Supplementary Information (SI) for Journal of Materials Chemistry B.
This journal is © The Royal Society of Chemistry 2025

Supporting Information

Robust-adhesion and high-mechanical strength hydrogel for efficient wet tissue adhesion

Chenyang Li[a], Yang Qian[a], Xueping Zhang[a*], and Rongwu Wang[a*]

[a]Key Laboratory of Textile Science & Technology, Ministry of Education, College of Textiles, Donghua University, Shanghai 201620, China

Chenyang Li and Yang Qian contributed equally to this work.

[*]Corresponding author. E-mails: xpzhang@dhu.edu.cn, wrw@dhu.edu.cn.

This file includes:

Figures S1 to S9

Tables S1 to S4

Videos S1 to S4

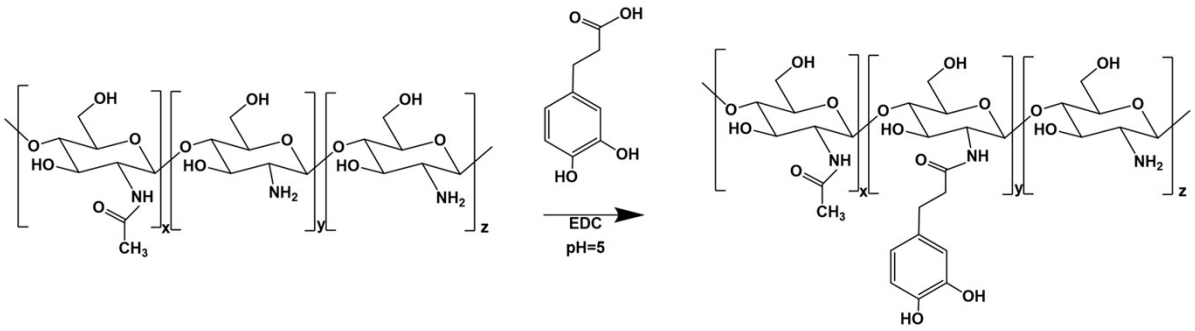

Figure S1. Schematic diagram of the synthesis of C-CS.

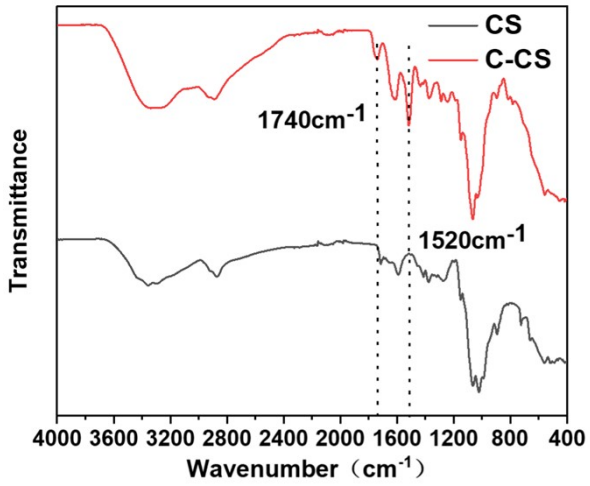

Figure S2. FT-IR spectra of CS and C-CS.

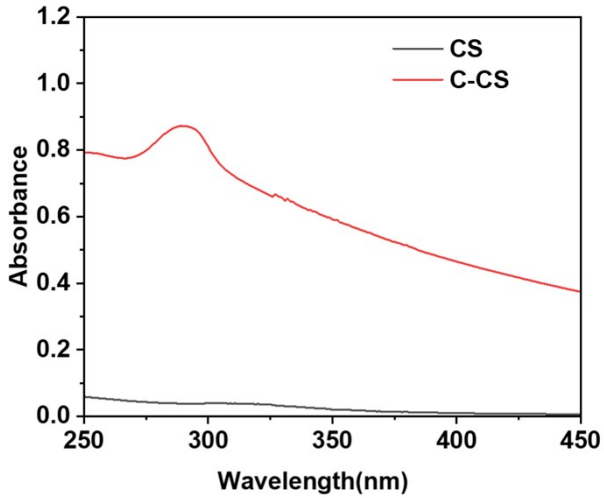

Figure S3. UV-Vis spectra of CS and C-CS.

