High-strength Janus-structured aramid nanofiber/calcium sulfate crystal–silver nanowire composite film for integrated insulation, sensing, and Joule heating

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Table S1 Porosity Calculation Table

Samples name	Density	Porosity
ANF/0.4MPa	$0.12716 g/cm^3$	91.17%
ANF/CSC30M/0.4MPa	$0.13529 g/cm^3$	90.6%

$$\rho = v/m$$

$$Porosity = \left(1 - \frac{\rho}{\rho_s}\right) \times 100\%$$

$$\rho_s = 1.44 g/cm^3$$

The Kevlar produced by the American company DuPont has a labeled density of 1.44 g/cm³, which is the physical density of the para-aramid fiber itself.
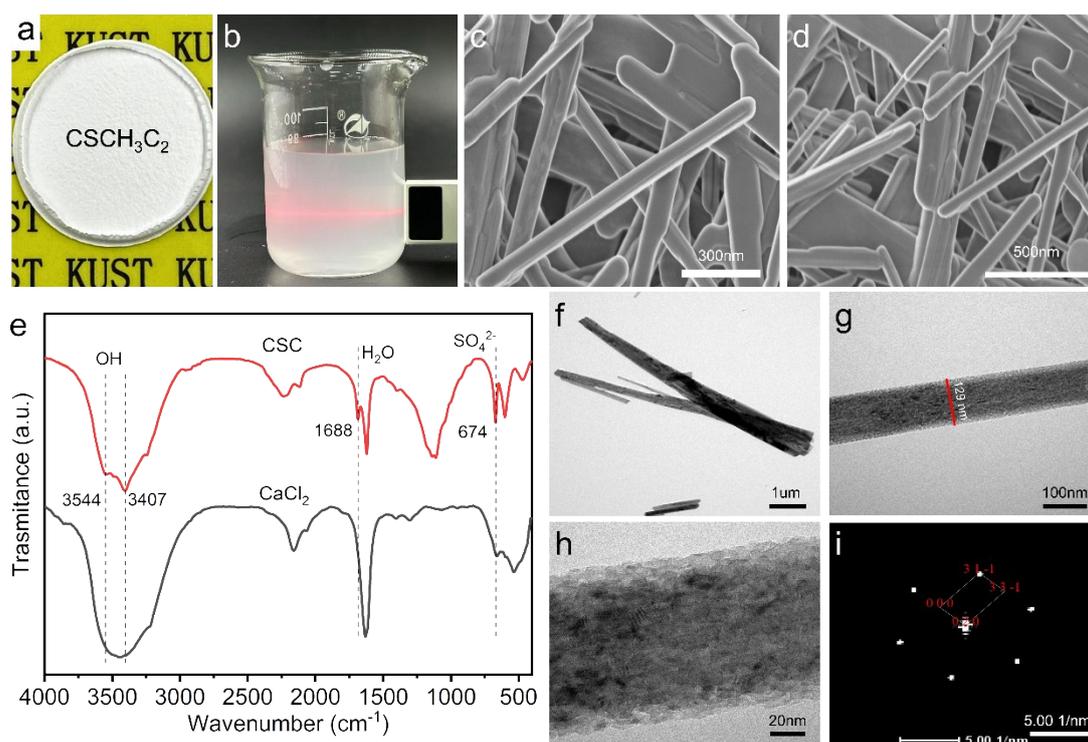

