Supporting Information

Tunable strain sensor based on carbon nanotubes/electrospun polyamide 6 conductive nanofibrous network embedded into poly(vinyl alcohol) with a capability of self-diagnosis

Ning Wang,[1] Zhuoyan Xu,[1] Pengfei Zhan,[1] Kun Dai,[1,2,*] Guoqiang Zheng,[1] Chuntai Liu,[1] and Changyu Shen[1]

[1]School of Materials Science and Engineering,
The Key Laboratory of Material Processing and Mold of Ministry of Education,
Zhengzhou University, Zhengzhou, Henan 450001, P.R. China

[2]State Key Laboratory of Polymer Materials Engineering, Sichuan University,
Chengdu, Sichuan 610065, PR China

*: *Correspondence authors*

Tel.: +86-371-63887969;

E-mail addresses: kundai@zzu.edu.cn (K. D.)

Fig. S1 shows the dependence of the CNTs content on ultrasonication time. The weights of the PA6 membranes (40×60 mm^2) before and after the ultrasonication treatment are measured by an electronic analytical balance (model ESJ182-4, supplied by Shenyang Longteng Electronic Co., Ltd.). Accordingly, the CNTs contents in CNTs-PA6 membrane are obtained by calculating the mass increment. Prior to weighing, the PA6 membranes are dried for at least 18 h at 40 °C in a vacuum oven. When the ultrasonication time is fixed at 15 s, the obtained CNTs content is 11 wt.%. For the ultrasonication time of 30 s, the CNTs content reaches saturation gradually.

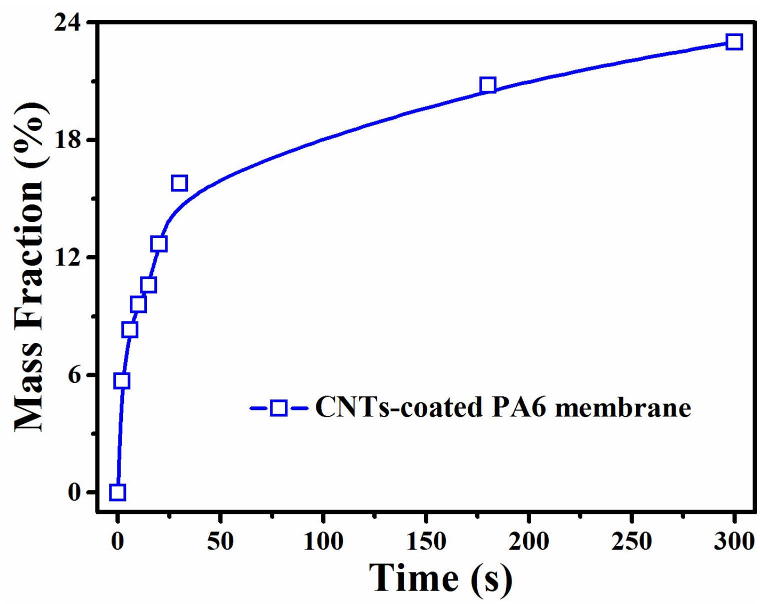

Fig. S1 The relationship between the CNTs contents in CNTs-PA6 membrane and ultrasonication time.

I-V curves of the conductive membrane under different strains are shown in Fig. S2. With the favorable conductive network, the membrane possesses an ohmic behavior regardless of applied strains. It is also worth mentioning that the resistance of the membrane increases stepwise (the inset in Fig. S2).

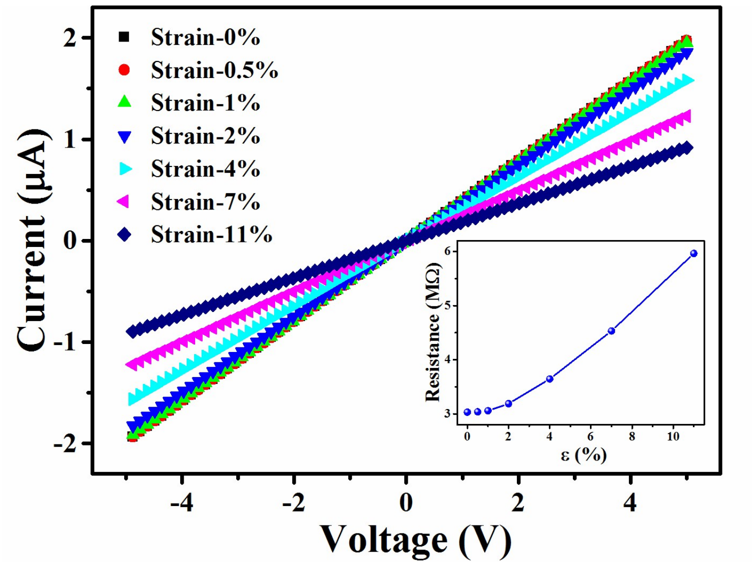

Fig. S2 I-V curves of the 11 wt.% CNTs-PA6 membrane under various strain loadings.

