Supporting Information

3D-Printed Flexible Supercapacitors with Multi-Level Bonded Configuration via Ion Cross-linking.

Jiayu Yang [a, b], *Yuxuan Wang* [a], *Junjie Du* [a], *Fan Bu* [a], *Qinghe Cao* [a], *Ting Meng* [a], *Xi Xu* [a, b], *and Cao Guan* [a, b] *

[a]Frontiers Science Center for Flexible Electronics, Institute of Flexible Electronics, Northwestern Polytechnical University, Xi'an 710072, P. R. China

[b]Ningbo Institute of Northwestern Polytechnical University, Northwestern Polytechnical University, Ningbo, 315103, China.

E-mail: iamcguan@nwpu.edu.cn.

Calculations

Areal capacitance (C_A), volumetric capacitance (C_V) and specific capacitance (C) of supercapacitors are calculated based on the galvanostatic charging and discharging curves according to the following equations:

$$C_A = \frac{I \times t}{\Delta V \times A} \tag{1}$$

$$C_V = \frac{I \times t}{\Delta V \times V} \tag{2}$$

$$C = \frac{I \times t}{\Delta V \times m} \tag{3}$$

where C_A, C_V and C are the areal, volumetric and specific capacitance, respectively. I is the discharge current, t is the discharge time, ΔV is the working voltage, A is the effective active area of the supercapacitor, V is the total volume of the supercapacitor and m is the mass loading of the total device. Areal energy density (E_A) and corresponding power density (P_A,) of supercapacitors are calculated according to the following equations:

$$E_A = \frac{1000}{2 \times 3600} \times C_A \times \Delta V^2 \tag{4}$$

$$P_A = \frac{3600 \times E_A}{t} \tag{5}$$

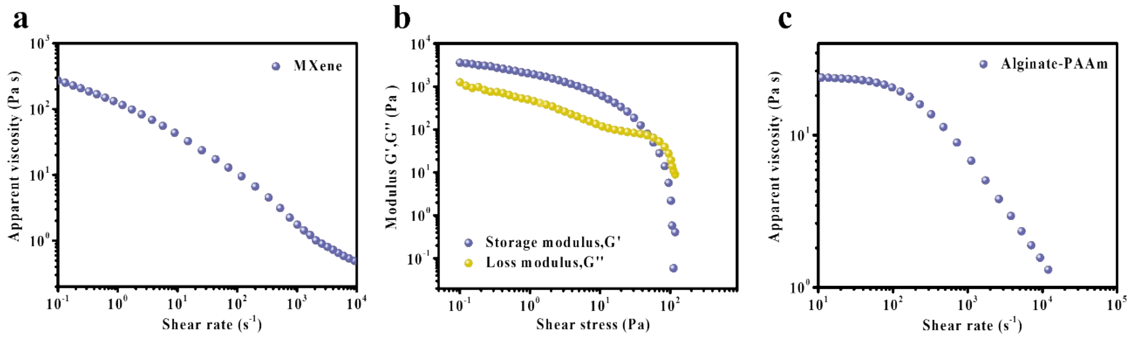

Figure S1. a) Apparent viscosity as a function of shear rate for the MXene ink. b) The storage (G′) and loss moduli (G″) as a function of shear stress for MXene ink. c) Apparent viscosity as a function of shear rate for the Alginate-PAAm gel-like electrolyte.

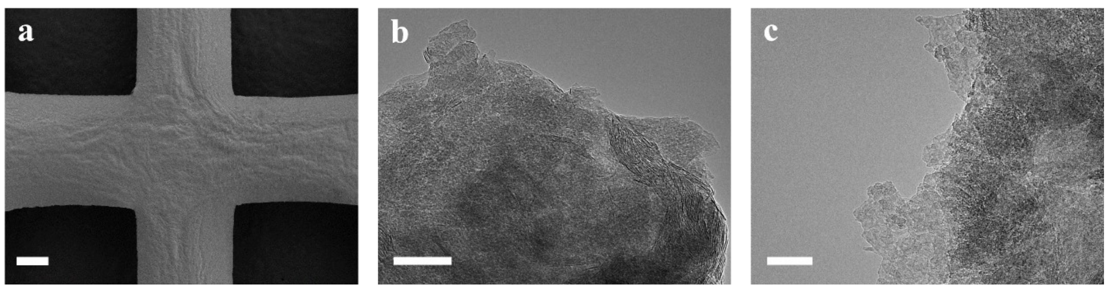

Figure S2. a) SEM image of the sequentially bridged Ca-alginate/MXene electrode. b, c) TEM images of the sequentially bridged Ca-alginate/MXene electrode. Scale bars: a) 200 μm, b, c) 50 nm.