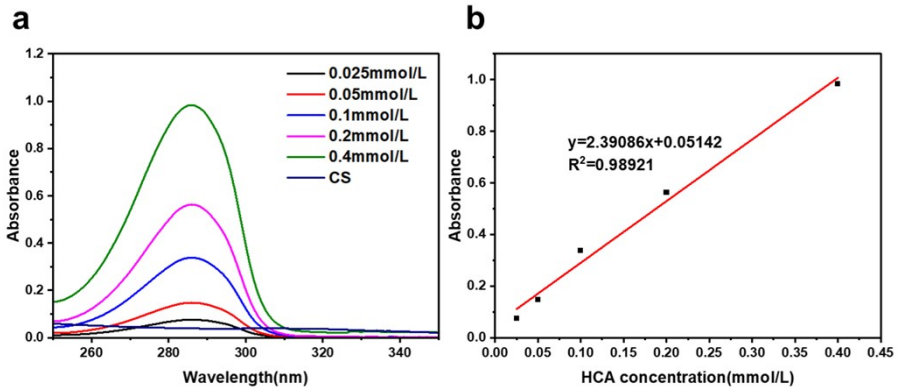

Figure S4. a) UV-Vis spectra of CS and different concentrations of HCA, b) standard working curve.

Table S1. Absorbance at 286 nm for different concentrations of HCA solution.

HCA solution（mmol/L）	Absorbance
0.025	0.076
0.05	0.148
0.1	0.339
0.2	0.563
0.4	0.984

Table S2. Composition of different hydrogels.

Samples	AA （wt%）	C-CS （wt%）	α-ketoglutaric acid （wt%）	AA-NHS ester （wt%）	PEGDMA （wt%）	Water (g)
PAA20-NHS1/C-CS2	20	2	0.2	1	0.05	8
PAA30-NHS1/C-CS2	30	2	0.2	1	0.05	7
PAA40-NHS1/C-CS2	40	2	0.2	1	0.05	6
PAA30/C-CS4	30	4	0.2	0	0.05	7
PAA30-NHS0.33/C-CS4	30	4	0.2	0.33	0.05	7
PAA30-NHS0.67/C-CS4	30	4	0.2	0.67	0.05	7
PAA30-NHS1	30	0	0.2	1	0.05	7
PAA30-NHS1/C-CS1	30	1	0.2	1	0.05	7
PAA30-NHS1/C-CS4	30	4	0.2	1	0.05	7
PAA30-NHS1/C-CS6	30	6	0.2	1	0.05	7

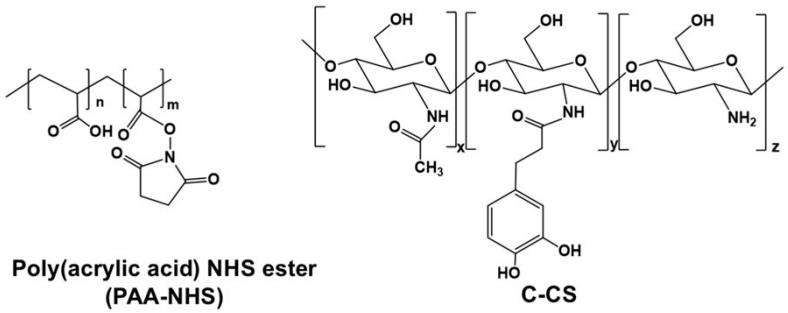

Figure S5. Chemical composition of the PAA-NHS/C-CS hydrogel based on PAA-NHS and C-CS.

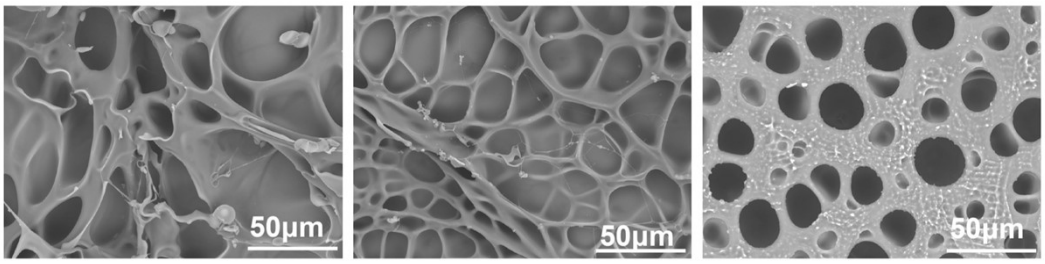

Figure S6. High-magnific SEM images of the freeze-dried PAA30/C-CS4, PAA30-NHS1, and PAA30-NHS1/C-CS4 hydrogel (from left to right).

