

Supporting Information

Enhanced electrical and thermal properties of semi-conductive PANI-CNCs with surface modified CNCs

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Table S1. Thermal properties and conductivity of MCC, S-CNC, C-CNC, SCNC-PANI, CCNC-PANI, and DBSA-SCNC-PANI nanocomposites.

Sample	C (S/cm)	T ₀ (°C)	T _{max} (°C)	T _{5%} (°C)	T _{15%} (°C)	Residual mass (%)
MCC	N/A	320	340.1	285.0	321.9	4.7
S-CNC	8.26×10^{-6}	237	294.8	99.2	249.0	21.3
C-CNC	1.27×10^{-6}	211	304.5	69.0	222.9	20.5
SP ₁₀	1.55×10^{-4}	145.0	199.6	105.3	164.9	34.4
SP ₂₀	9.60×10^{-4}	167.5	188.7	68.1	174.3	37.3
SP ₃₀	1.06×10^{-2}	156.8	187.6	63.4	165.2	40.0
CP ₁₀	8.60×10^{-6}	158.4	192.6	64.8	164.1	33.4
CP ₂₀	1.19×10^{-4}	225.6	277.9	54.3	228.5	38.2
CP ₃₀	3.00×10^{-3}	189.9	209.4	75.2	202.0	36.7
DSP ₁	5.4×10^{-4}	177.3	206.7	121.4	189.7	35.06
DSP ₂	2.5×10^{-2}	179.3	199.5	153.2	193	34.7
DSP ₃	1.25×10^{-1}	182.4	182.8	84.8	189.5	32.1
DSP ₄	2.5×10^{-1}	192.0	209.6	148.7	206.2	40.0
DSP ₅	1.9×10^{-2}	168.8	211	105.6	180.1	31.64
DSP ₆	2.9×10^{-2}	199.9	210	102.5	205.6	31.49
DSP ₇	1.17×10^{-2}	156.2	195	78.1	166.1	33.9

