Supplementary information

Eco-friendly and sustainable approach of assembling sugar into biobased carbon fibers

Yu Yang[1], Daming Chen[1], Yuan Cheng[1], Boqian Sun[1], Guangdong Zhao[2], Weidong Fei[3],

Wenbo Han[1], Jiecai Han[1] & Xinghong Zhang[1*]*

[1]Science and Technology on Advanced Composites in Special Environments Laboratory, Harbin Institute of Technology, Harbin 150006, China.

[2]School of Chemistry and Materials Science, Heilongjiang University, Harbin 150080, China.

[3]The National Key Laboratory for Precision Hot Forming of Metals, Harbin Institute of Technology, Harbin 150006, China.

[*]Correspondence: zhangxh@hit.edu.cn (X.Z.); wbhan@hit.edu.cn (W.H.);

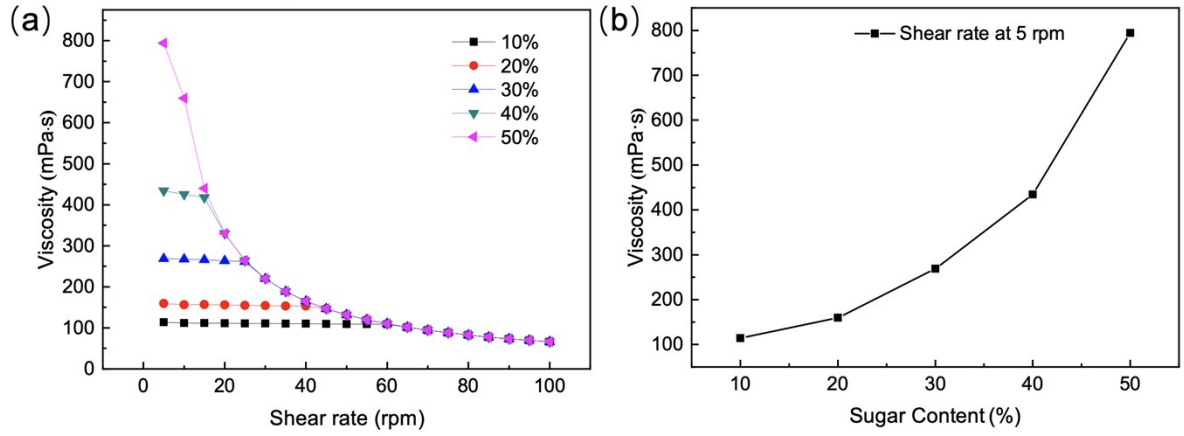

Figure S1. The rheological properties of the solution under fixed SA content. (a)viscosity change of the solutions at different shear rate. (b) viscosity of the solutions with different sugar content at shear rate of 5rpm.

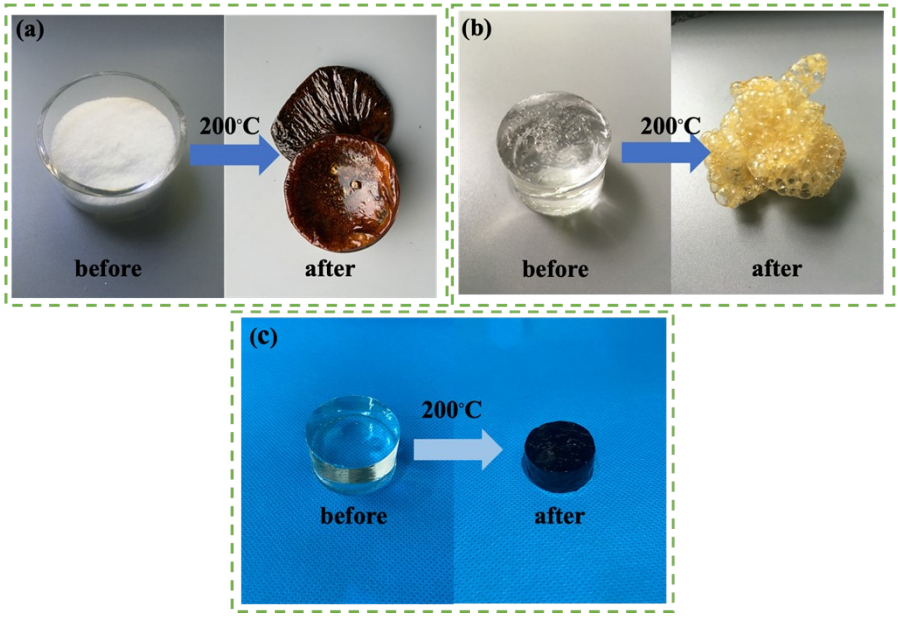

Figure S2. Uncontrollable deformation of the structure under 200°C (a) Glucose. (b) polyacrylamide hydrogel. (c) Glucose/polyacrylamide hydrogel.

