

Supporting Information

Silkworms with Spider Silk-Like Fibers Using Synthetic Silkworm Chow Containing Calcium Lignosulfonate, Carbon Nanotubes, and Graphene

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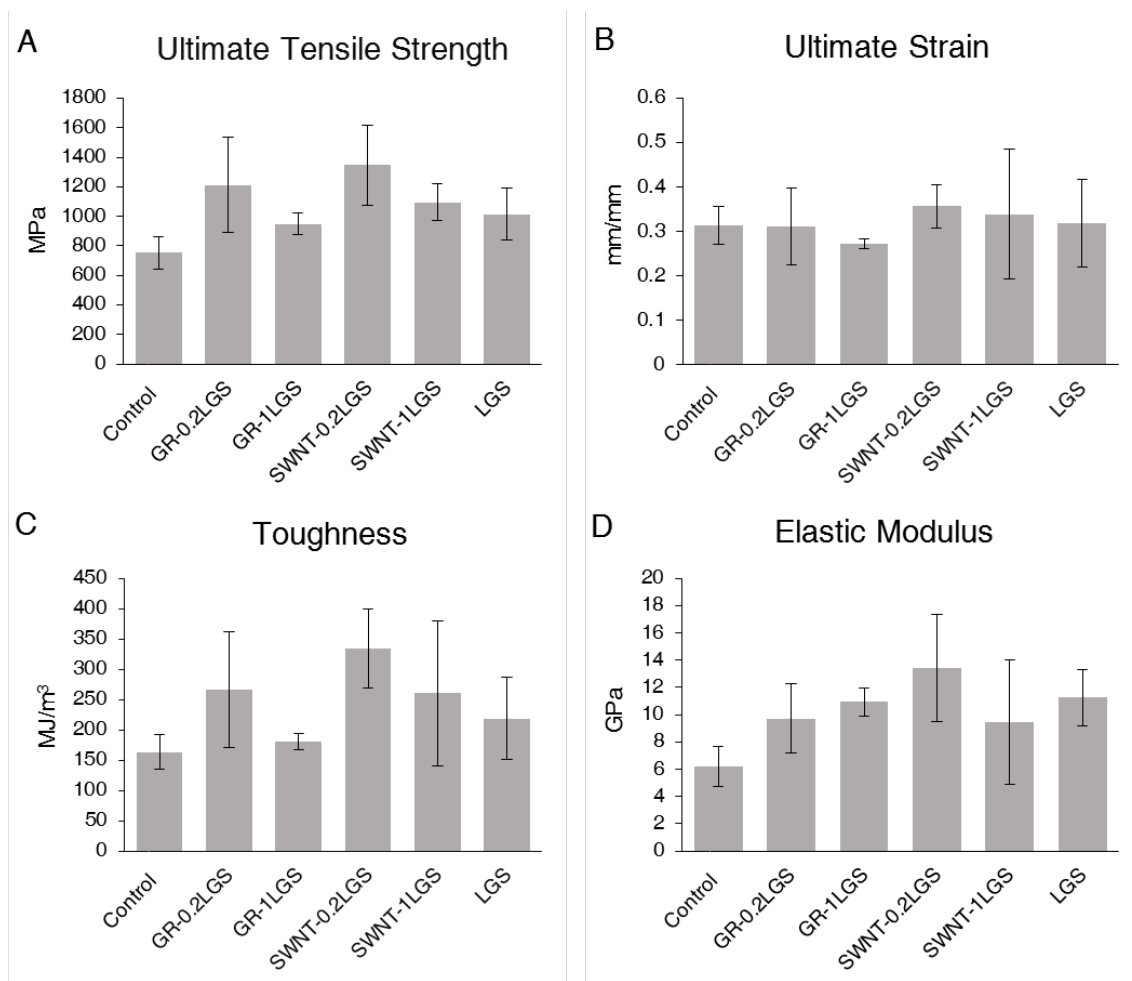


Figure S1. Average mechanical properties for all silkworm treatment groups with standard deviations. (A) Mean maximum stress values for all silkworm fibers. (B) Mean strain at break for all silkworm fibers. (C) Mean energy-to-break for all silkworm fibers. (D) Mean elastic modulus for all silkworm fibers.

