Energy Materials

Supplementary Materials

Two-dimensional (2D) materials for 3D printed micro-supercapacitors and micro-batteries

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Table S1: Electrochemical performance of 2D driven materials for 3D printed electric double layer capacitors (EDLCs), pseudocapacitors, and hybrid capacitors.

3D-printed EESDs type	2D materials	Electrolyte	Voltage window (ΔV)	Specific/Areal capacitance	Energy density	Cycling stability (%)	References
Electric Double Layer Capacitors (EDLCs)	GO	1M H_2SO_4	0.8	212 F g^{-1} at 1 A g^{-1}	-	50000 (90)	[1]
	G-CNT	PVA/H_3PO_4	1.0	9.81 mF cm^{-2} at 0.05 mA cm^{-2}	1.12 μWh cm^{-2} at 0.25 mW cm^{-2}	10000 (95.5)	[2]
	G/Ethyl cellulose	PVA/H_3PO_4	1.0	13.2 mF cm^{-2} at 0.4 mA cm^{-2}	2.68 μWh cm^{-2} at 7 μW cm^{-2}	10000 (96)	[3]
	3D-MCA	0.5 M $TEABF_4$ in AN/MF	1.6	148.6 F g^{-1} at 5 mV s^{-1}	-	-	[4]
	TROG	1M KOH	1.0	60 F g^{-1} at 5 mV s^{-1}	7.68 Wh kg^{-1} at 115.8 kW kg^{-1}	-	[5]
	AC	PVA/H_2SO_4	1.0	0.121 F g^{-1} at 4.5 mA cm^{-2}	-	-	[6]
	AC	PVA/H_3PO_4	0.8	1.48 F cm^{-2} at 20 mV s^{-1}	0.064 Wh kg^{-1} at 57.6 W kg^{-1}	500 (56)	[7]
	rGO	1M Na_2SO_4	1.2	10.84 F g^{-1} at 0.1 A g^{-1}	-	200 (70)	[8]
Pseudocapacitors	Ti_3C_2	PVA/H_2SO_4	0.6	393 F g^{-1} at 5 mV s^{-1}	0.1 mWh cm^{-2} at 0.38 mW cm^{-2}	10000 (95.5)	[9]
	Ti_3C_2	PVA/H_2SO_4	0.6	1035 mF cm^{-2} at 2 mV s^{-1}	0.184 μWh cm^{-2}	-	[10]

	MXene-N	3M H_2SO_4	0.6	66.7 F g^{-1} at 12 mA cm^{-2}	0.42 μWh cm^{-2}	5000 (96.2)	[11]
	Ti_3C_2	PVA/H_2SO_4	0.6	50 mF cm^{-2} at 25 μA cm^{-2}	0.76 μWh cm^{-2}	10000 (94.1)	[12]
	NiV-LDH	6M KOH	1.8	1069 F g^{-1} at 1 A g^{-1}	75.8 μWh cm^{-2}	1500 (68.0)	[13]
	MXene/C12E9	PVA/H_2SO_4	0.6	2.66 F cm^{-2} at 11.1 mA cm^{-2}	-	10000 (86.5)	[14]
	MXene	PVA/H_2SO_4	0.6	61 mF cm^{-2} at 800 μA cm^{-2}	-	10000 (93.7)	[12]
	$Ti_3C_2T_x$ MSC	PVA/H_2SO_4	0.6	2.1 F cm^{-2} at 1.7 mA cm^{-2}	24.4 μWh cm^{-2} at 0.64 mW cm^{-2}	10000 (90.36)	[15]
	ZIF-8	2M $ZnSO_4$	1.8	16.9 F cm^{-2} at 5 mA cm^{-2}	7.23 mWh cm^{-2} at 34.7 mW cm^{-2}	2000 (>100)	[16]
Hybrid capacitors	Kcu_7S_4/rGO/MWCNTs	3M KOH	0.7	1674.3 F g^{-1} at 0.5 A g^{-1}	-	2000 (88.6)	[17]
	Ti_3C_2/Cellulose	1M H_2SO_4	0.9	2.02 F cm^{-2} at 1 mA cm^{-2}	101 μWh cm^{-2}	5000 (85)	[18]
	GF-Ni-Au@NiO_x	2M KOH	1.6	3.57 F cm^{-2} at 3 mA cm^{-2}	6.19 mWh cm^{-3}	15000 (92.1)	[19]
	SWNT-$NiCo_2O_4$	6M KOH	0.4	588 mF cm^{-2} at 1 mA cm^{-2}	138 μWh cm^{-2}	50000 (82)	[20]
	Cu/Co-THQ	$LiPF_6$/EC/DMC	1.6	178.68 F g^{-1} at 1 A g^{-1}	396.89 Wh kg^{-1}	4000 (89.43)	[21]
	G/ZnV_2O_6@$Co_3V_2O_8$	1M KOH	1.6	149.71 F g^{-1} at 0.5 A g^{-1}	52.64 Wh kg^{-1}	10000 (95.5)	[22]