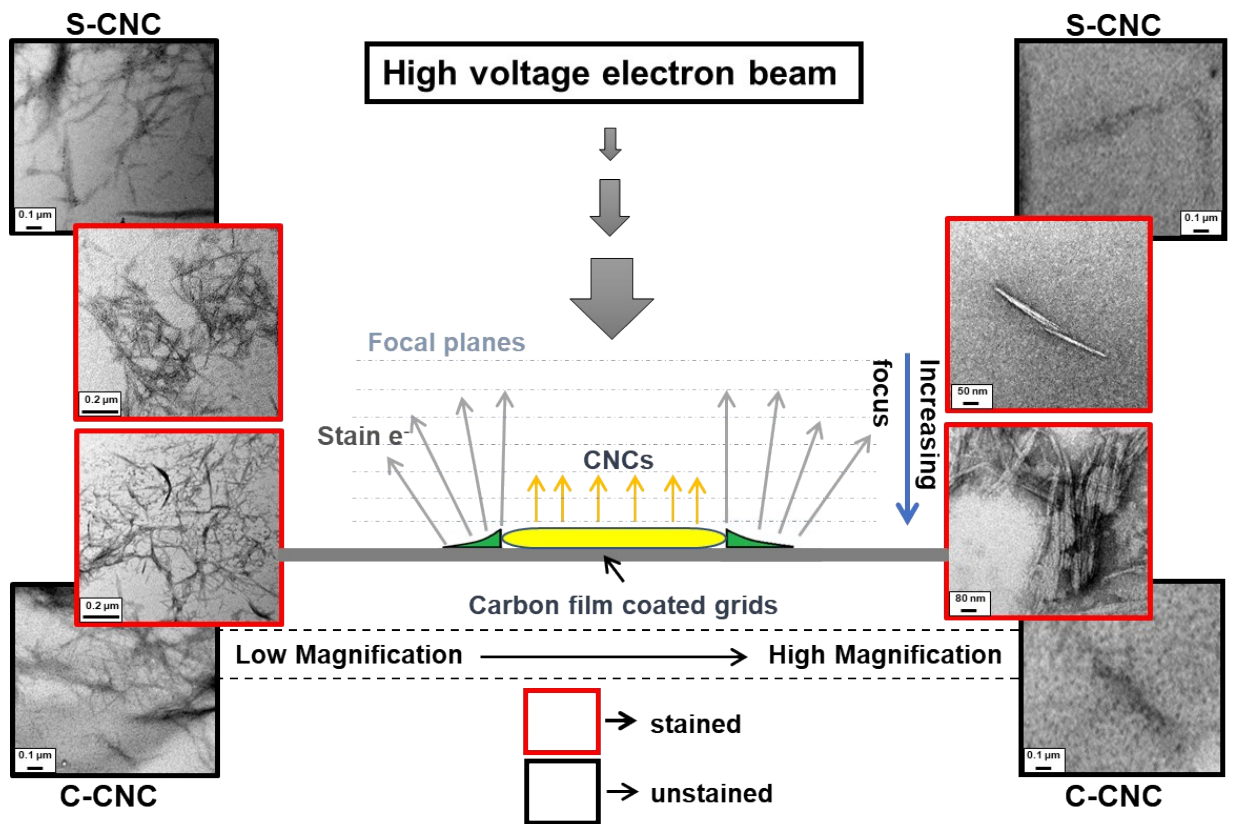


Figure S1. Comparison between negative stain electron microscopy (Red) by using Uranyl acetate (UA) combined with carbon grid exhibited higher resolution under dark background and transmission electron microscopy (Black)