Figure S1 photo (a), and water dispersion solution (b), SEM (c, d), FTIR (e), TEM (f, g, h), electron diffraction patterns (i) of the $CSCH_3C_2$.
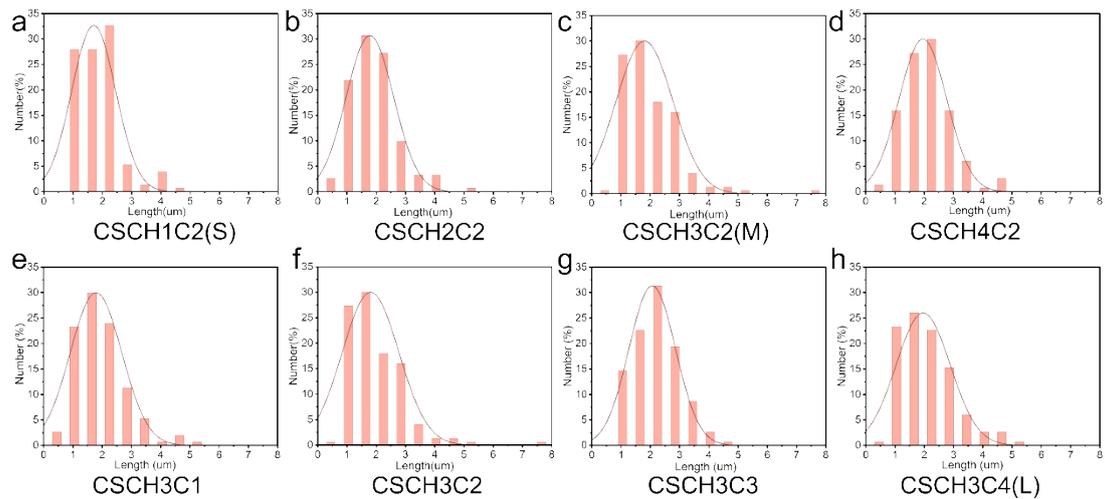
Figure S2 The size distribution of CSC prepared under different concentrations of sulfuric acid and CTAB.
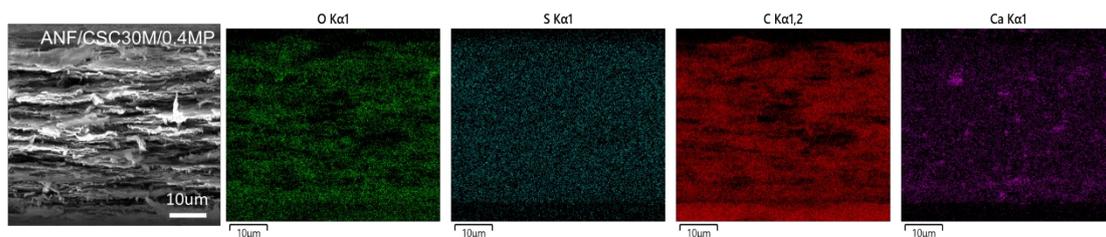

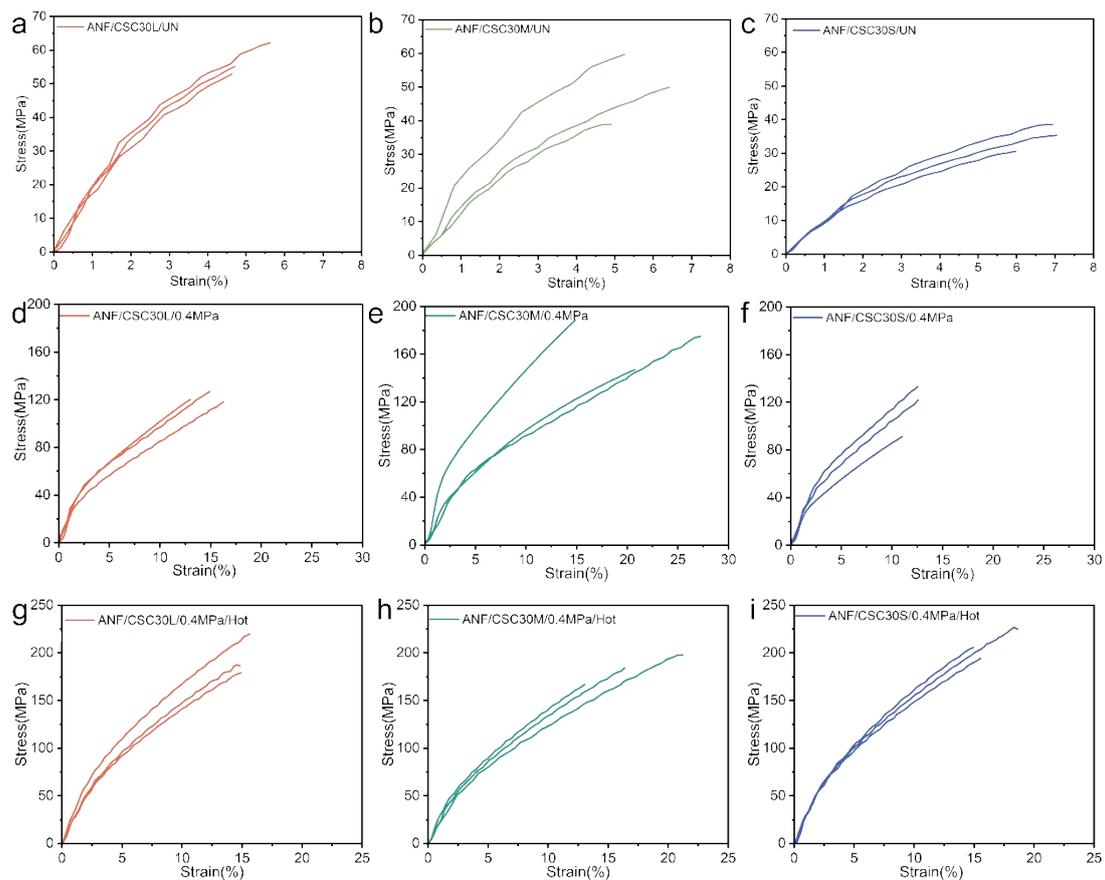Figure S3 Cross-sectional SEM and EDX images of ANF/CSC30M/0.4MPa.

