Electronic supplementary information

Conductive MXene nanosheets infused in curli fibers for bioprinting and thin film electrodes

Mario Alfonso Arenas García[a], Slah Hidouri[a], Joshua M. Little[b], Daniel Modafferi[a], Xinxin Hao[a], Po-Yen Chen[b] & Noémie-Manuelle Dorval Courchesne[a]

[a]Department of Chemical Engineering, McGill University, 3610 University Street, Montréal, QC, H3A 0C5, Canada

[b]Department of Chemical and Biomolecular Engineering, University of Maryland, 4418 Stadium Drive, College Park, MD, 20742, United States

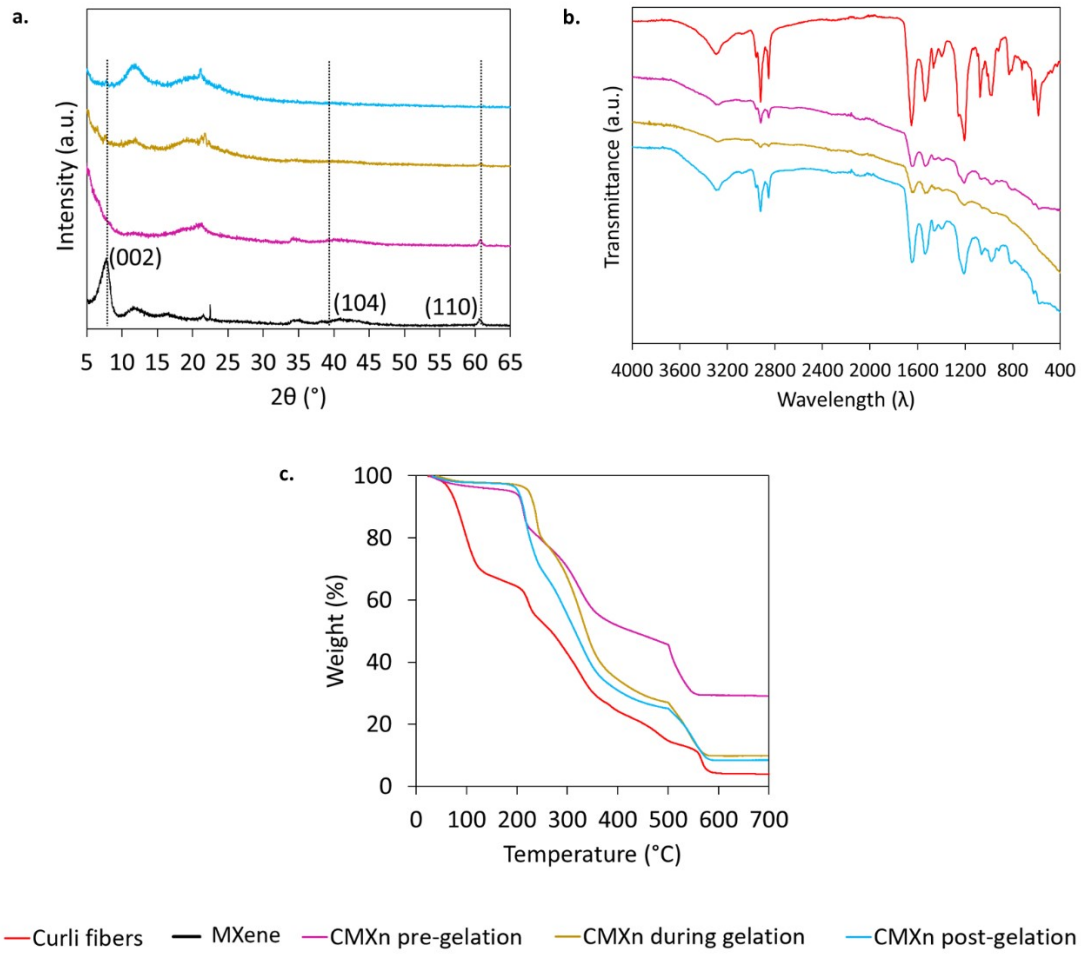

Figure S1. Characterization of curli-MXene nanocomposites (CMXn) for MXene integrated at different stages of the curli fiber isolation process via vacuum filtration (pre-gelation, during gelation and post-gelation). (a) X-ray diffraction (XRD), (b) Fourier-transform infrared (FTIR) spectroscopy and (c) thermogravimetric analysis (TGA).

