

Conductive epoxidized natural rubber/Chitin
nanocrystals/Polyaniline composite with high toughness, high
strength, and low-hysteresis as flexible strain sensors

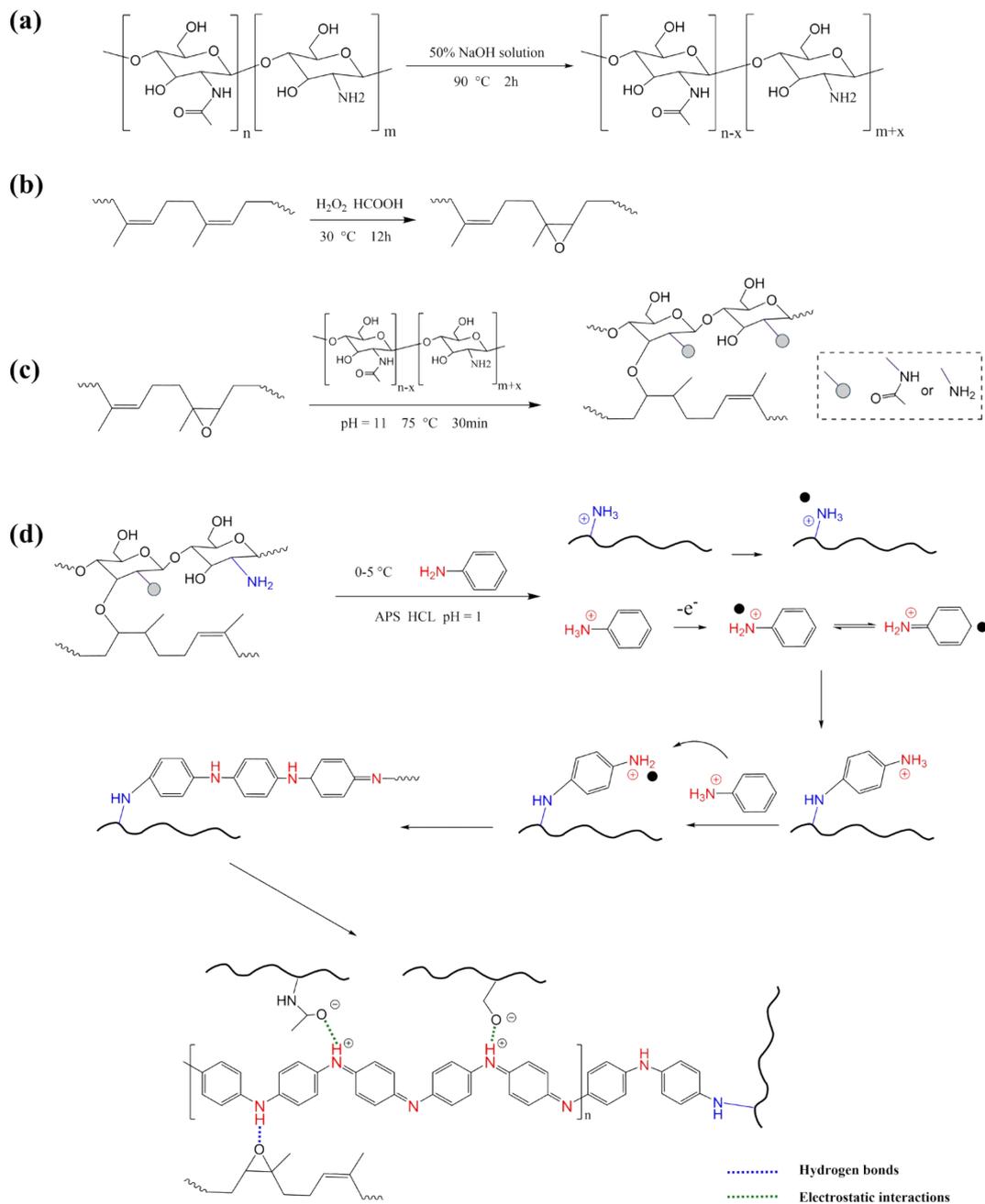
*Yao Zhang,^a Yizhong Yuan,^{*a} Huimei Yu,^{*b} Jinyu Sun,^a Xiaohui Tian,^a and Chunhua Cai^c*

^a School of Materials Science and Engineering, Shanghai Key Laboratory of Advanced Polymeric Materials, East China University of Science and Technology, Shanghai, 200237, P. R. China.

