Key Issues Facing Electrospun Carbon Nanofibers in Energy Applications: On-going Approaches and Challenges

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Table S1. Summary of the activation methods and electrochemical performance of the electrospun CNFs as supercapacitor electrodes.

Materials	**Precursors and additives**	**Activation methods**	**Surface area, pores, and conductivity**	**Electrolyte**	**Specific capacitance**	**Energy/Power density**	**Cyclic Stability**	**Ref.**
PCNFs	PAN + PVP + $Co(NO_3)_2$ + DMF	Catalytic graphitization + Inorganic and organic template	S_{BET} = 468.9 m^2 g^{-1}	0.5 M H_2SO_4	104.5 F g^{-1} at 0.2 A g^{-1}	3.22 Wh kg^{-1} at 600 W kg^{-1}	94.0% after 2000 cycles	29
CNF280@700	PAN + PVP + DMF	Tailoring thermal treatment temperature + Organic template	S_{BET} = 230.4 m^2 g^{-1}, V_{total} = 0.156 cm^3 g^{-1}, V_{micro} = 0.102 cm^3 g^{-1}	2 M KOH	155.0 F g^{-1} at 0.5 A g^{-1}	7.78 Wh kg^{-1} at 400 W kg^{-1}	91.0% after 5000 cycles	39
HPCNFs	PAN + $CaCO_3$ + DMF/THF	Catalytic graphitization + Inorganic template	S_{BET} = 679.0 m^2 g^{-1}, V_{total} = 0.410 cm^3 g^{-1}	6 M KOH	251.0 F g^{-1} at 0.5 A g^{-1}	—	88.0% after 5000 cycles	44
Graphene-beaded CNFs	PAN + oxidized graphene + DMF	Integration with graphene + Physical activation by air	—	6 M KOH	263.7 F g^{-1} at 0.1 A g^{-1}	—	86.9% after 2000 cycles	48
CNF/graphene composites	PAN + DMF + GO (ultrasonic spray)	Integration with graphene	S_{BET} = 480.0 m^2 g^{-1}, V_{total} = 0.240 cm^3 g^{-1}, σ = 65.9 S cm^{-1}	6 M KOH	183.0 F g^{-1} at 1.0 A g^{-1}	—	92.0% after 4500 cycles	49
CNF/graphene composites	PAN + GO + DMF	Integration with graphene	S_{BET} = 555.97 m^2 g^{-1}, V_{total} = 0.350 cm^3 g^{-1}, V_{micro} = 0.266 cm^3 g^{-1}, σ = 13.41 S cm^{-1}	6 M KOH	146.6 F g^{-1} at 1.0 mA cm^{-2}	19.44 Wh kg^{-1} at 400 W kg^{-1}	—	50
CNF/graphene composites	PAN + PVP + graphene	Integration with graphene + Organic template	S_{BET} = 627.0 m^2 g^{-1}, V_{total} = 0.350 cm^3 g^{-1}	6 M KOH	265.0 F g^{-1} at 0.001 A g^{-1}	—	—	51