	e-$ReSe_2$@INC	$NaPF_6$	3.5	252.5 mAh g^{-1} at 20 A g^{-1}	81.4 Wh kg^{-1} at 9992.1 W kg^{-1}	3500 (89.6)	[23]
	PEDOT:PSS/MXene	PVA/H_2SO_4	0.8	242.4 mF cm^{-2} at 51 mA cm^{-2}	-	6000 (83)	[24]
	PANI/rGO	1M H_2SO_4	1.0	311 F g^{-1} at 0.86 A g^{-1}	-	1000 (75)	[25]
	G-VNQDs/GO	LiCl-PVA	1.6	207 mF cm^{-2} at 0.43 mA cm^{-2}	73.9 μWh cm^{-2} at 3.77 mW cm^{-2}	8000 (65)	[26]
	MXene-AgNW-MnONW-C60	PVA-KOH	0.8	216.2 mF cm^{-2} at 10 mV s^{-1}	19.2 μWh cm^{-2} at 58.3 mW cm^{-2}	10000 (85)	[27]
	Ex-$Ti_3C_2T_x$/CC || MoS_3@3DnCF/CC	PVA/H_2SO_4	1.6	90 F g^{-1} at 1 A g^{-1}	56.9 μWh cm^{-2} at 0.20 mW cm^{-2}	25000 (92.8)	[28]
	V_2O_5/MWCNTs|| VN/MWCNTs	PVA-KOH	1.6	152.7 mF cm^{-2}	54.3 μWh cm^{-2}	12000 (93.1)	[29]

Table S2: Electrochemical performance of 2D driven materials for 3D printed Li-based batteries and next generation batteries.

3D-printed EESDs type	2D materials	Electrolyte	Voltage window (ΔV)	Specific/Areal capacity	Energy density	Cycling stability (%)	References
Li-based batteries	rGO-AgNWs-LTO	1 M $LiFP_6$ in EC/DEC/DMC (1:1:1 volume)	1.5 V	132.8 mAh g^{-1} at 5C, 200 cycles	199.2 mWh kg^{-1}	200 cycles (99.1)	[30]
	3DP-pSG	1 M LiTFSI in DMC/DOL (1:1 volume) with 1 wt.% $LiNO_3$	1.5V	352.8 mAh g^{-1} at 50 mA g^{-1}, 50 cycles	529.13 mWh kg^{-1}	50 cycles (43.4)	[31]
	Ni/r-GO	1 M LiTFSI in TEGTME	1 V	14.6 mAh cm^{-2} at 0.1 mA cm^{-2}, Full discharge	14.6 mWh cm^{-2}	Full discharge (-)	[32]
	3D-PC	1 M LiTFSI in DOL/DME (1:1 volume) with 1 wt.% $LiNO_3$	1.3 V	505.4 mAh g^{-1} at 0.2 C, 500 cycles	657.02 mWh kg^{-1}	500 cycles (76.8)	[33]
	LFP/rGO	1 M $LiPF_6$ in EC/DEC (1:1 volume)	2 V	169 mAh g^{-1} at 10 mA g^{-1}, 20 cycles	338 mWh kg^{-1}	20 cycles (91.8)	[34]
	3DP-VAE	1 M LiTFSI in DME/DOL (1:1 volume) with 1 wt% $LiNO_3$	1 V	739.6 mAh g^{-1} at 1 mA cm^{-2}, 200 cycles	739.6 mWh kg^{-1}	200 cycles (80)	[35]
	r-hGO	1 M LiTFSI in DMSO	2.5 V	3879 mAh g^{-1} at 0.1 mA cm^{-2}, Full discharge	9.70 Wh kg^{-1}	Full discharge (-)	[36]
	$V_2O_5/Ti_3C_2T_x$	1 M $LiPF_6$ in	2 V	112 mAh g^{-1} at	224 mWh kg-	680 cycles	[37]

		EC/DMC (1:1 volume)		10.5C, 680 cycles	1	(91.7)	
	3D printed MXene	1 M LiTFSI in DOL/DME (1:1 volume) with 1 wt.% $LiNO_3$	2 V	25.3 mAh cm^{-2} at 1C, 500 cycles	81.6 mWh cm^{-2}	500 cycles (73.8)	[38]
	V_2CT_x/rGO-CNT microgrid Aerogel (NIBs)	1 M $NaPF_6$ in diglyme	1.8 V	86.27 mAh g^{-1} at 100 mA g^{-1}, 400 cycles	155.29 mWh kg^{-1}	400 cycles (99.31)	[39]
	rGO/Super-P aerogel (VRBs)	2 M H_2SO_4	1.5 V	620.2 mA h cm^{-2} at 80 mA cm^{-2}, 100 cycles	930.3 mWh cm^{-2}	300 cycles (-)	[40]
	3DP-FeVO/rHGO (ZIBs)	2.5 M $Zn(CF_3SO_3)_2$	1.2 V	126.4 mAh g^{-1} at 2 A g^{-1}, 675 cycles	151.68 mWh kg^{-1}	675 cycles (93.3)	[41]
Next generation batteries	3DP-NGA (NIBs)	1 M $NaPF_6$ in diglyme	1.8 V	85.3 mA h g^{-1} at 100 mA g^{-1}, 1000 cycles	153.54 mWh kg^{-1}	1000 cycles (99.93)	[42]
	NVPF/EC, NTP/EC (Ionogel-based NIBs)	NaTFSI-IE	1.8 V	4.5 mAh cm^{-2} at 2 mA cm^{-2}, 6000 cycle	7.33 mWh cm^{-2}	6000 cycles (80)	[43]
	Na@rGO/CNT (NIBs)	1 M $NaPF_6$ in diglyme	1.8 V	67.6 mA h g^{-1} at 100 mA g^{-1}, 100 cycle	121.68 Wh kg^{-1}	600 cycles (>99)	[44]
	NVP-rGO (NIBs)	1 M $NaClO_4$ in EC/PC (1:1 w/w) with 5 wt.% FEC	2 V	1.07 mAh cm^{-2} at 1C, 900 cycles	0.771 mWh cm^{-2}	900 cycles (90.1)	[45]

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