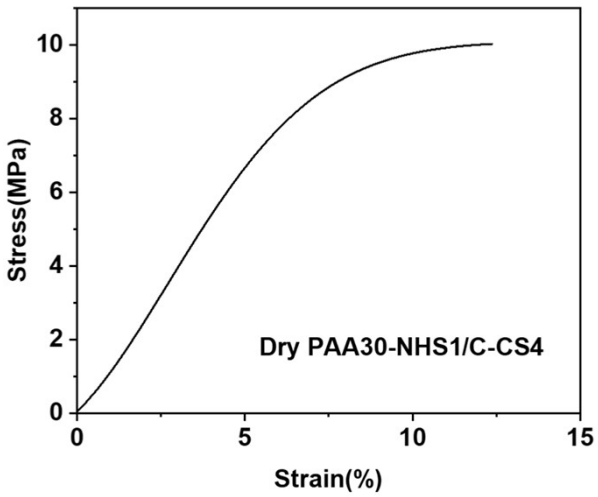

Figure S7. Stress-strain curves for the dry PAA30-NHS1/C-CS4 hydrogel.

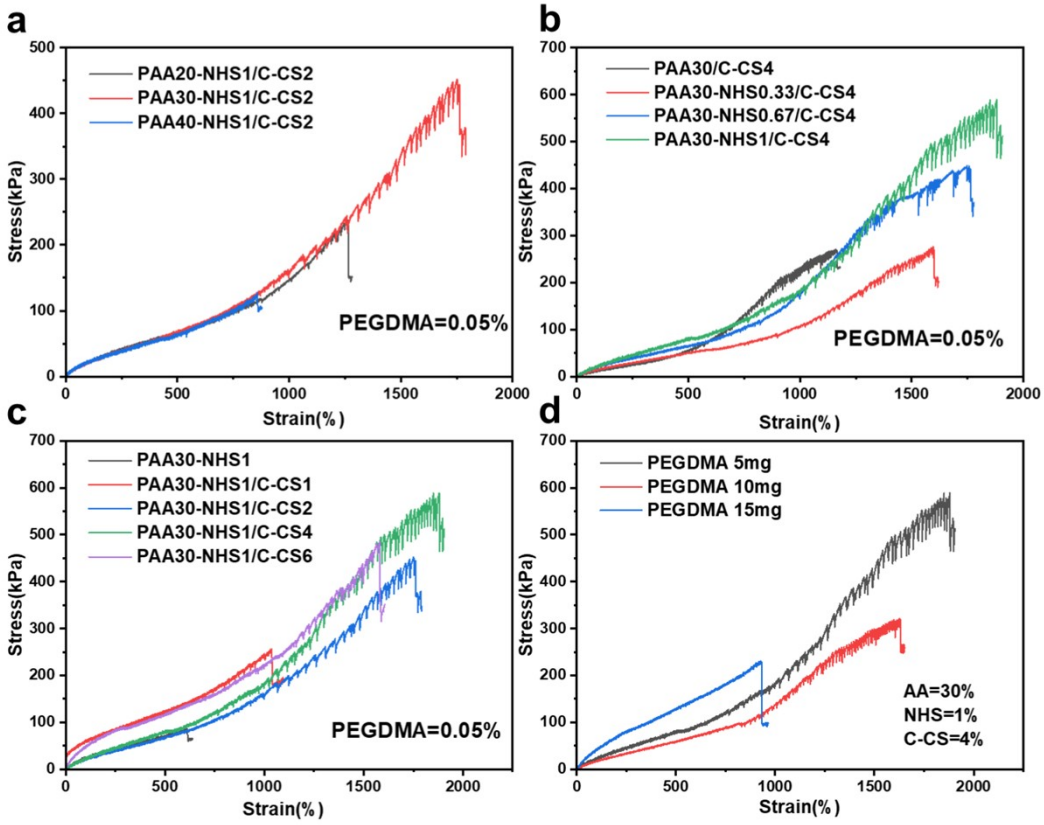

Figure S8. Effect of AA, AA-NHS ester, C-CS, and PEGDMA contents on the tensile properties of swollen hydrogels. Tensile stress-strain curves of swollen hydrogels with different (a) AA content, (b) AA-NHS ester content, (c) C-CS content, and (d) PEGDMA content.

Table S3. Mechanical properties of hydrogels.

	Name	Tensile stress (kPa)	Strain (%)
Varied AA content	PAA20-NHS1/C-CS2	246.5±13.44	1265.73±92.33
	PAA30-NHS1/C-CS2	457.66±21.08	1847.14±86.07
	PAA40-NHS1/C-CS2	121.5±7.78	840.74±53.05
Varied AA-NHS ester content	PAA30/C-CS4	253±45.74	1271.30±18.31
	PAA30-NHS0.33/C-CS4	269.67±7.09	1535.39±85.83
	PAA30-NHS0.67/C-CS4	386.67±53.27	1585.28±42.20
	PAA30-NHS1/C-CS4	632±60.81	1974.19±96.03