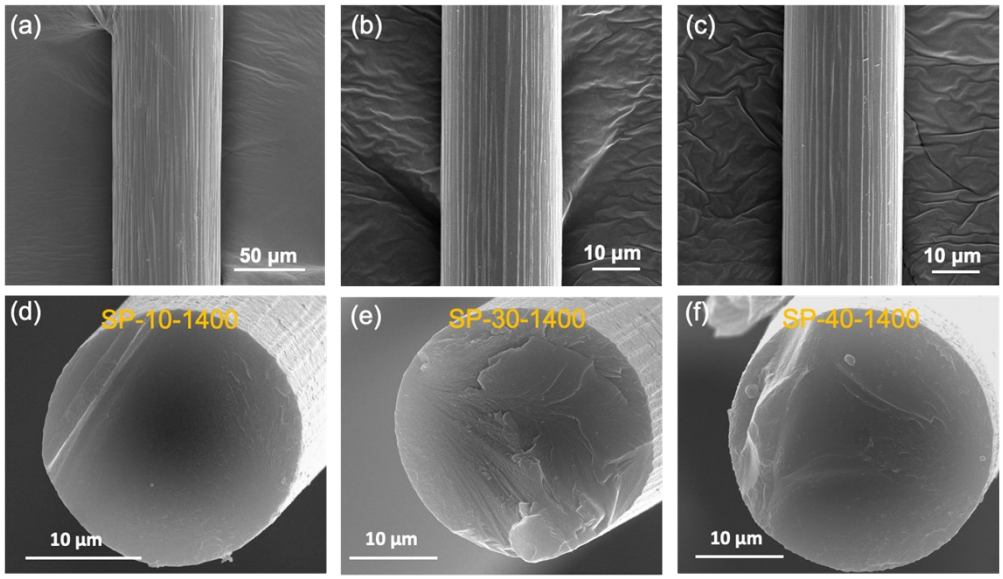

Figure S3. SEM image of SBCFs. (a)~(c) Surface morphology of the SBCFs with different diameter. (d)~(f) Cross section morphology of the SBCFs with different PAM concentration

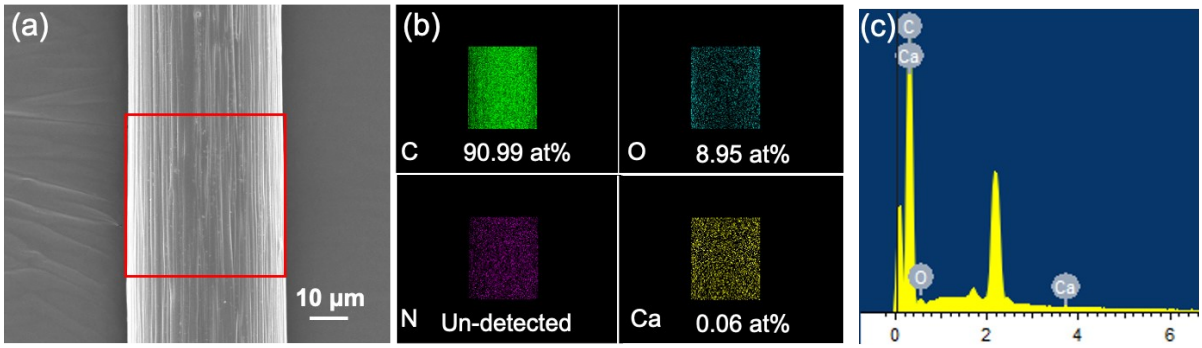

Figure S4. EDS analysis of SBCFs.