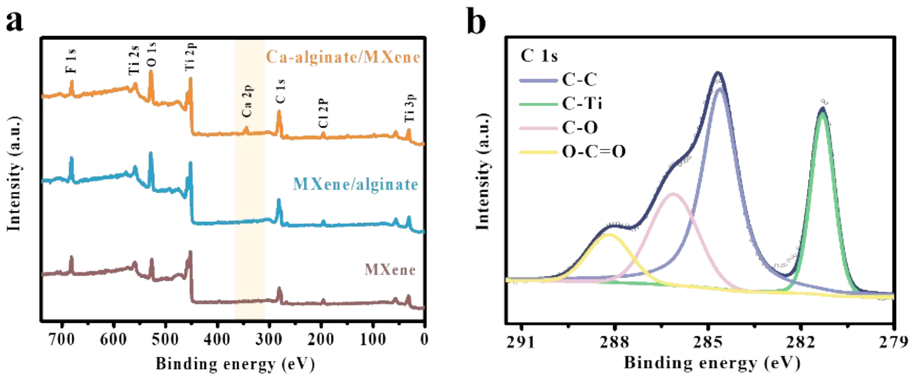

Figure S3. a) XPS spectra of Ca-alginate/MXene, MXene/alginate, and MXene. b) XPS spectra C1s for MXene/alginate.

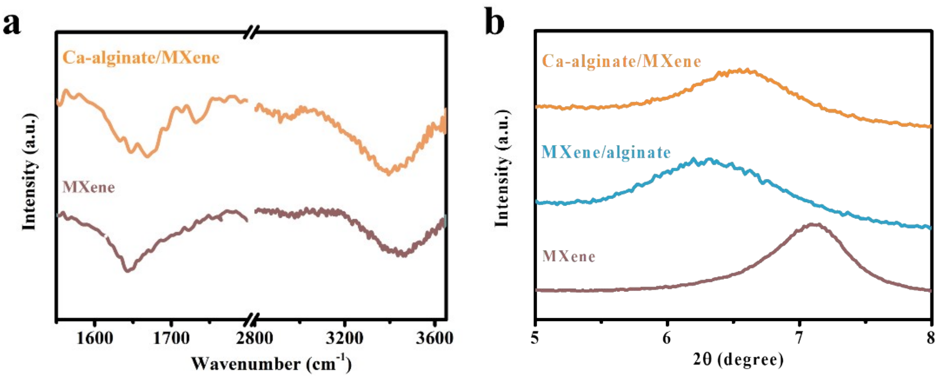

Figure S4. a) FTIR spectra for the Ca-alginate/MXene, and MXene. b) XRD patterns of Ca-alginate/MXene, MXene/alginate, and MXene.

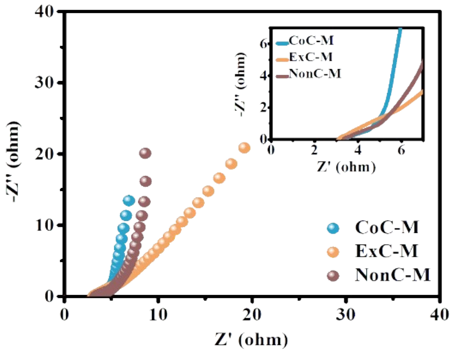

Figure S5. Nyquist plots of CoC-M, ExC-M, and NonC-M supercapacitors.