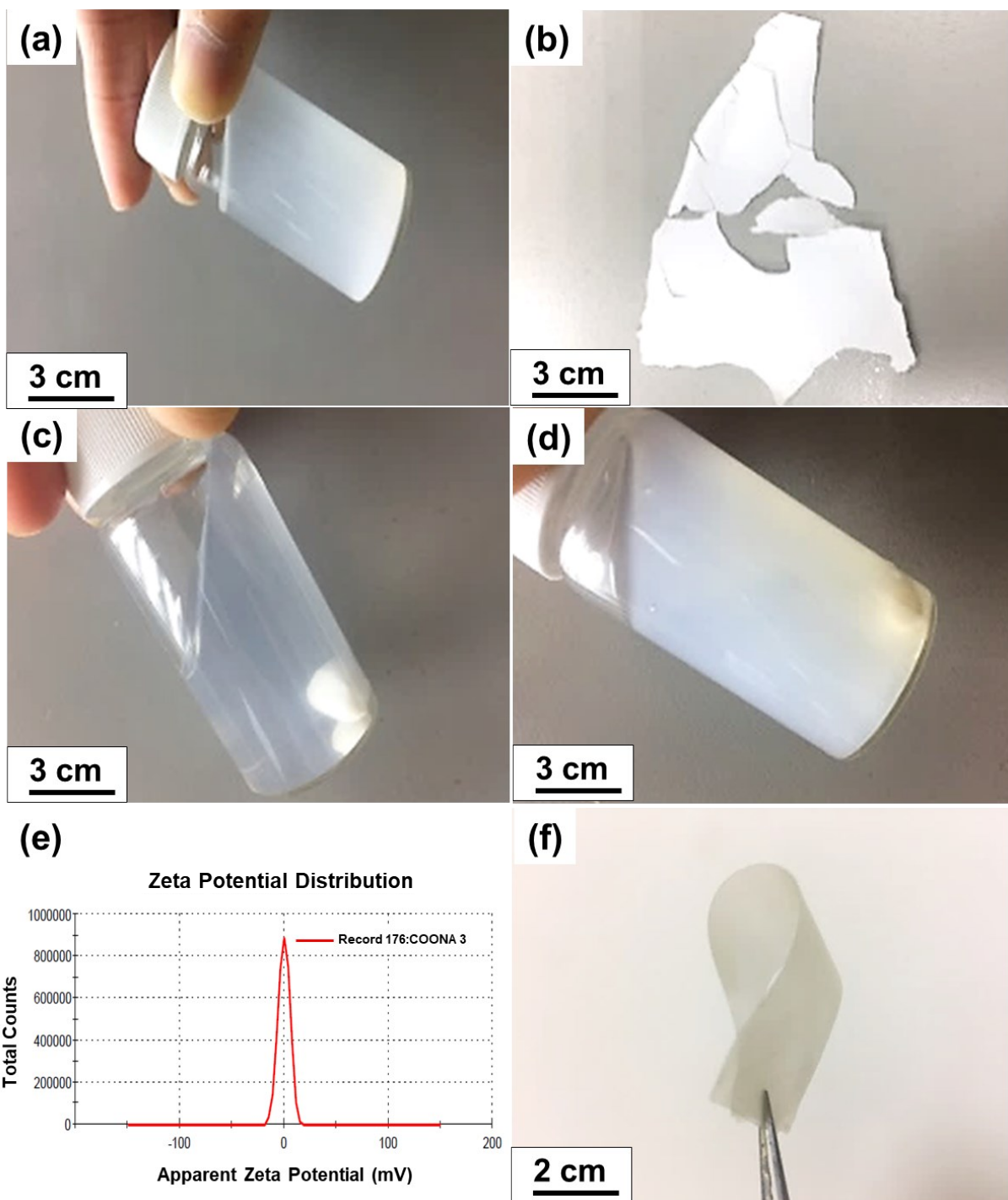


Figure S2. Visual aspect of (a) C-CNC aqueous, (b) C-CNC films before modification, (c) 2wt% C-CNC-COONa⁺ aqueous, (d) 5wt% C-CNC-COONa⁺ aqueous, (e) Zeta potential distribution of 5wt% C-CNC-COONa⁺, (f) C-CNC films after modification.