Five elongation/contraction cycles are used to examine the repeatability of the CNTs-PA6 membrane (without immersed in the PVA matrix), the result is shown in Fig. S3. Clearly, a better repeatability is observed when the applied strain is low (ε_{max} = 1%). At a “higher” deformation level (ε_{max} = 5%), the relative resistance of the conductive membrane cannot return to the initial value. The result indicates that an irreversible change of the conductive network occurs when the applied strain is higher.

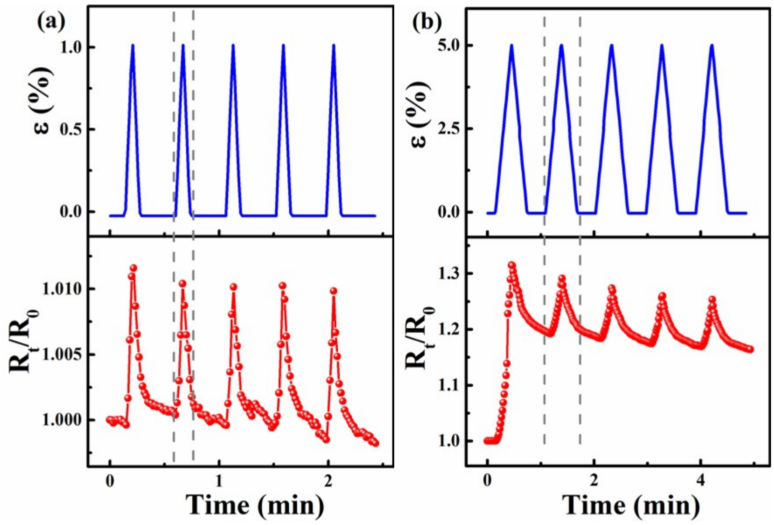

Fig. S3 Strain sensing behaviors of CNTs-PA6 membrane under cycle tension with a strain up to (a) 2% and (b) 5%. The test speed is 5 mm/min. The CNTs content is 11 wt.%.

Fig. S4a shows a schematic of the CNTs-$PA6_2$/PVA composite. SEM image for the fractured surface of a sample is shown in Fig. S4c. It is found that the distance between two layers of the PA6 membrane is large enough (＞20 μm). Hence, it can be conceptually considered that the CNTs-$PA6_2$/PVA composite is composed of two layers of the CNTs-$PA6_1$/PVA composites. And the initial resistance of the CNTs-$PA6_2$/PVA composite (R_0) can be expressed by shunt circuit as:

$$\frac{1}{R_0} = \frac{1}{R_{m1}} + \frac{1}{R_{m2}} \tag{1}$$

where R_{m1} and R_{m2} are the resistance of the CNTs-$PA6_1$/PVA composites. Based on the equation (1), it is deduced that the resistivity of the CNTs-$PA6_2$/PVA composite is lower than that of the CNTs-$PA6_1$/PVA composite.

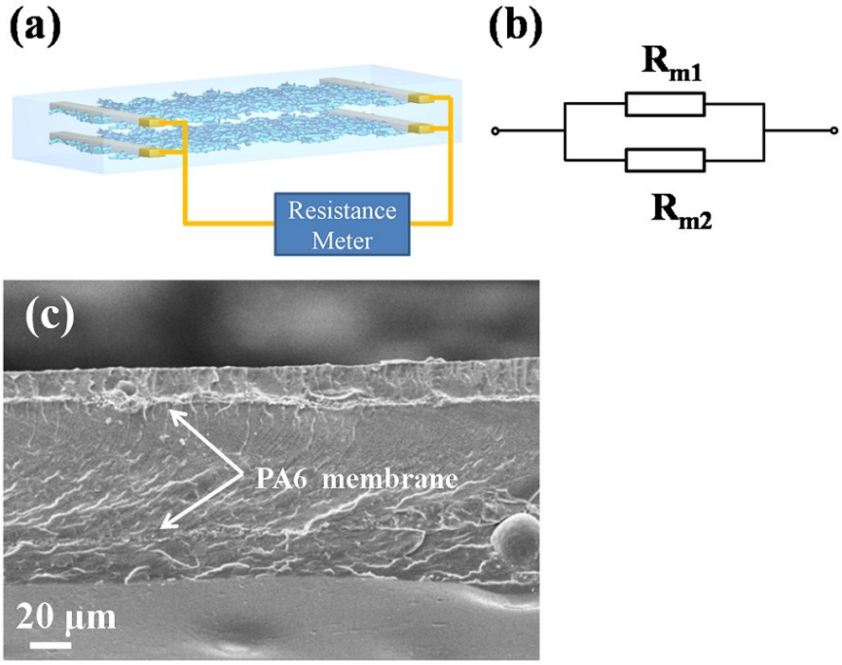

Fig. S4 (a) Schematic illustration of the CNTs-PA6$_2$/PVA composite. (b) The circuit diagram of the CNTs-PA6$_2$/PVA composite. (c) SEM micrograph of the fracture surface of the composite. The CNTs content in the CNTs-PA6 membrane is 11 wt.%.