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
CNFs/rGO	PAN + GO/PMMA + DMF	Integration with graphene + Organic template	—	6 M KOH	140.1 F g^{-1} at 1.0 A g^{-1}	—	96.2% after 1000 cycles	53
CNF/graphene composites	Phenolic resin + GO/PVA + water	Integration with graphene + Organic template	S_{BET} = 767.0 m^2 g^{-1}, V_{total} = 0.370 cm^3 g^{-1}	6 M KOH	279.1 F g^{-1} at 0.2 A g^{-1}	—	100% after 5000 cycles	54
CNFs/CNTs	PVA + MWCNTs + SDS + starch + *p*-toluenesulfonic acid + water	Integration with CNTs + Organic template + Physical activation by air	S_{BET} = 350.0 m^2 g^{-1}, V_{total} = 0.310 cm^3 g^{-1}, σ = 2.1 S cm^{-1}	1 M H_2SO_4	170.0 F g^{-1} at 10 mV s^{-1}	—	—	55
CNFs/CNTs	CA + MWCNTs + DMAc + acetone	Integration with CNTs + Physical activation by steam	S_{BET} = 1120.0 m^2 g^{-1}, σ = 12.55 S cm^{-1}	6 M KOH	160.0 F g^{-1} at 0.5 A g^{-1}	—	94.0% after 1000 cycles	56
CNFs/CNTs	PAN + CNTs/maleic anhydride + DMF	Integration with CNTs + Organic template	σ = 2.2 S cm^{-1}	1 M H_2SO_4	382.0 F g^{-1} at 1.0 A g^{-1}	—	93.2% after 1000 cycles	57
CNFs/rGO/CNTs	PAN + GO + MWCNTs + DMF	Integration with graphene and CNTs	S_{BET} = 175.1 m^2 g^{-1}, V_{total} = 0.156 cm^3 g^{-1}	0.5 M Na_2SO_4	120.5 F g^{-1} at 0.5 A g^{-1}	—	109% after 5000 cycles	58
CNFs/carbon black	PVP + modified carbon black + ethanol	Integration with carbon black	S_{BET} = 548.0 m^2 g^{-1}, V_{total} = 0.374 cm^3 g^{-1}, V_{micro} = 0.144 cm^3 g^{-1}	6 M KOH	166.0 F g^{-1} at 0.1 A g^{-1}	—	—	59
CNFs/ACNWs	PAN-derived CNFs + PANi coating	Graphitization + Integration with PANi-derived carbon + Chemical activation by KOH	S_{BET} = 421.8 m^2 g^{-1}, V_{total} = 0.390 cm^3 g^{-1}	6 M KOH	176.5 F g^{-1} at 0.5 A g^{-1}	24.5 Wh kg^{-1} at 250 W kg^{-1}	100% after 10000 cycles	60

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
CNFs/CNTs	PAN + MWCNTs + DMF	Integration with CNTs + Activation by a steam mixture of hydroperoxide and water	S_{BET} = 810.0 m^2 g^{-1}, V_{total} = 0.294 cm^3 g^{-1}, V_{micro} = 0.135 cm^3 g^{-1}, σ = 5.32 S cm^{-1}	1 M H_2SO_4	310.0 F g^{-1} at 0.1 A g^{-1}	—	97.0% after 1000 cycles	61
CNF/graphene composite paper	Phenolic nanofibers + GO (vacuum-assisted filtration)	Integration with graphene	σ = 7.6 S cm^{-1}	6 M KOH	112.0 F cm^{-3} at 0.5 A g^{-1}	—	—	62
CNF aerogels	Pre-oxidized PAN fibers + GO (freeze-drying)	Integration with graphene	S_{BET} = 57.8 m^2 g^{-1}	6 M KOH	180.0 F g^{-1} at 1.0 A g^{-1}	—	94.8% after 2000 cycles	64
CNTs on CNFs	Pre-oxidized PAN/PVP/Ni(Ac)$_2$ + PVP	Integration with CNTs + Chemical activation by KOH + Catalytic graphitization + Organic template	S_{BET} = 950.0 m^2 g^{-1}	$EMIMBF_4$ ionic liquid	146.8 F g^{-1} at 0.5 A g^{-1}	70.7 Wh kg^{-1} at 614.4 W kg^{-1}	97.0% after 20000 cycles	65
CNTs on CNFs	CA-derived CNFs + CNT growth (CVD)	Integration with CNTs + Chemical activation by KOH	S_{BET} = 1211.0 m^2 g^{-1}, V_{total} = 0.530 cm^3 g^{-1}, V_{micro} = 0.390 cm^3 g^{-1}	6 M KOH	149.0 F g^{-1} at 0.5 A g^{-1}	—	90.0% after 1000 cycles	66
CNF/rGO/rGO paper	PAN/GO/DMF (electrospinning) + GO (spraying)	Integration with graphene + Physical activation by air	S_{BET} = 523.0 m^2 g^{-1}, V_{total} = 0.320 cm^3 g^{-1}, V_{micro} = 0.170 cm^3 g^{-1}	6 M KOH	241.0 F g^{-1} at 0.2 A g^{-1}	—	100% after 2000 cycles	67
HPCNFs	PAN + SiO_2 + DMF	Inorganic template + Chemical activation by KOH	S_{BET} = 1632.0 m^2 g^{-1}, V_{total} = 1.530 cm^3 g^{-1}, V_{micro} = 0.600 cm^3 g^{-1}	1 M H_2SO_4	197.0 F g^{-1} at 5 mV s^{-1}	—	—	70