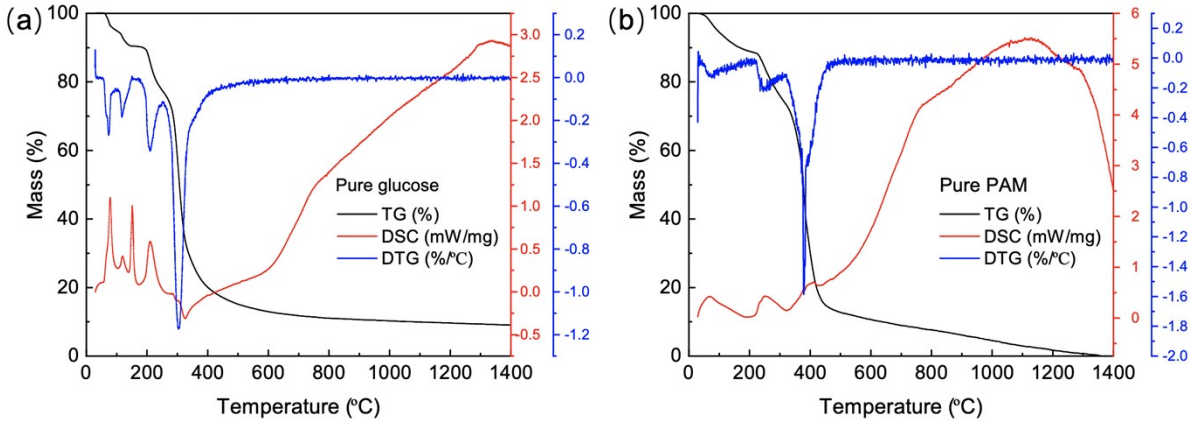

Figure S5. Thermogravimetric analysis of pure glucose and PAM. (a)glucose. (b)PAM.

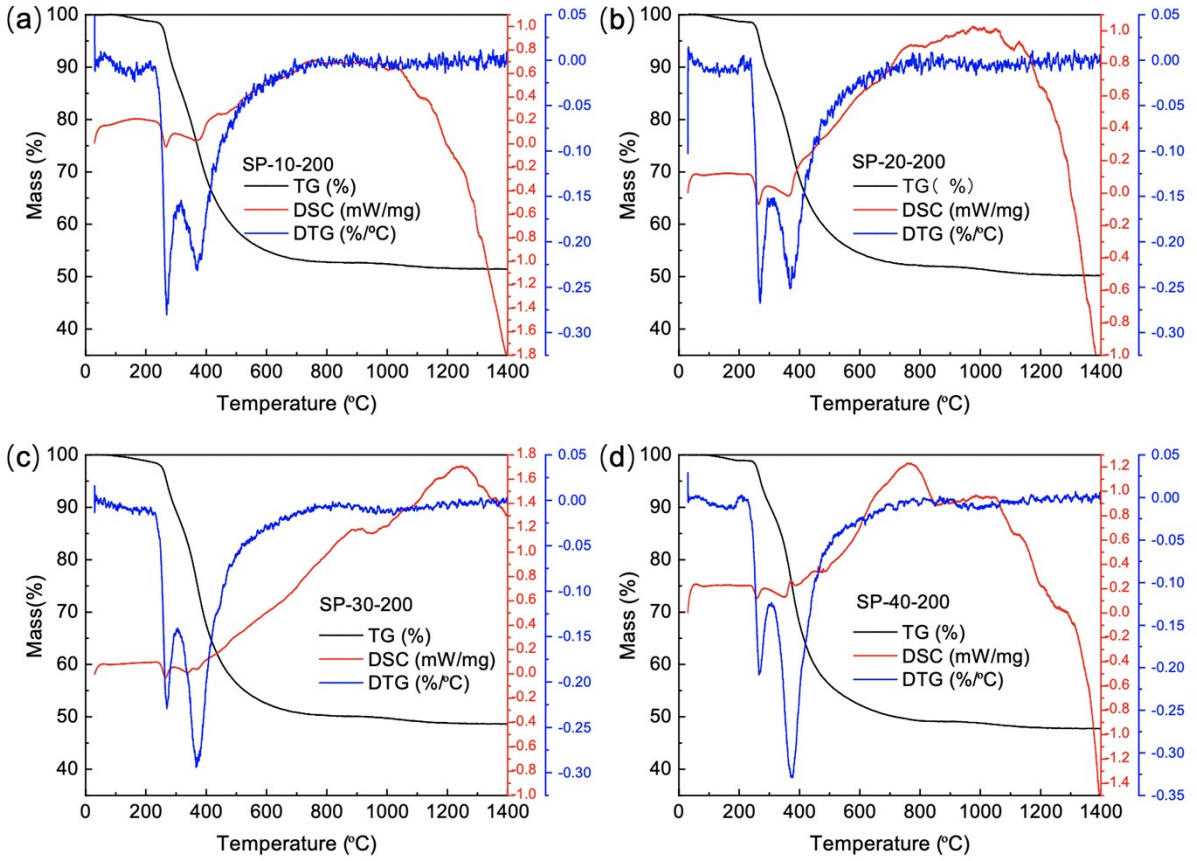

Figure S6. Thermogravimetric analysis of precarbonized fibers with different PAM content. (a)10%. (b)20%. (c)30%. (d)40%.