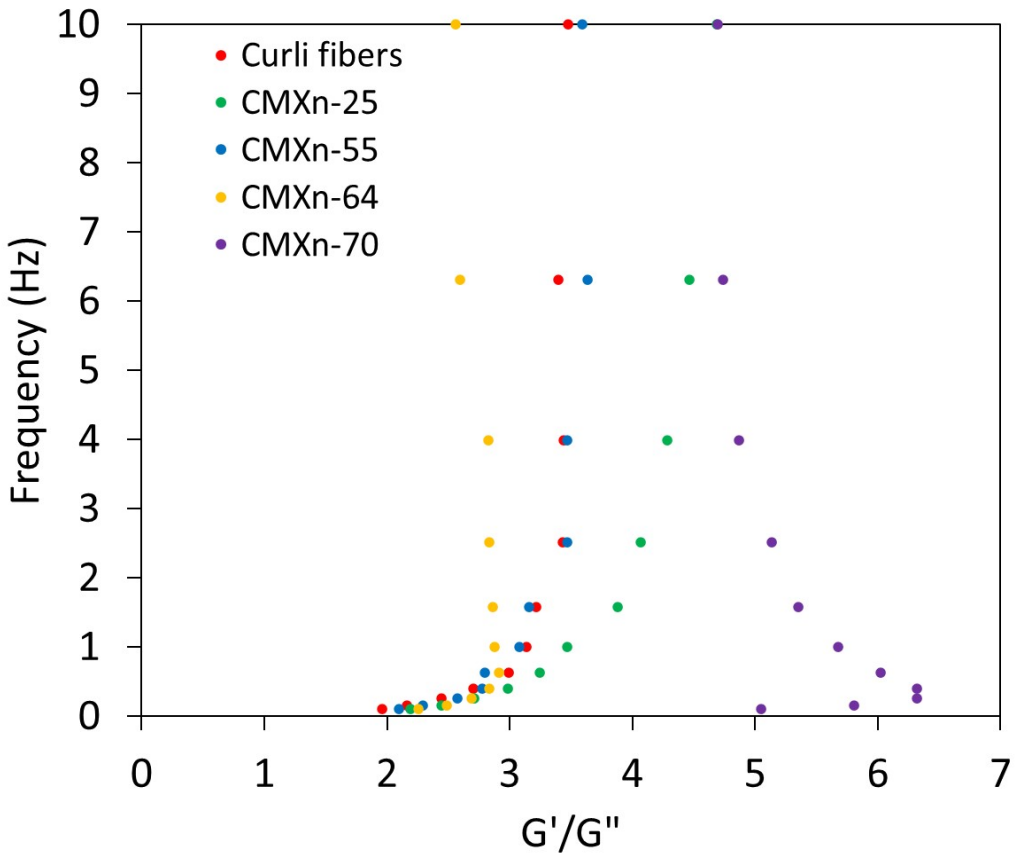

Figure S2. G'/G" ratios for frequency sweeps for curli fibers and CMXn with different loadings.

