Supplementary notes

Force/Extension and Torsion Experiments

We performed conventional force/extension and torsion experiments with the Autograph Shimadzu Universal Testing Machine. For torsion experiments we adapted a torsion fixture device. The metal helical springs displayed a perfectly linear force/extension behaviour under axial tensile tests, with elastic constant $K_{91} = 0.0138\text{N/mm}$ for a spring with 91 loops. Helices had a helical pitch $h_0 = 3.4\text{mm}$, radius $R = 3\text{mm}$ and thickness $\delta = 0.4\text{mm}$. We used springs $20cm$ long in Fig. 5.a,b and $2cm$ long in Fig. 5c. Experiments in Fig. 5a,b were carried at a speed of 100mm/min, while 5^0/min were applied in the torsion experiments.

We used the Worm-like-Chain (WLC) model[16], $F = A\left(\frac{1}{4}\left(1-\frac{x}{L}\right)^{-2} - \frac{1}{4} + \frac{x}{L}\right)$, with $L = 460\text{mm}$ and $A = 4.85\text{N}$, to fit the curve in Fig. 5a. L is considerably larger than what one should expect by considering the full length of the two springs ($L_{\text{springs}} = 270\text{mm}$). Nevertheless, the fits are remarkable and reproducible for other springs and experimental configurations, when the system stays in the elastic regime. Deviations from WLC regimes, due to entering in the plastic regime are also possible, as shown in Fig. 1b. In this case the WLC fit used the paramaters $L = 650\text{mm}$ and $A = 6\text{N}$. In these cases the system can withstand forces at least two times larger.