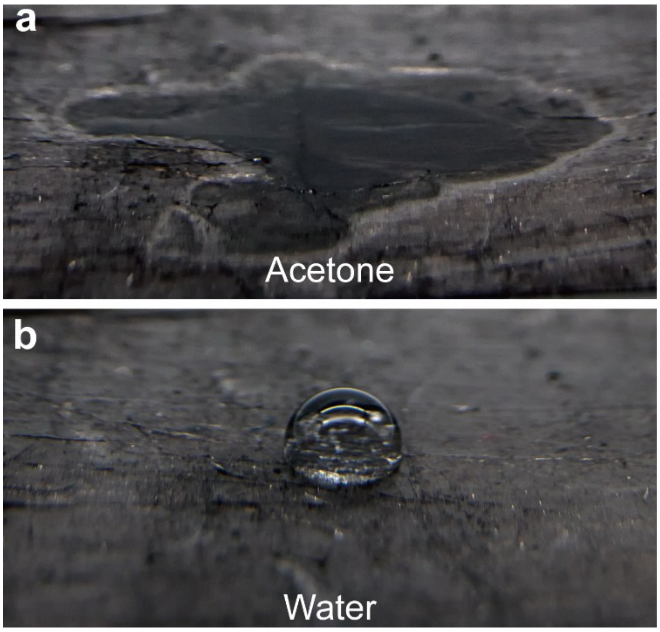

Fig. S9. Photographs of CNT film after applying droplets of (a) acetone and (b) water. The CNT film was prepared using the same method as that for CNT yarns, which is floating catalytic chemical vapor deposition.

Table S1 Properties of different solvents.

	Viscosity (mPa·s)	Surface tension (mN/m)	Polarity	Boiling point (°C)
Acetone	0.32	23.7	5.4	57
Cyclohexane	0.94	24.3	0.1	81
Isopropyl alcohol	2.37	21.7	4.3	82
Acetonitrile	0.37	29.58	6.2	82
Ethanol	1.17	22.27	4.3	78.3
Isobutanol	4.7	23	3	108
Water	1.002	72.75	10.2	100

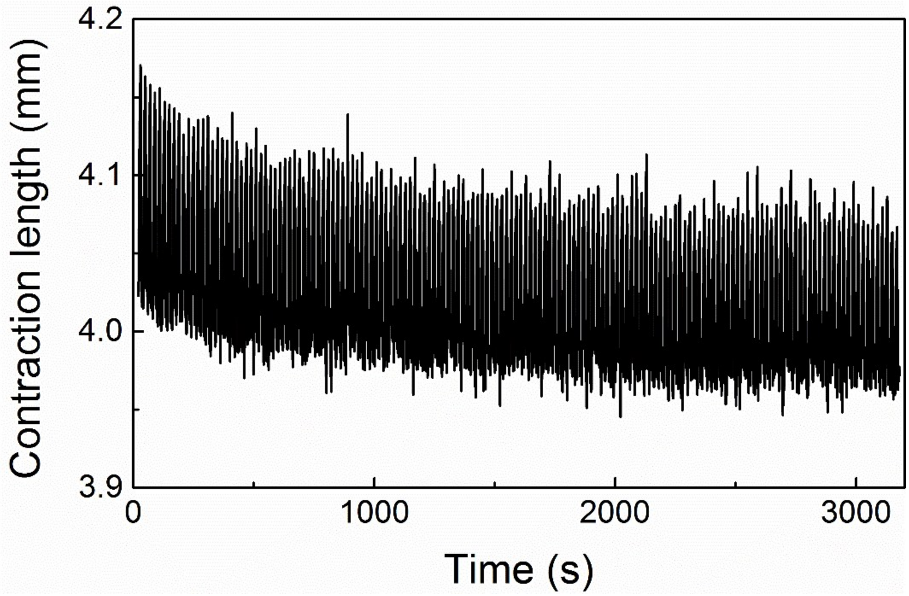

Fig. S10. Cycling stability results for the muscle tested in acetone vapor (N_2 flow rate: 60 mL/min) for about 200 cycles by applying a square-patterned current of 50 mA. A tensile stress of about 3.0 MPa was applied on the muscle during the test.