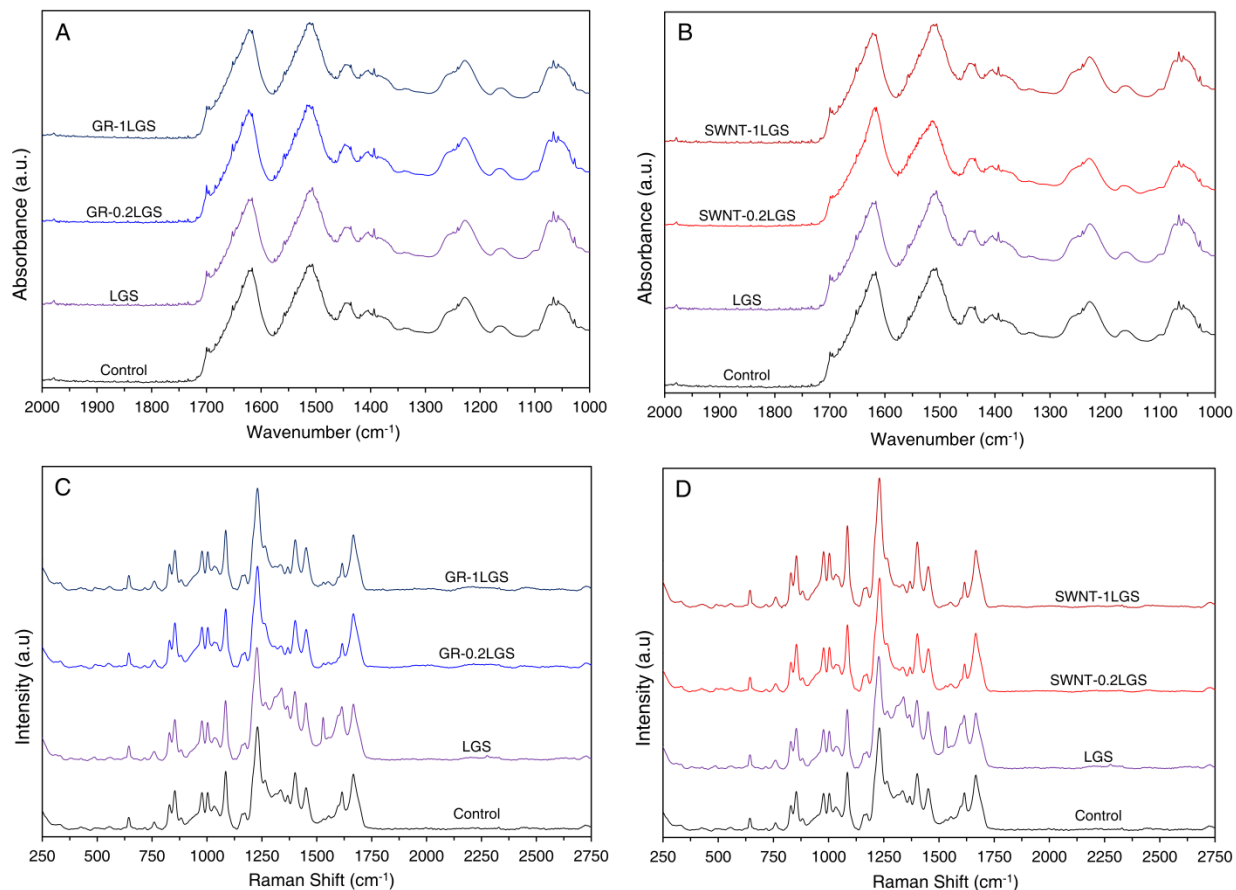


Figure S2. Structural characterization of collected silkworm fibers exposed to differing treatments.