Figure S4 Stress-strain diagrams of ANF films with different lengths of CSC.
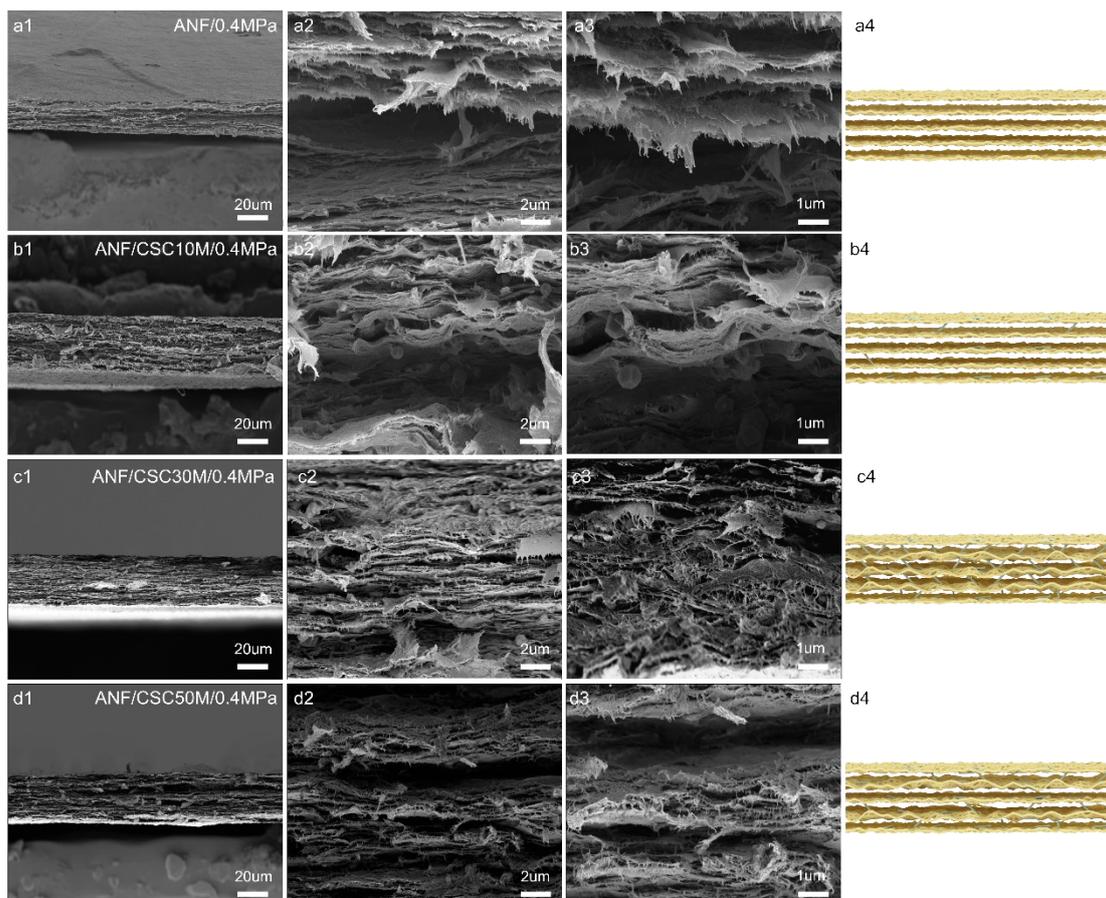
Figure S5 Cross-sectional morphologies and structural model of the ANF/0.4MPa (a), ANF/CSC10M/0.4MPa (b), ANF/CSC30M/0.4MPa (c) and ANF/CSC50S/0.4MPa (d).
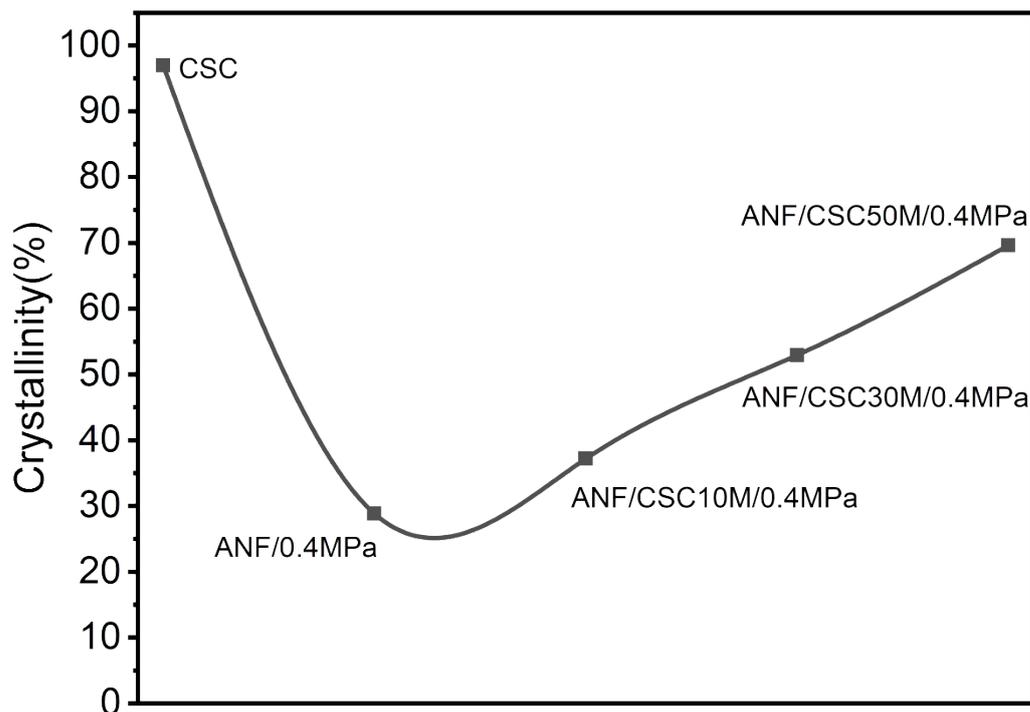
Figure S6 Crystallinity of CSC and ANF-based films.

The crystallinity of the samples was calculated using the software Jade 6. The procedure involved initial data smoothing and baseline establishment for background removal. Subsequently, the diffraction profiles were subjected to peak fitting via the software's peak deconvolution program, yielding a satisfactory fit with an R-factor of approximately 10%. For the crystallinity calculation, the broad and diffuse peaks were manually excluded, while the sharp and intense diffraction peaks were selected. Taking the ANF/0.4 MPa sample as an example, the peaks at (11.312), (20.541), (31.983), (36.324), and (56.708) were designated for the final computation. The crystallinity was subsequently calculated by the software using the following equation:

$$Crystallinity = \frac{Crystalline\ Peak\ Area}{Crystalline\ Peak\ Area + Non-crystalline\ Area} \times 100\%$$

Figure S7 (a) TG and (b) DTG curves of ANF/0.4 MPa and ANF/CSC30M/0.4 MPa.

Figure S8 Test equipment (a) and thermal diffusion images (b) of the ANF/CSC-ANF/AgNWs film.

Figure S9 Morphology of AgNWs under the microscope