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
Mesoporous CNFs	PAN + SiO_2 + DMF	Inorganic template	S_{BET} = 496.5 m^2 g^{-1}, V_{total} = 1.490 cm^3 g^{-1}, V_{micro} = 0.581 cm^3 g^{-1}	1 M H_2SO_4	247.8 F g^{-1} at 1.0 A g^{-1}	9.9 Wh kg^{-1} at 690 W kg^{-1}	88.9% after 5000 cycles	71
Nitrogen-doped PCNFs	PAN + PVP + SiO_2 + DMF	Inorganic and organic template + Nitrogen doping	S_{BET} = 57.0 m^2 g^{-1}, V_{total} = 0.260 cm^3 g^{-1}	1 M H_2SO_4	242.0 F g^{-1} at 0.2 A g^{-1}	—	99.0% after 5000 cycles	72
Bubbled CNFs	PAN + SiO_2 + DMF	Inorganic template	S_{BET} = 593.2 m^2 g^{-1}, V_{total} = 0.109 cm^3 g^{-1}	1 M H_2SO_4	287.0 F g^{-1} at 0.4 A g^{-1}	—	90.6% after 500 cycles	73
Bubbled PCNFs	ZnO nanofibers + ethanol	Inorganic template	S_{BET} = 588.0 m^2 g^{-1}	1 M H_2SO_4	150.0 F g^{-1} at 0.5 A g^{-1}	—	94.1% after 35000 cycles	74
Inner PCNFs	SnO_2/Fe_2O_3 nanofibers + PDA	Inorganic template	S_{BET} = 967.0 m^2 g^{-1}, V_{total} = 1.560 cm^3 g^{-1}	6 M KOH	328.0 F g^{-1} at 1.0 A g^{-1}	13.6 Wh kg^{-1} at 500 W kg^{-1}	73.0% after 5000 cycles	75
CNFs	PAN + NaCl + DMF	Inorganic template	S_{BET} = 24.0 m^2 g^{-1}, V_{total} = 0.017 cm^3 g^{-1}	1 M H_2SO_4	204.0 F g^{-1} at 0.5 A g^{-1}	—	>100% after 1000 cycles	76
Nitrogen-rich HPCNFs	PAN/PVP nanofibers + H_2O + KCl/K_2CO_3	Inorganic and organic template + Nitrogen doping	S_{BET} = 726.0 m^2 g^{-1}, V_{total} = 0.510 cm^3 g^{-1}	6 M KOH	293.0 F g^{-1} at 0.2 A g^{-1}	—	95.7% after 1000 cycles	77
HPCNFs	PAN + K_2S + DMF	Inorganic template	S_{BET} = 835.0 m^2 g^{-1}, V_{total} = 0.678 cm^3 g^{-1}, V_{micro} = 0.387 cm^3 g^{-1}	6 M KOH	210.7 F g^{-1} at 0.2 A g^{-1}	27.2 Wh kg^{-1} at 508.7 W kg^{-1}	89.0% after 10000 cycles	78
Ribbon-shaped CNFs	Phenolic resin + PVP + $Co(NO_3)_2$ + ethanol	Catalytic graphitization + Inorganic and organic template	S_{BET} = 463.0 m^2 g^{-1}, V_{total} = 0.575 cm^3 g^{-1}	6 M KOH	228.0 F g^{-1} at 0.2 A g^{-1}	—	95.0% after 5000 cycles	81