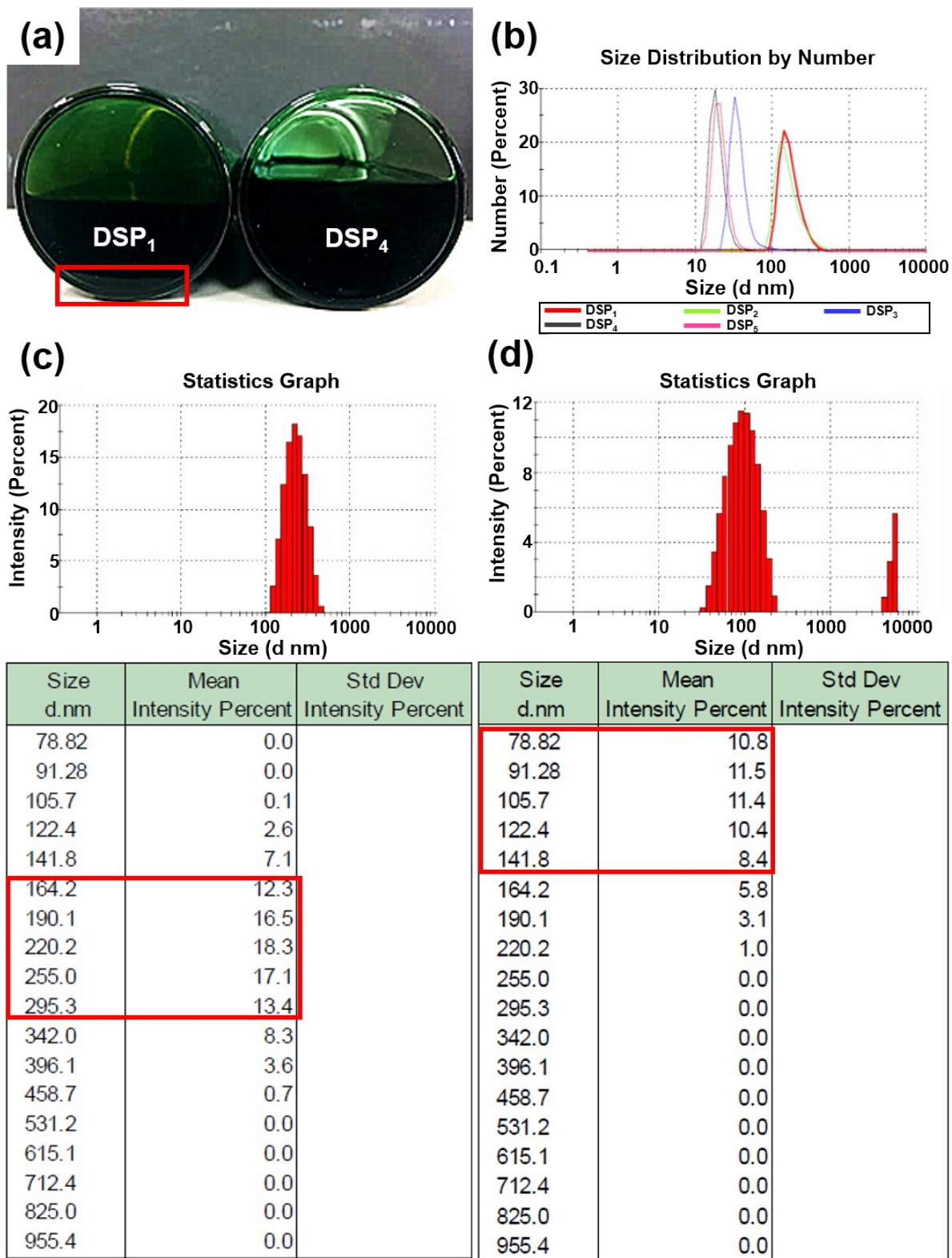


Figure S3. Settling test of DSP₁ and DSP₄ suspension after emulsion polymerization, (b) Particle size distribution of DSP₁, DSP₂, DSP₃, DSP₄, and DSP₅, (c) Particle size distribution of DSP₁ and DSP₄.