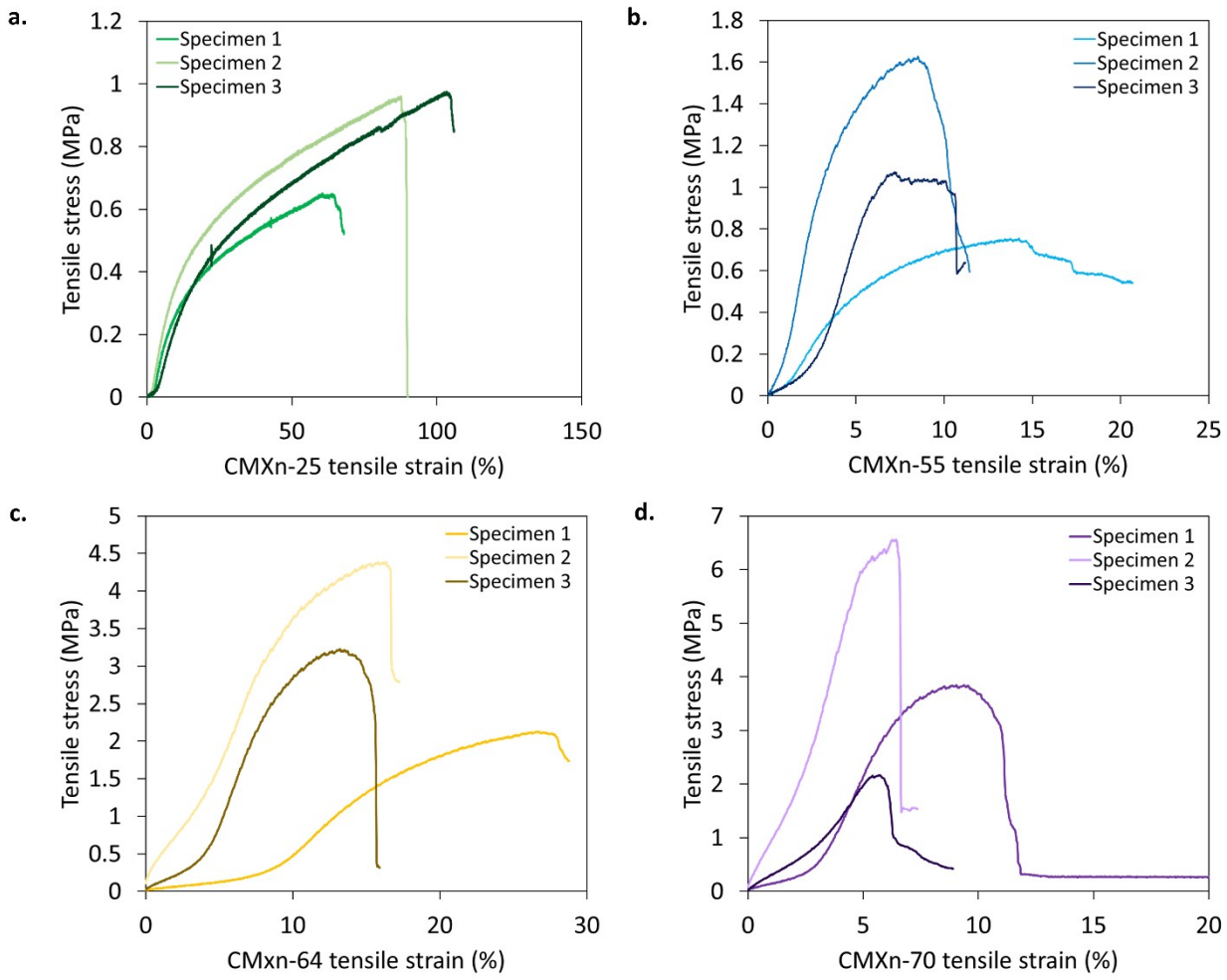

Figure S3. Stress-strain curves for CMXn thin films with different MXene loading: a) CMXn-25, b) CMXn-55, c) CMXn-64 and d) CMXn-70. Three replicates are presented for each loading.

Table S1. Nomenclature for MXene composites with their corresponding ultimate strain and conductivity values.

Label	Composite (name)	Maximum ε (%)	Maximum conductivity (S/cm)	Reference
This work	CMXn	83.81	49.34	This work
i	MXene-bacterial cellulose	16	1000	1
ii a	Hydrogen-bonded MXene-carboxymethyl cellulose film (HBM)	6.41	7644	2
ii b	Covalently bridged MXene-boron film (CBM)	2.13	9746	2
ii c	Sequentially bridged MXene- carboxymethyl cellulose-boron film (SBM)	5.26	6484	2
ii d	Sequentially bridged MXene- carboxymethyl cellulose-boron doctor bladed film (SBM-DB)	4.62	5976	2
iii	MXene-MMT-PVA	2	1.25	3
iv	MXene-chitosan	8.5	9.69	4
v	MXene	2	12300	5
vi	MXene-polyurethane	1857	0.01	6
vii a	MXene-polyurethane, coagulating bath with isopropanol (IPA)	6.41	22.6	7
vii b	MXene-polyurethane, coagulating bath with acetic acid (AcOH)	6.41	392	7
viii	MXene, coagulation solution with NH_4 ions	0.22	7713	8

Table S2. Comparison of mechanical and conductive properties of MXene composites in literature.