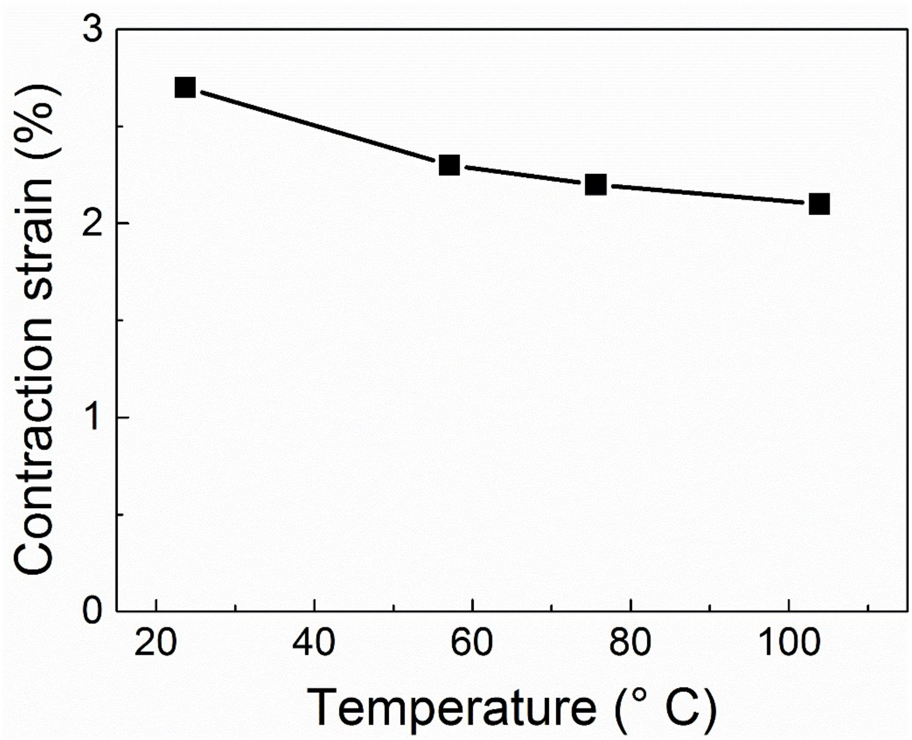

Fig. S11. Characterization of the tensile actuations of a self-plied CNT yarn muscle at 24 °C, 57 °C, 76 °C and 104 °C driven by acetone vapour. These temperatures were enabled by Joule heating of the CNT yarn and measured using an inferred detector.

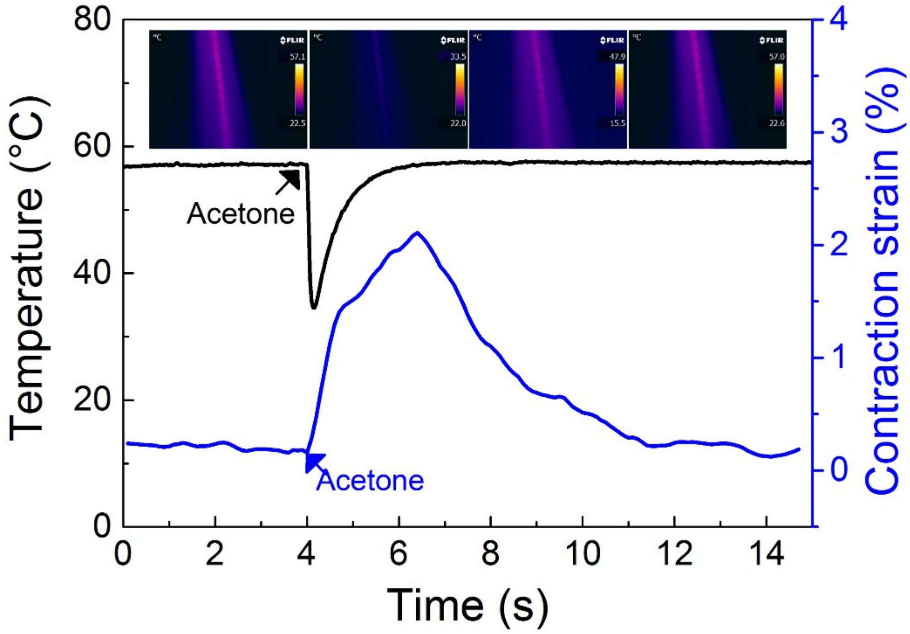

Fig. S12. The temperature (left axis) and contraction strain (right axis) of a self-plied CNT yarn as a function of time. A current of 80 mA was passed through the CNT yarn, which enabled a stable temperature of about 57 °C. The inset images show the temperature variations during the adsorption and desorption of acetone.