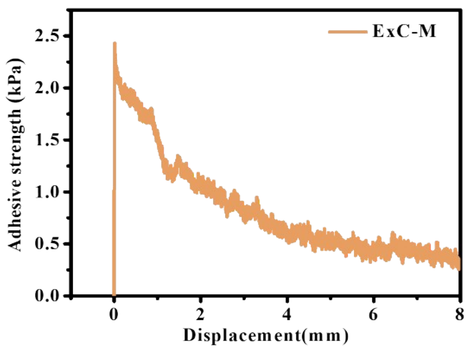

Figure S6. The adhesive strength of the ExC-M supercapacitor.

Table 1 The comparison of the flexibility, durability and electrochemical performance with literature reports on flexible supercapacitors.

Ref.	Capacitance	Deformations	Durability	Capacity retention
This work	2.7 F cm^{-2} (7 mA cm^{-2})	Bending	1500 times	96.9%
[1]	0.273 mF cm^{-2} (300 mV s^{-1})	Bending	100 times	75%
[2]	3.3 mF cm^{-2} (0.02 mA cm^{-2})	Bending	1200 times	92%
[3]	81.5 μF cm^{-2} (0.1 V s^{-1})	Bending	1800 times	87.5%
[4]	580 μF cm^{-2} (5.8 μA cm^{-2})	Bending	1000 times	93%
This work	2.7 F cm^{-2} (7 mA cm^{-2})	Stretching	2000 times	83.2%
[5]	216.2 mF cm^{-2} (10 mV s^{-1})	Stretching	1000 times	75%
[6]	450 mF cm^{-2} (1 mA cm^{-2})	Stretching	1000 times	78%
[7]	23.2 F g^{-1} (0.5 A g^{-1})	Stretching	1000 times	81%

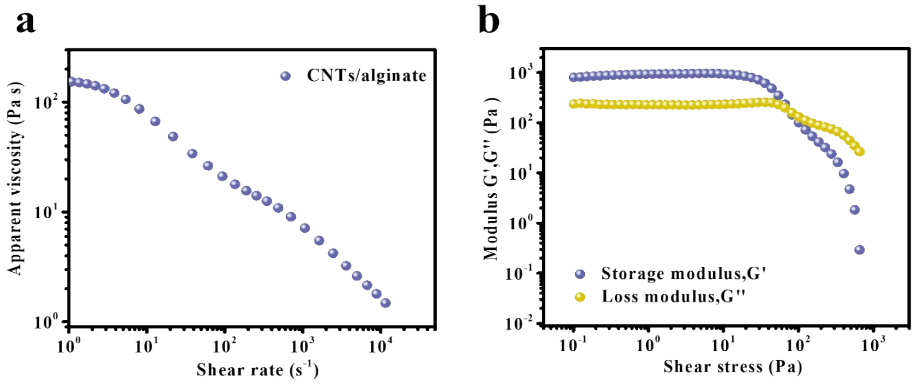

Figure S7. a,b) Rheological behaviors of printable CNTs/alginate ink. a) Apparent viscosity in terms of shear rate for the CNTs/alginate ink. b) The storage (G′) and loss moduli (G″) as a function of shear stress for CNTs/alginate ink.

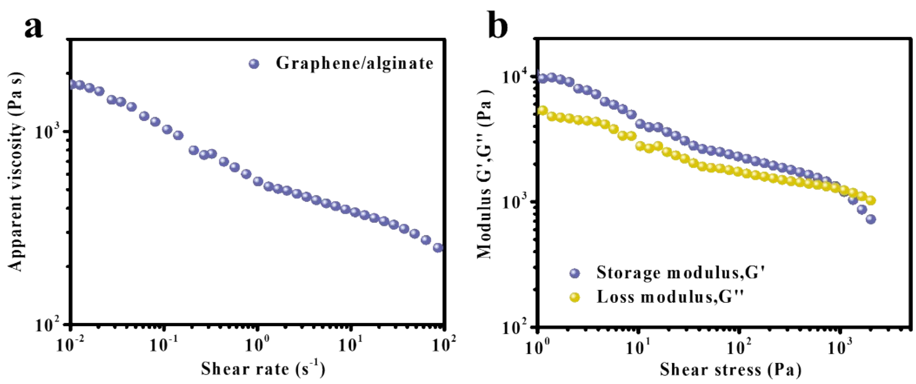

Figure S8. a,b) Rheological behaviors of printable Graphene/alginate ink. a) Apparent viscosity in terms of shear rate for the Graphene/alginate ink. b) The storage (G′) and loss moduli (G″) as a function of shear stress for Graphene/alginate ink.