Assembly technique	Composition	MXene loading (wt. %)	Mechanical properties	Conductivity (S/cm)	Application	Reference
Vacuum assisted filtration (VAF)	MXene-curli fibers	CMXn-25 25.12 ± 2.40	CMXn-25 Young's Modulus: 4.28 ± 1.06 MPa Stress: 0.86 ± 0.18 MPa Strain: 83.81 ± 21.60 %	CMXn-25 4.41 ± 1.21 x 10^{-8}	Strain sensor, electromagnetic interference (EMI) shielding	This work
		CMXn-55 54.94 ± 7.43	CMXn-55 Young's Modulus: 101.17 ± 41.95 MPa Stress: 7.97 ± 2.26 MPa Strain: 20.03 ± 3.92 %	CMXn-55 34.98 ± 1.92 x 10^{-3}		
		CMXn-64 63.72 ± 9.88	CMXn-64 Young's Modulus: 39.67 ± 19.52 MPa Stress: 3.25 ± 1.13 MPa Strain: 18.75 ± 7.09 %	CMXn-64 21.51 ± 12.22		
		CMXn-70 69.67 ± 5.31	CMXn-70 Young's Modulus: 109.84 ± 56.69 MPa Stress: 4.19 ± 2.22 MPa Strain: 7.12 ± 1.98 %	CMXn-70 49.34 ± 28.27		
	MXene-bacterial cellulose	43 – 83	Stress: 40 – 70 MPa Strain: 6 – 16 %	250 – ~1000	Micro-supercapacitor arrays	1
	Hydrogen-bonded MXene-carboxymethyl cellulose film (HBM)	HBM 81.5 – 95.7	HBM Young's Modulus: 7.0 ± 0.1 – 12.9 ± 1.3 GPa Tensile strength: 178 ± 7 – 310 ± 11 MPa Strain: 3.62 ± 0.12 – 6.41 ± 0.17 %	HBM 1028 ± 29 – 7644 ± 82	EMI shielding	
	Covalently bridged MXene-boron film (CBM)	CBM 98.68 – 99.72	CBM Young's Modulus: 9.8 ± 0.8 – 25.0 ± 1.0 GPa Tensile strength: 143 ± 5 – 263 ± 8 MPa Strain: 1.34 ± 0.07 – 2.13 ± 0.11 %	CBM 9375 ± 113 – 9746 ± 128		2
	Sequentially bridged MXene- carboxymethyl cellulose-boron film (SBM)	SBM 89.93 – 90.57	SBM Young's Modulus: 14.2 ± 0.8 – 29.4 ± 2.5 GPa Tensile strength: 432 ± 17 – 583 ± 16 MPa Strain: 3.71 ± 0.06 – 5.26 ± 0.27 %	SBM 5850 ± 54 – 6484 ± 59		

Table S2. (continued)

Assembly technique	Composition	MXene loading (wt. %)	Mechanical properties	Conductivity (S/cm)	Application	Reference
VAF	MXene-graphdiyne nanotube	–	Can achieve bending angles up to 90°	1667	Supercapacitors	9
Layer by layer	MXene-MMT-PVA	45.5	Young's Modulus: 10.5 ± 6.6 GPa Tensile strength: 225 ± 25 MPa Strain: 2 %	0.53 to 1.25	EMI shielding	3
	MXene-chitosan	9.1 – 25.9	Stress: ~12 – 25 MPa Strain: ~4.5 – ~8.5 %	0.14 – 9.69	EMI shielding & thermal management capacity	4
Doctor blading	MXene	100	Young's Modulus: 10.5 ± 6.6 GPa Tensile strength: 225 ± 25 MPa Strain: 2 %	10,220 ± 480 – 12,300 ± 170	Photodetectors	5
	Sequentially bridged MXene- carboxymethyl cellulose-boron film (SBM-DB)	90.23	Young's Modulus: 26.8 ± 1.3 GPa Tensile strength: 559 ± 10 MPa Strain: 4.62 ± 0.21 %	5976 ± 68	EMI shielding	2
Hot press	MXene-polyurethane	0.0 – 1.0	Tensile strength: 17.3 – 20.6 MPa Strain: 1700 – 1857 %	–	Coating, adhesives, etc.	6
Wet-spinning	MXene-polyurethane, coagulating bath with isopropanol (IPA) & acetic acid (AcOH)	0.50, 0.99, 1.96, 4.76, 9.09, 13.04, 16.67, 23.08, 28.57, 44.44, 61.54, 80.00 & 100.00	IPA bath Young's Modulus: 7.0 ± 0.1 – 12.9 ± 1.3 GPa Tensile strength: 178 ± 7 – 310 ± 11 MPa Strain: 3.62 ± 0.12 – 6.41 ± 0.17 % AcOH bath Young's Modulus: 7.0 ± 0.1 – 12.9 ± 1.3 GPa Tensile strength: 178 ± 7 – 310 ± 11 MPa Strain: 3.62 ± 0.12 – 6.41 ± 0.17 %	IPA bath ~5.0×10^{-5} – 22.6 AcOH bath ~4.0×10^{-3} – 392	Textile strain sensors	7
	MXene, coagulation solution with NH_4 ions	100	Young's Modulus: 29.6 ± 5.1 GPa Tensile strength: 63.9 ± 13.1MPa Strain: 0.22 ± 0.05 %	7713 ± 110	Electrical wires	8
Rolling mill	MXene	100	–	1500	–	10

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