	PAA30-NHS1	85±7.21	562.69±105.72
Varied C-CS content	PAA30-NHS1/C-CS1	275.33±46.17	1028.18±77.35
	PAA30-NHS1/C-CS2	457.66±21.08	1847.14±86.07
	PAA30-NHS1/ C-CS4	632±60.81	1974.19±96.03
	PAA30-NHS1/C-CS6	561.33±37.91	1422.91±157.55
PAA30-NHS1/C-CS4 with varied PEGDMA content	5 mg	632±60.81	1974.19±96.03
	10 mg	349.5±22.31	1805.64±193.84
	15 mg	234.5±28.29	1100.6±118.99

Table S4. Comparison of wet tissue adhesive properties of PAA30-NHS1/C-CS4 hydrogel with other reported hydrogel adhesives.

Name	Adhesion strength test Method	Wet adhesion strength to porcine skin	Reference
PDA-Silicate-CG	Shear	21.3 kPa	1
TA/PVA/PAA	Shear	31 kPa	2
CMC-DA/TA	Shear	45.9 kPa	3
PEG-SG/TA	Shear	62 kPa	4
PVA/PAAc-N	Shear	63.1 kPa	5
Fe-PAM-C-M	Shear	77.5 kPa	6
P（AA-co-UCAT5）–CS3	Shear	187.1 kPa	7
G0.6-T0.6-U0.12	Shear	152.9 kPa	8
PAA30-NHS1/C-CS4	Shear	163 kPa	This work