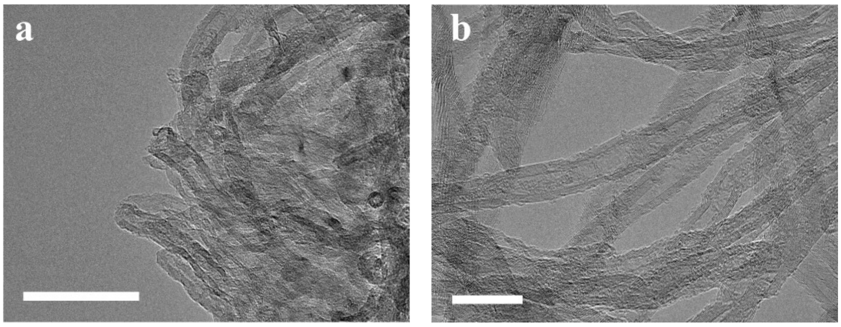

Figure S9. a) and b) TEM images of Ca-alginate/CNTs electrode. Scale bars: a) 50 nm, b) 20 nm.

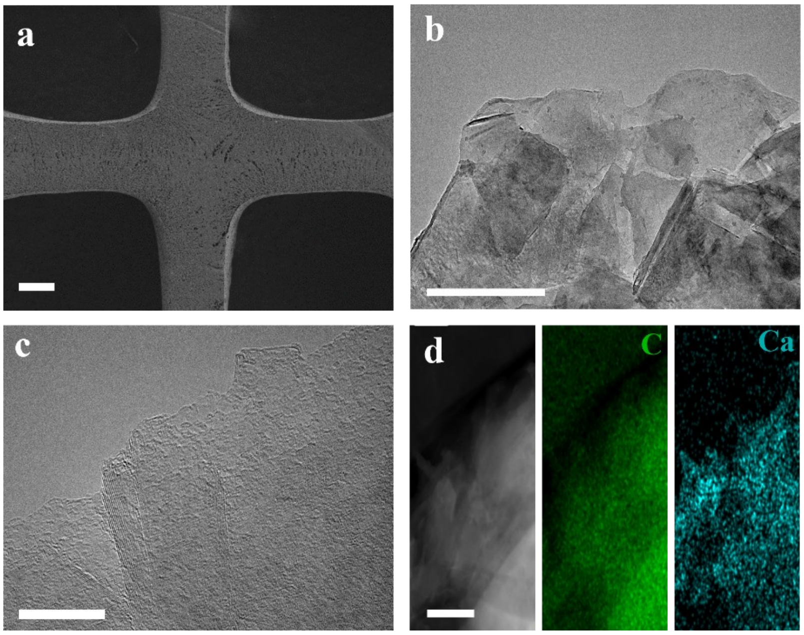

Figure S10. a) SEM image of the sequentially bridged Ca-alginate/graphene electrode. b,c) TEM and d) EDS mapping images of Ca-alginate/graphene electrode. Scale bars: a) 200 μm, b) 500 nm, c) 20 nm, d) 200 nm.