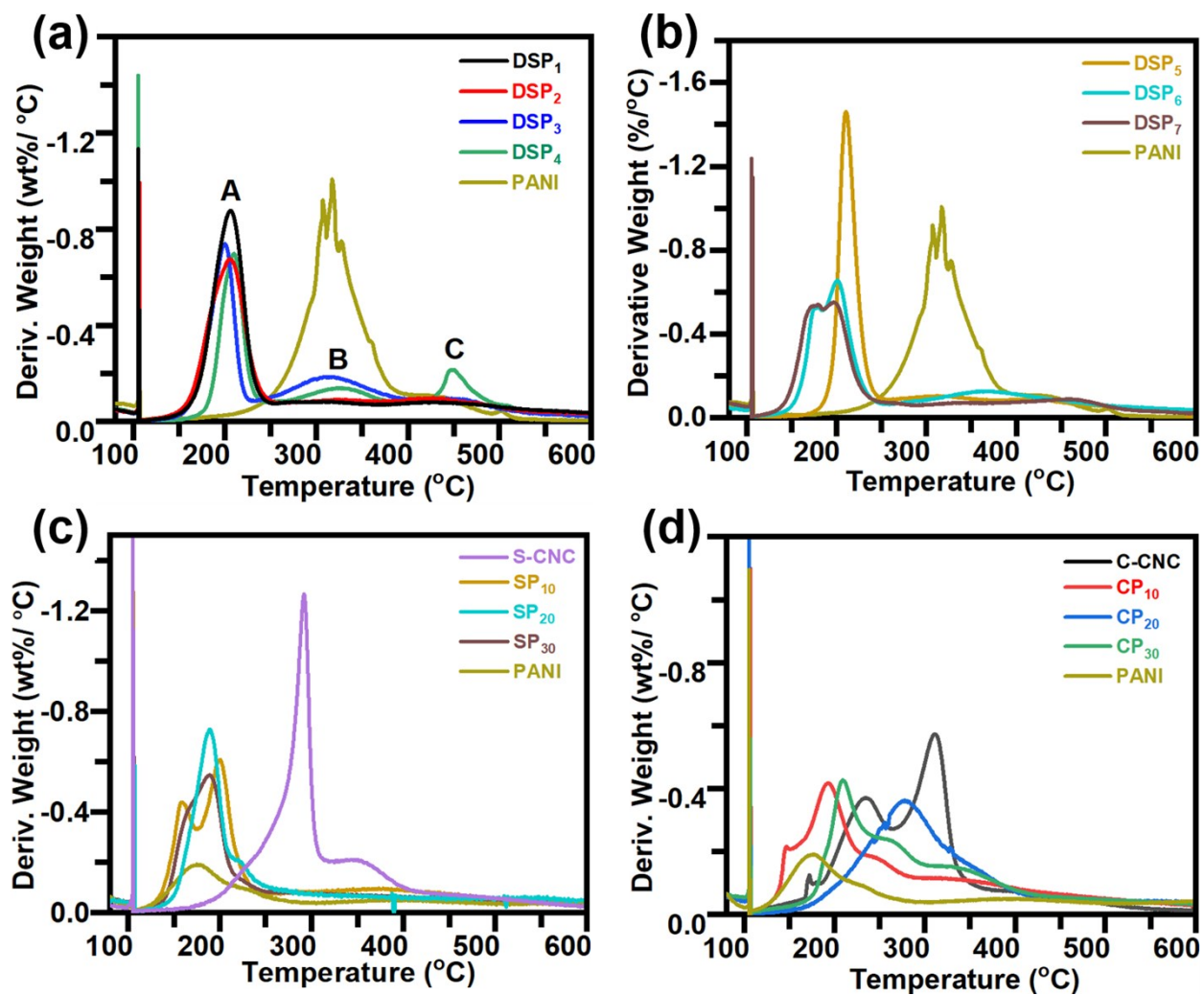


Figure S4. DTG curves of (a) DSP₁, DSP₂, DSP₃, DSP₄, and PANI, (b) DSP₅, DSP₆, DSP₇, and PANI, (c) S-CNC, SP₁₀, SP₂₀, SP₃₀, and