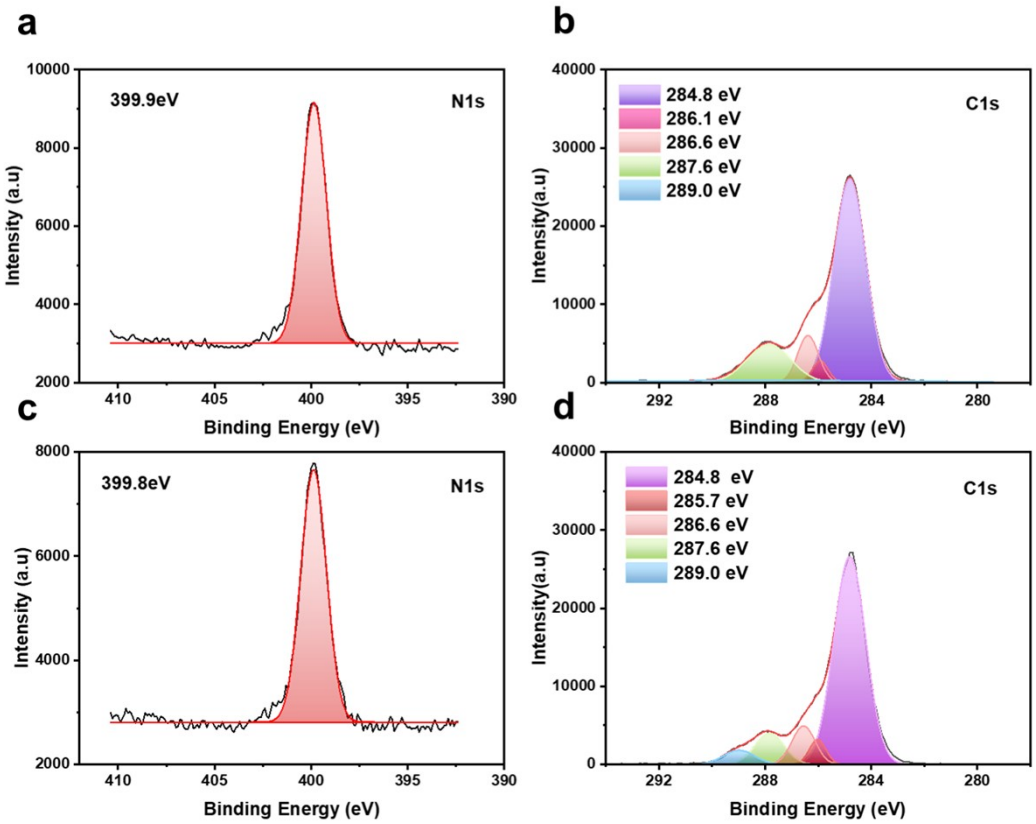

Figure S9. a) The N1s spectrum of untreated porcine skin. The peak at the binding energy of 399.9 eV could be attributed to C-N, demonstrating the presence of the -NH_2 group in the porcine skin. b) The C1s spectrum of untreated porcine skin. The peaks at the binding energy of 284.8, 286.6, 287.6, and 289.0 eV could be assigned to C-C, C-O, N-C=O, and O-C=O, respectively. c) and d) The N1s and C1s spectrum of porcine skin after 30-minute adhesion of PAA30-NHS1/C-CS hydrogel.

Supporting Videos

Video S1. The overall process of adhesion formation between wet porcine skins by the PAA30-NHS1/C-CS4 hydrogel.

Video S2. The PAA30-NHS1/C-CS4 hydrogel adhered for 5 min is peeled off from the porcine skin.

Video S3. The repeatable underwater adhesion of the PAA30-NHS1/C-CS4 hydrogel to porcine skin.

Video S4. Different adhesive properties of the PAA30-NHS1/C-CS4 hydrogel to underwater glass and porcine skin.

Supporting References

1. Y. Chen, Y. Qiu, Q. Wang, D. Li, T. Hussain, H. Ke and Q. Wei, *Chemical Engineering Journal*, 2020, **399**, 125668.
2. J. Park, T. Y. Kim, Y. Kim, S. An, K. S. Kim, M. Kang, S. A. Kim, J. Kim, J. Lee, S.-W. Cho and J. Seo, *Advanced Science*, 2023, **10**, 2303651.
3. H. Xie, G. Shi, R. Wang, X. Jiang, Q. Chen, A. Yu and A. Lu, *Carbohydrate Polymers*, 2024, **334**, 122014.
4. F. Sun, Y. Bu, Y. Chen, F. Yang, J. Yu and D. Wu, *ACS Applied Materials & Interfaces*, 2020, **12**, 9132-9140.
5. P. Ma, W. Liang, R. Huang, B. Zheng, K. Feng, W. He, Z. Huang, H. Shen, H. Wang and D. Wu, *Advanced Materials*, 2024, **36**, 2305400.
6. L. Han, M. Wang, L. O. Prieto-López, X. Deng and J. Cui, *Advanced Functional Materials*, 2020, **30**, 1907064.
7. X. Fan, Y. Fang, W. Zhou, L. Yan, Y. Xu, H. Zhu and H. Liu, *Materials Horizons*, 2021, **8**, 997-1007.
8. X. Su, W. Xie, P. Wang, Z. Tian, H. Wang, Z. Yuan, X. Liu and J. Huang, *Materials Horizons*, 2021, **8**, 2199-2207.