^b School of Materials Science and Engineering, East China University of Science and Technology, Shanghai, 200237, P. R. China. huimeiyu@ecust.edu.cn.

^c Shanghai Key Laboratory of Advanced Polymeric Materials, Key Laboratory for Ultrafine Materials of Ministry of Education, Frontiers Science Center for Materiobiology and Dynamic Chemistry, School of Materials Science and Engineering, East China University of Science and Technology, Shanghai, 200237, P. R. China.

*Corresponding author.



Scheme S1. (a) Deacetylation of ChNCs. (b) Epoxidation of DPNR. (c) The grafting of ChNCs onto the ENR. (d) Mechanism of PANI synthesis and its grafting onto the

ENR/ChNCs.

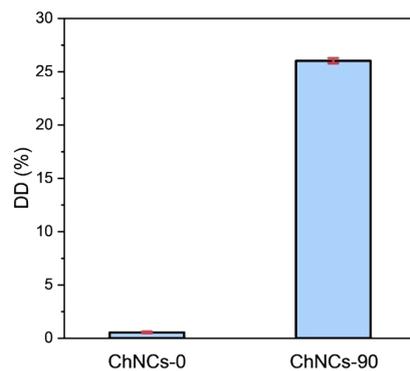


Figure S1. Deacetylation degrees of ChNCs-0 and ChNCs-90.

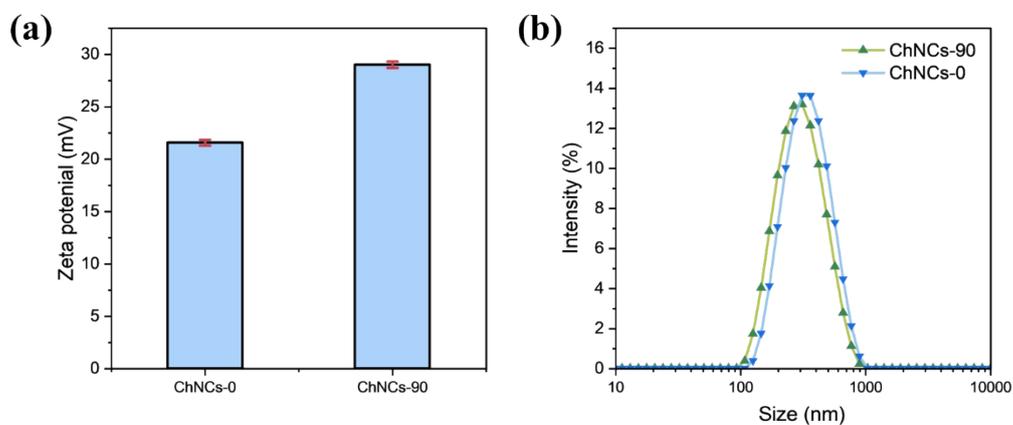


Figure S2. Zeta potential (a) and particle size distribution (b) of ChNCs-0 and ChNCs-90.

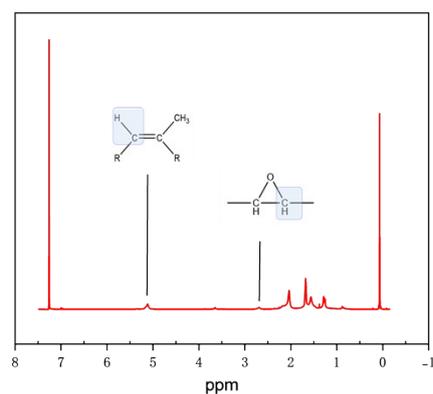
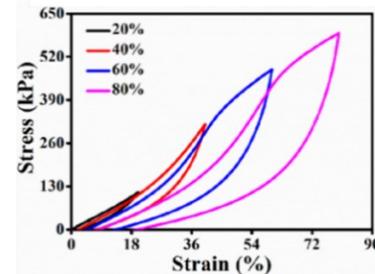
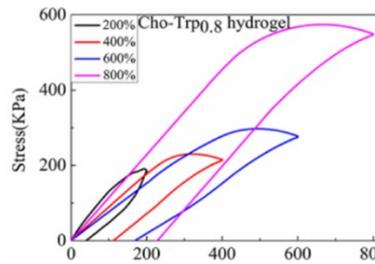
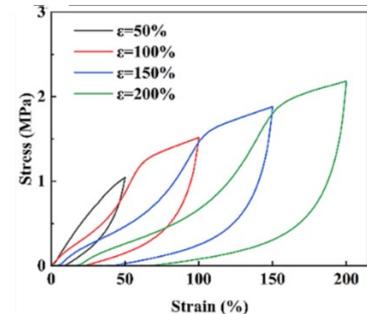
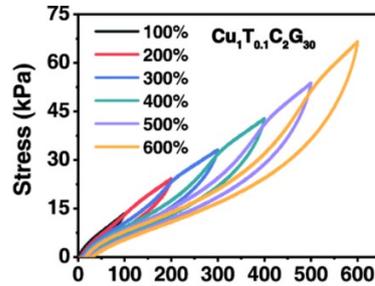
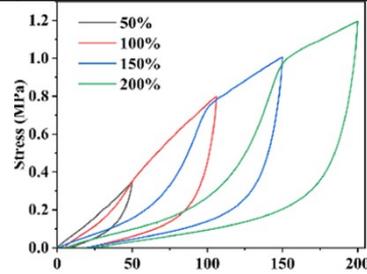