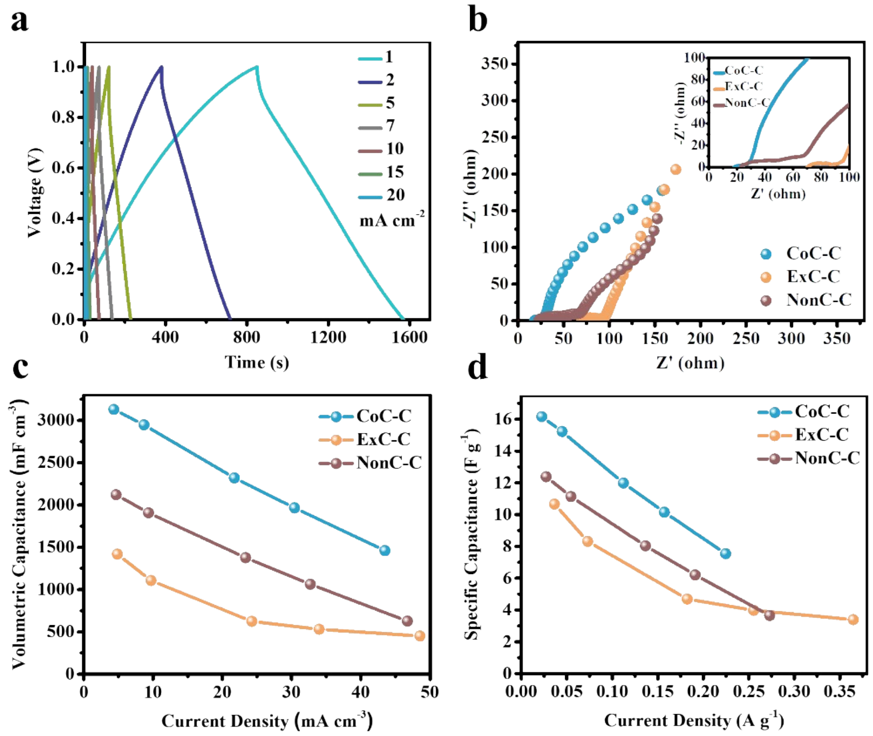

Figure S11. a) charge-discharge curves of CoC-C supercapacitor collected at different current densities. b) Nyquist plots of CoC-C, ExC-C, and NonC-C supercapacitors. c) volumetric capacitances and d) specific capacitances of CoC-C, ExC-C, and NonC-C supercapacitors obtained at various current densities.

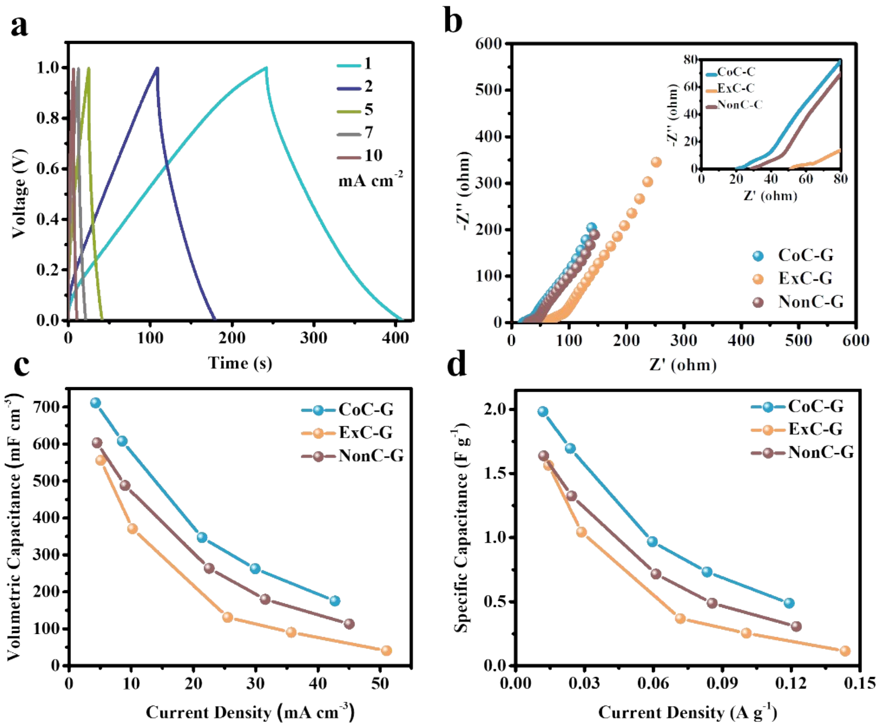

Figure S12. a) charge-discharge curves of CoC-G supercapacitor collected at different current densities. b) Nyquist plots of CoC-G, ExC-G, and NonC-G supercapacitors. c) volumetric capacitances and d) specific capacitances of CoC-G, ExC-G, and NonC-G supercapacitors obtained at various current densities.

References

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