PANI, (d) C-CNC, CP₁₀, CP₂₀, CP₃₀, and PANI.

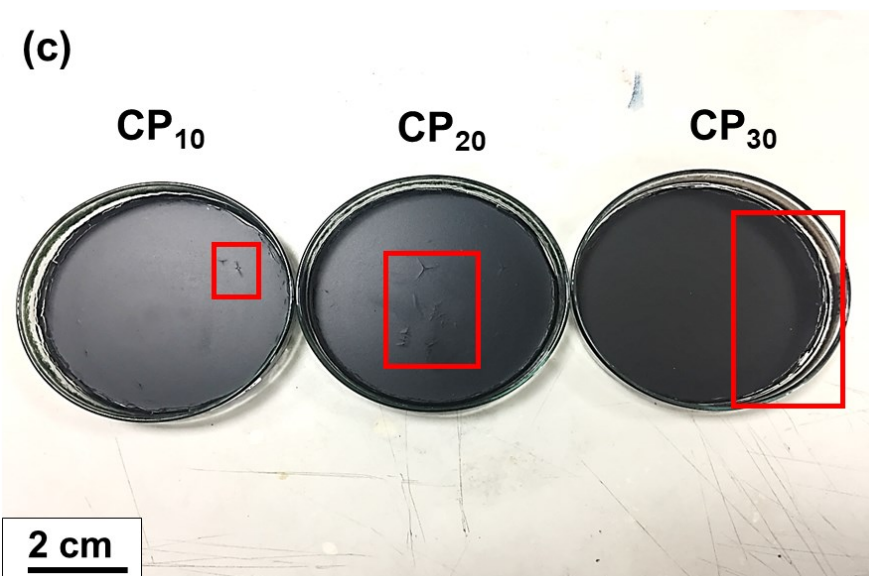
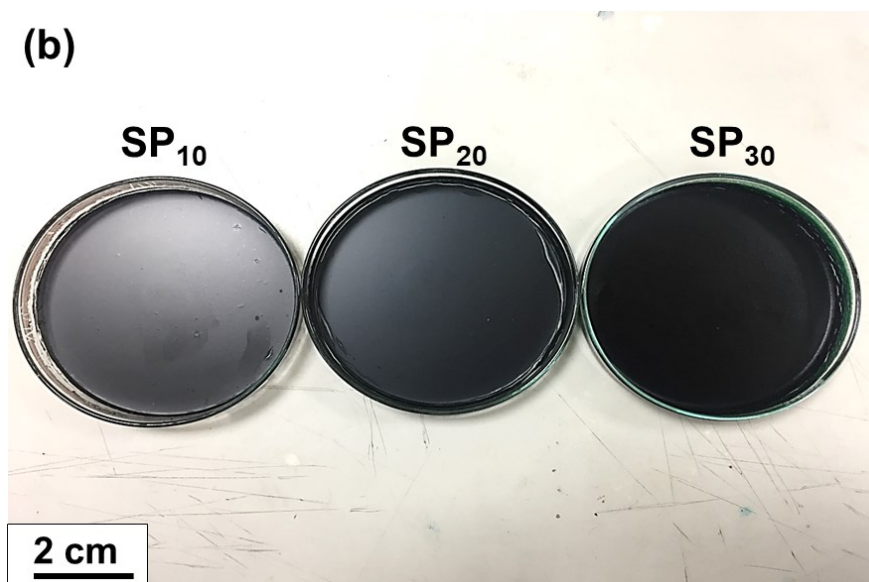
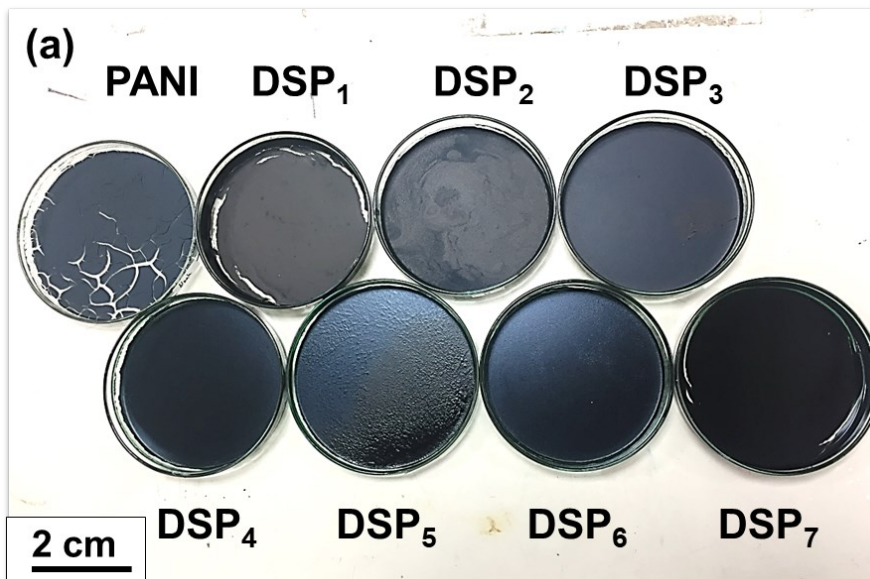