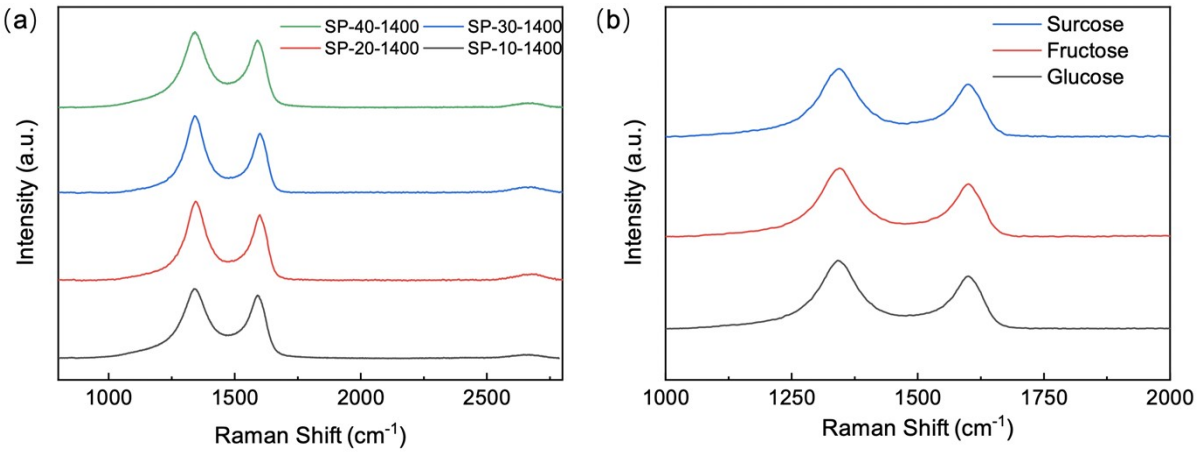

Figure S7. Raman pattern of SBCFs (a) Raman pattern of SBCFs with PAM content from 10% to 50%. (b) Raman pattern of SBCFs manufactured from different sugar.