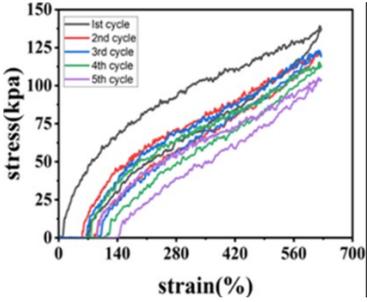
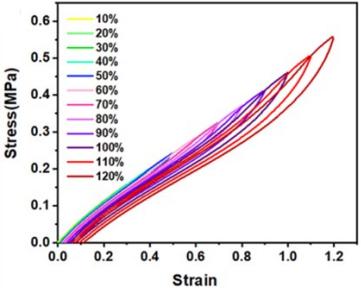
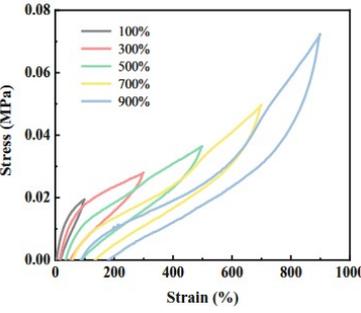
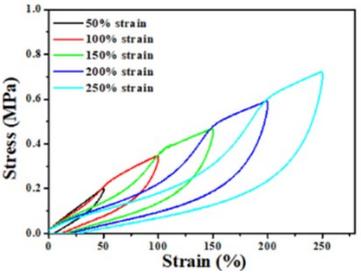
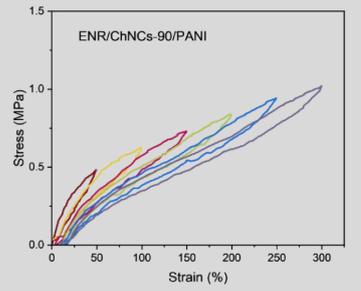
Figure S3. $^1\text{H-NMR}$ spectra of ENR with epoxidation degree of 28% ($A_{2.69}$: 0.38, $A_{5.12}$: 0.98).

Table S1. The comparison of this work with recently reported flexible conductive sensors in terms of mechanical properties, cyclic stretching properties, and sensing performance.

| Materials | Max stress (MPa) | Max strain (%) | Cyclic stretching properties | | | GF | | Ref. |
|--|------------------|----------------|------------------------------|----------------------------|------------|------------|----------|------|
| | | | Hysteretic strain(%) | Energy dissipation rate(%) | Strain (%) | Strain (%) | GF value | |
| CNC/TEMP O- CNF/Al ³⁺ /PA A/ChCl/Na ⁺ | 2.0 | 323 | 50 | 100 | 0-50 | 0.85 | 1 | |
| | | | | | 50-100 | 0.92 | | |
| | | | | | 100-200 | 1.06 | | |
| | | | | | 100 | 1.84 | | |
| TA@CNF/C u2+/glycerol/ PAM | 0.15 | 1624 | 100 | 200 | 200 | 2.81 | 2 | |
| | | | | | 400 | 4.09 | | |
| | | | | | 200 | 2.01 | | |
| PVA/SA/ED S | 3.78 | 432 | 50 | 100 | 200 | 2.01 | 3 | |
| | | | | | 100 | 2.65 | | |
| BC/PAA/Fe ³⁺ /VILs | 0.2 | 800 | 200 | 400 | 100 | 2.65 | 4 | |
| | | | | | 200 | 1.26 | | |
| Gelatin/ PVA/PAM/ MBAA/Fe ³⁺ | 0.49 | 880 | 20 | 55.6 | 7 | 11.15 | 5 | |
| | | | | | 12 | 20.06 | | |
| | | | | | 80 | | | |