Figure S5. Photographs of (a) PANI, DSP₁, DSP₂, DSP₃, DSP₄, DSP₅, DSP₆, DSP₇ films casting on the petri deck, (b) SP₁₀, SP₂₀, SP₃₀ films casting on the petri deck, (c) CP₁₀, CP₂₀, CP₃₀ films casting on the petri deck.

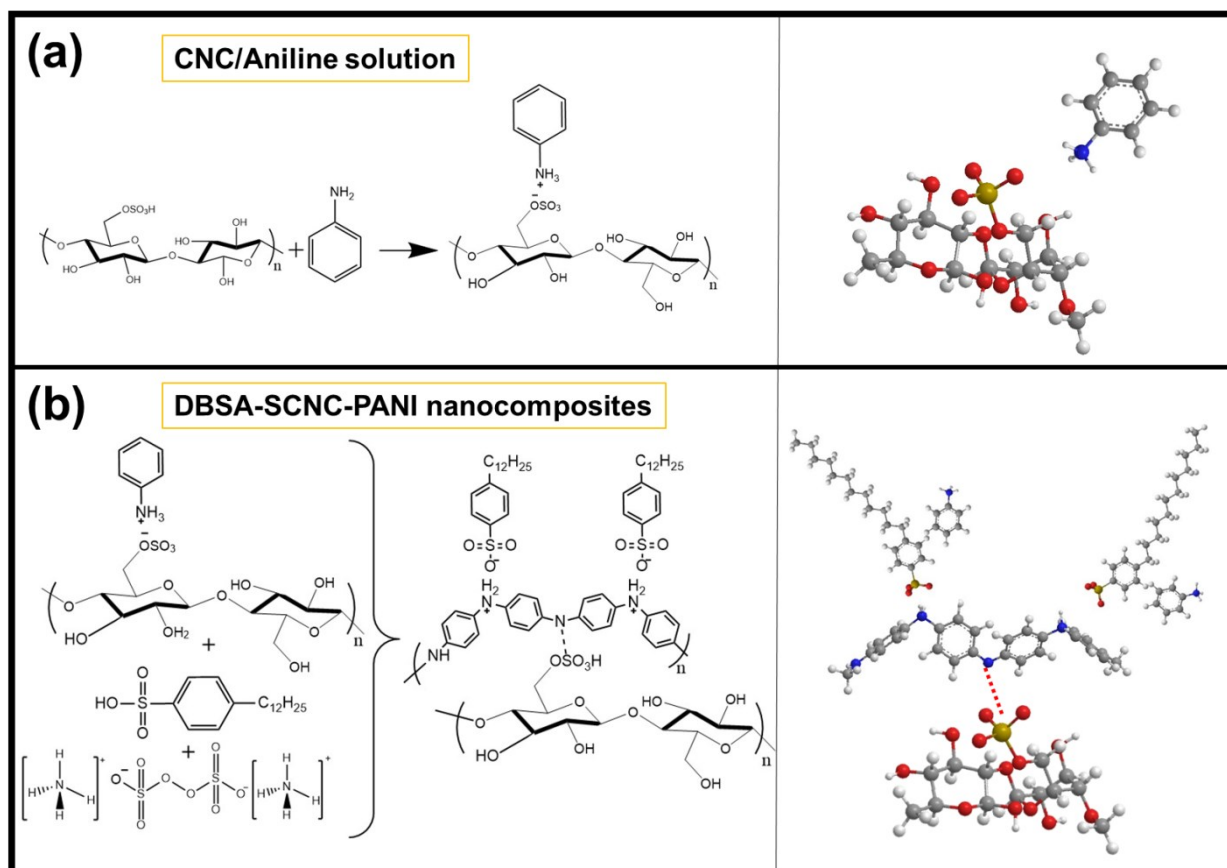


Figure S6. Polymerization of SCNC-ANI by adding DBSA to fabricate the DSP nanocomposites.

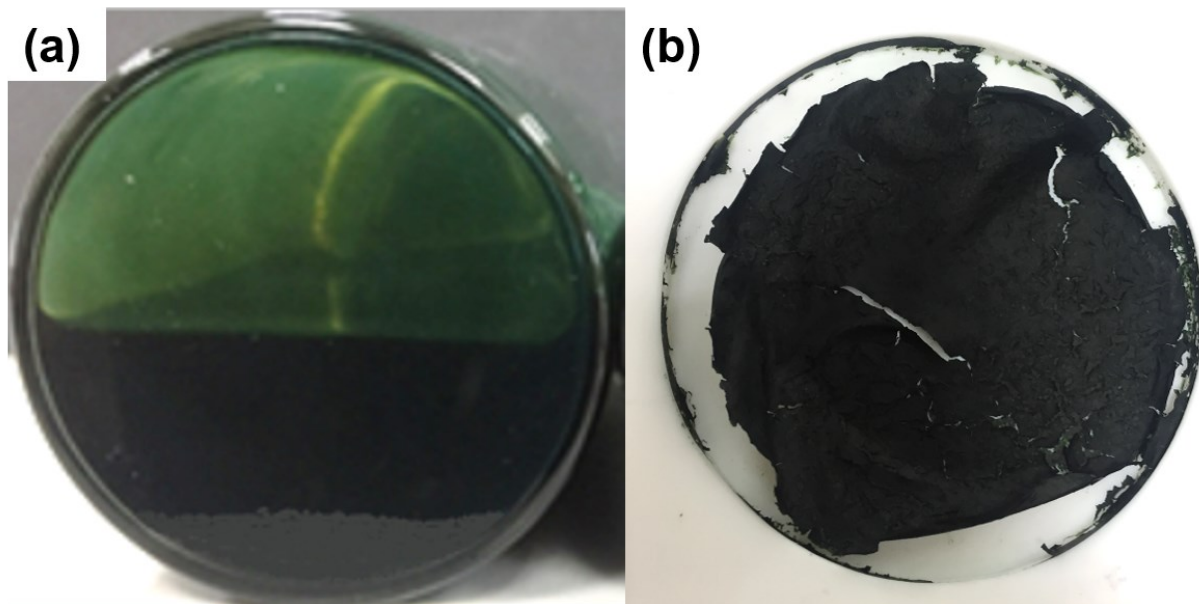


Figure S7. Photographs of CNC/ANI after adding DBSA through emulsion polymerization shows (a) insolubility issues and (b) broken film with large particle aggregation.