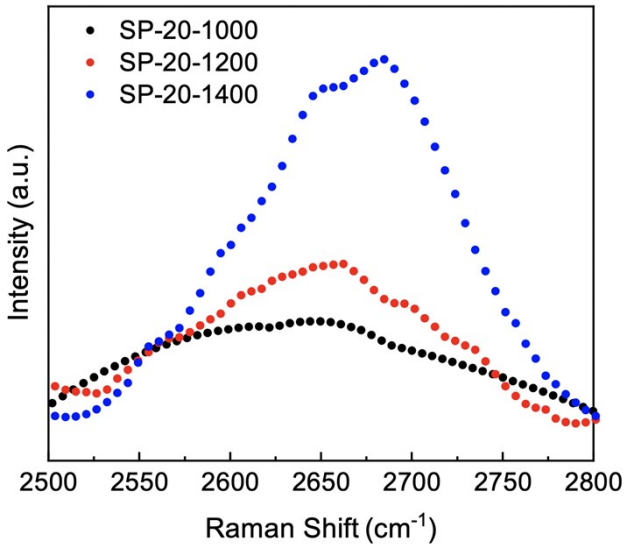

Figure S8. 2D peaks of SBCFs at various temperatures

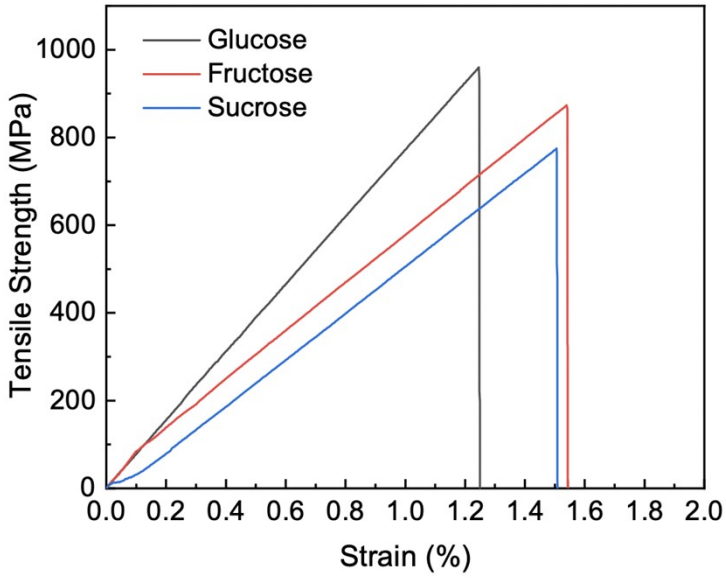

Figure S9. Tensile strength made from different sugar.

Table S1. Mechanical properties of SBCFs

Sugar type	number	diameter	Highest Tensile strength (MPa)	Average Tensile strength (MPa)	Average Modulus (GPa)
glucose	SP-10-1400	26.1 ± 4.52	521	424 ± 74.1	43.0 ± 4.1
	SP-20-1400	27.3 ± 5.41	960	775 ± 115.0	70.6 ± 7.0
	SP-30-1400	28.3 ± 3.03	893	698 ± 126.1	64.6 ± 9.6
	SP-40-1400	30 ± 4.17	632	534 ± 71.2	41.0 ± 9.2

	SP-50-1400	33 ± 5.94	448	367 ± 103.8	33.1 ± 9.0
	SP-20-1000	30.2 ± 4.92	624	517 ± 74	36.4 ± 3.7
	SP-20-1200	28.4 ± 5.01	653	547 ± 87	42.9 ± 9.7
fructose	SP-20-1400	27.6 ± 3.3	873	754 ± 107.6	61.9 ± 14.2
sucrose	SP-20-1400	29.5 ± 3.1	775	714 ± 85.5	56.1 ± 4.3

Note S1.

Calculation of graphitic crystal parameters: X-ray resource was generated at 40 mA current and 40 kV voltage with Cu Ka wavelength (λ) of 1.542 Å. The diffractograms of all samples were recorded in the 2θ range of 10 -90. Scanning step size was set at 0.05°, and the scanning rate was 5°/min.

The distance between two crystalline lattices (d_{hkl}) was estimated using Bragg's law:

$$2d\sin\theta = n\,\lambda \quad (1)$$

Where d is the distance in nm; θ is the Bragg angle in degree; n is set as 1; λ is the X-ray wavelength (1.542 Å)

The crystalline size (L_{hkl}) was calculated using Scherrer equation:

$$L = \frac{K\,\lambda}{\beta\cos\theta} \quad (2)$$

Where L is the crystalline size, nm; K is shape factor, set as 1.84 and 0.89 for L_a and L_c in this calculation, respectively; λ is the X-ray wavelength (1.542 Å); β is the full width at half maximum (FWHM) in radian; θ is the Bragg angle in degree.

Note S2.

Calculation of order parameters of SAXS and WAXS: SAXS and WAXS measurements were performed in a transmission geometry with an X-ray wavelength λ= 1.542 Å and sample-to-detector distance fixed at 2316 mm for SAXS and 130 mm for WAXS.

The quantification of the SAXS and WAXS patterns was performed by first transforming the diffractogram into a rectangular image with the scattering vector, q (defined as $q= 4\pi \sin(\theta)/\lambda$, where θ is the scattering angle), and the azimuthal angle φ, as coordinates. At each q-value the distribution was normalized with the highest intensity. The final orientation (intensity) distributions were then found by taking the mean between $0.13<q< 3.5nm^{-1}$ for SAXS. WAXS measurement were carried out for a scattering angle range of 0.2-80°. The orientation of crystallographic in the fibers was quantified by the (002) reflection on the WAXS patterns.

The alignment of the SBCFs was quantified by converting the orientation distribution into a Hermans order parameter, H, defined as:

$$H = \left\langle \frac{3}{2}\cos^2\varphi - \frac{1}{2} \right\rangle \tag{3}$$

and the order parameter can be expanded as

$$H = \int_0^{\pi} I(\varphi)\left(\frac{3}{2}\cos^2\varphi - \frac{1}{2}\right)\sin\varphi d\varphi \tag{4}$$

which is normalized according to:

$$\int_0^{\pi} I(\varphi)\sin\varphi d\varphi = 1 \tag{5}$$

Where $I(\varphi)$ is the intensity distribution along a constant q-value.