(A) FTIR spectra of representative fibers for control and graphene (GR) groups. (B) FTIR Spectra of representative fibers for control and single-wall carbon nanotubes (SWNT) groups. (C) Raman spectra of representative fibers for control and graphene (GR) groups. (D) Raman spectra of representative fibers for control and single-wall carbon nanotubes (SWNT) groups.

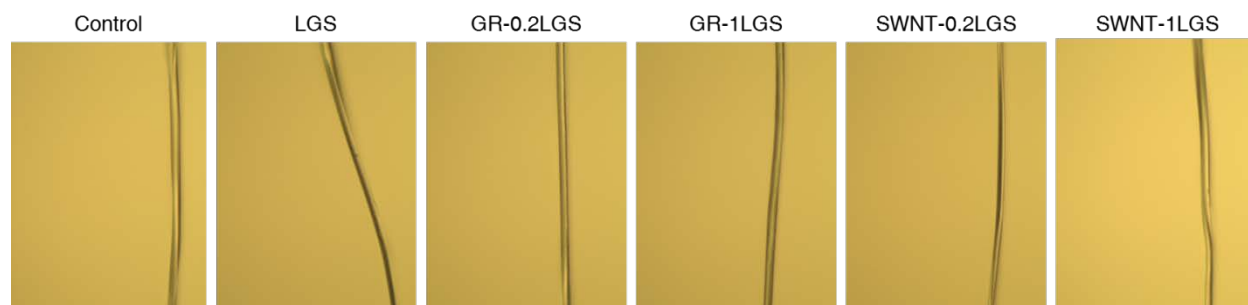


Figure S3. Optical brightfield microscopy images from representative silkworm fibers from each treatment group.

Table S1. Mechanical properties of natural dragline silk from *Nephila clavipes*^a.

| | n | Maximum Stress (MPa) | | Maximum Stain (mm/mm) | | Toughness (MJ/m ³) | | Elastic Modulus (GPa) | |
|----------|----|----------------------|-----------|-----------------------|-----------|--------------------------------|-----------|-----------------------|-----------|
| | | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| Spider 1 | 10 | 1105 | 354 | 0.18 | 0.06 | 122 | 72 | 9.4 | 3.1 |
| Spider 2 | 10 | 1339 | 500 | 0.17 | 0.05 | 133 | 83 | 9.4 | 2.6 |
| Spider 3 | 9 | 998 | 272 | 0.08 | 0.02 | 44.6 | 16 | 14 | 5.4 |

^aSpider silk fibers were tested with the same conditions and instrumentation as the silkworm fibers.



Figure S4. Cocoon Morphology. (1) Control, (2) LGS, (3) GR-0.2LGS, (4) GR-1LGS, (5) SWNT-0.2LGS, (6). SWNT-1LGS.

Table S2. Mechanical properties and change of control silkworm fibers tested at differing extension speeds^a.

| | (A) Maximum Stress (MPa) | | | (B) Maximum Strain (mm/mm) | | |
|------------|---|-----------|----------|-----------------------------------|-----------|----------|
| | Mean | Std. Dev. | % Change | Mean | Std. Dev. | % Change |
| 1 mm/min | 502.7 | 156.4 | -33.1 | 0.22 | 0.10 | -29.9 |
| 500 mm/min | 751.7 | 110.6 | - | 0.31 | 0.04 | - |
| | (C) Toughness (MJ/m³) | | | (D) Elastic Modulus (GPa) | | |
| | Mean | Std. Dev. | % Change | Mean | Std. Dev. | % Change |
| 1 mm/min | 84.0 | 52.7 | -48.5 | 9.86 | 2.18 | 59.1 |
| 500 mm/min | 163.0 | 28.3 | - | 6.20 | 1.45 | - |

^a% Change is determined from the differences between the used test speed of 500 mm/min for this work and the 1 mm/min speed used previously in the literature.