20 55.6 80

| | | | | | | | | |
|------------------------------|------|------|--|------|-----|-------|-----------|-------|
| | | | | | 50 | 7.2 | | |
| AM-co-BA/XnG/Li ⁺ | 0.66 | 1100 |  | | 800 | 28.8 | 13 | |
| PVA/P(AA-co-AM)/PDA/CNT | 1.21 | 221 |  | | 10 | 0.6 | 14 | |
| | | | | | 120 | 1.52 | | |
| PAA/CS/Gly | 0.27 | 2500 |  | | 100 | 2.492 | 15 | |
| | | | | | 300 | 4.862 | | |
| | | | | | 900 | 9.499 | | |
| PVA/PAM/CS | 2.11 | 511 |  | | 120 | 0.935 | 16 | |
| | | | | | | 2 | | |
| PAA/PEG/PANI | 0.75 | 910 | / | 35.4 | 50 | | 17 | |
| | | | / | 33.1 | 100 | 300 | | 0.27 |
| | | | / | 32.2 | 150 | | | |
| | | | / | 31.6 | 200 | 550 | | 0.84 |
| | | | / | 29.9 | 250 | | | |
| | | | / | 28.2 | 300 | 620 | | 3.53 |
| ENR/ChNCs-90/PANI | 2.5 | 1000 |  | | 150 | 4.44 | This work | |
| | | | | | | 650 | | 62.56 |

| | | | | |
|------|------|-----|-----|-----|
| 0.1 | 25.4 | 50 | | |
| 3.5 | 22.8 | 100 | | |
| 5.0 | 15.2 | 150 | | |
| 9.8 | 14.8 | 200 | 900 | 3.8 |
| 12.4 | 14.3 | 250 | | |
| 13.3 | 13.6 | 300 | | |

Abbreviations:

/: No direct indication in the related manuscript. CNC: Cellulose nanocrystals. TEMPO-CNF: 2,2,6,6-tetramethylpiperidine-1-oxy-oxidized cellulose nanofibers. ChCl: Choline chloride. PAA: Polyacrylic acid.

PAM: Polyacrylamide. PVA: Polyvinyl alcohol. SA: Sodium alginate. EDS: Zinc chloride + glycerol + ethylene glycol. BC: Bacterial cellulose. VILs: Vinyl-Cho-AA ILs. MBAA: N, N' -methylene-bisacrylamide. VSNPs: Vinylfunctionalized silica nanoparticles. HPEC: Hydroxypropyl methyl cellulose. PEDOT:PSS: Poly (3,4-ethylenedioxythiophene): poly (styrene sulfonic acid). PUS: Polyurethane sponges. CNT: Multiwalled carbon nanotubes. SEBS: Styrene-ethylene-butylene-styrene. BB: boric acid and borax. GO: Graphite. PEG: Polyethylene glycol. PANI: Polyaniline. AM-co-BA: Acrylamide-co-Butylacrylate.

XnG: Xanthan Gum. CS: Chitosan. G: Graphene. Gly: Glycerol.

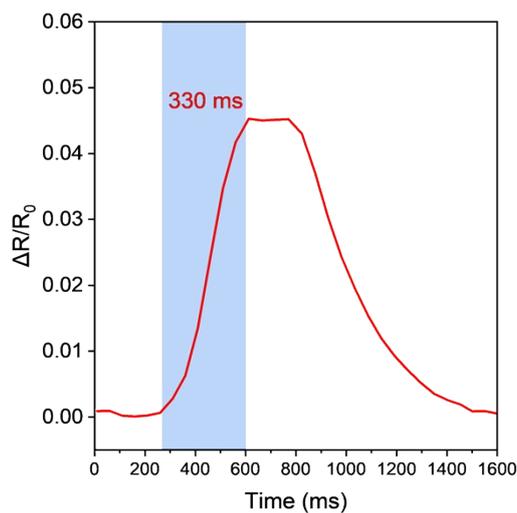


Figure S4. The responses of ENR/ChNCs-90/PANI composites sensor.

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