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
PCNFs	Pre-oxidized PI/PVP fibers + $Mg(NO_3)_2$	Inorganic and organic template	S_{BET} = 1836 m^2 g^{-1}, V_{total} = 0.880 cm^3 g^{-1}	1 M $LiPF_6$	140.0 F g^{-1} at 0.1 A g^{-1}	30.0 Wh kg^{-1} at 25 W kg^{-1}	91.0% after 3000 cycles	82
HPCNFs	Lignin + PVP + $Mg(NO_3)_2$ + DMF	Inorganic and organic template	S_{BET} = 1140 m^2 g^{-1}, V_{total} = 0.627 cm^3 g^{-1}, V_{micro} = 0.137 cm^3 g^{-1}	6 M KOH	248.0 F g^{-1} at 0.2 A g^{-1}	—	97.0% after 1000 cycles	83
Nitrogen-doped PCNFs	PAN + $Mg(OH)_2$ + DMF	Inorganic template + Nitrogen doping	S_{BET} = 926.4 m^2 g^{-1}, V_{total} = 0.420 cm^3 g^{-1}	6 M KOH	327.3 F g^{-1} at 1.0 A g^{-1}	42.5 Wh kg^{-1} at 500 W kg^{-1}	93.0% after 10000 cycles	84
Activated PCNFs	PAN/PVP/DMF (shell) + PVP/$SnCl_2$/DMF (core)	Inorganic and organic template	S_{BET} = 1082 m^2 g^{-1}, V_{total} = 0.649 cm^3 g^{-1}, V_{micro} = 0.422 cm^3 g^{-1}	0.5 M H_2SO_4	289.0 F g^{-1} at 10 mV s^{-1}	14.4 Wh kg^{-1} at 80 W kg^{-1}	~100% after 10000 cycles	85
Oxygen/nitrogen *co*-doped PCNFs	PAN + $SnCl_2$ + DMF	Inorganic template + Oxygen/nitrogen *co*-doping	S_{BET} = 772.7 m^2 g^{-1}, V_{total} = 0.470 cm^3 g^{-1}, V_{micro} = 0.300 cm^3 g^{-1}	6 M KOH	233.1 F g^{-1} at 0.2 A g^{-1}	5.14 Wh kg^{-1} at 100 W kg^{-1}	~100% after 10000 cycles	86
PCNFs	PAN + $ZnCl_2$ + DMF	Inorganic template	S_{BET} = 550.0 m^2 g^{-1}, V_{total} = 0.340 cm^3 g^{-1}, V_{micro} = 0.260 cm^3 g^{-1}, σ = 1.39 S cm^{-1}	6 M KOH	140.0 F g^{-1} at 5 mV s^{-1}	—	—	87
PCNFs	PAN + CA + $ZnCl_2$ + DMAc + acetone	Inorganic and organic template	S_{BET} = 887.0 m^2 g^{-1}, V_{total} = 0.410 cm^3 g^{-1}, V_{micro} = 0.320 cm^3 g^{-1}	6 M KOH	280.0 F g^{-1} at 0.1 A g^{-1}	—	96.8% after 2000 cycles	88

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
Cross-linked PCNFs	PAN + $ZnCl_2$ + DMF	Inorganic template	S_{BET} = 520.0 m^2 g^{-1}, σ = 2.33 S cm^{-1}	6 M KOH	163.0 F g^{-1} at 1.0 A g^{-1}	3.04 Wh kg^{-1} at 15000 W kg^{-1}	97.3% after 60000 cycles	89
Bamboo-like graphitic CNFs	PAN + TEOS + DMF	Organic template	S_{BET} = 1912 m^2 g^{-1}, V_{total} = 2.270 cm^3 g^{-1}	3 M KOH	236.0 F g^{-1} at 5.0 A g^{-1}	2.37 Wh kg^{-1} at 61300 W kg^{-1}	96.0% after 10000 cycles	90
HPCNFs	PAN + PMMA + TEOS + DMF	Organic template	S_{BET} = 698.9 m^2 g^{-1}, V_{total} = 0.212 cm^3 g^{-1}, V_{micro} = 0.196 cm^3 g^{-1}	6 M KOH	170.0 F g^{-1} at 1.0 A g^{-1}	7.20 Wh kg^{-1} at 7500 W kg^{-1}	94.2% after 8000 cycles	91
Double-capillary CNFs	PVP/TEOS/ethanol/acetic acid (outer) + Lignin/PEO/DMF (inner)	Organic template	S_{BET} = 870.0 m^2 g^{-1}, V_{total} = 0.720 cm^3 g^{-1}	$EMIMBF_4$ ionic liquid	245.0 F g^{-1} at 0.5 A g^{-1}	56.6 Wh kg^{-1} at 1760 W kg^{-1}	94.0% after 10000 cycles	92
PCNFs	PVP + PFA + TEOS + HCl + pluronic F127 + ethanol	Organic template	S_{BET} = 897.0 m^2 g^{-1}, V_{total} = 0.723 cm^3 g^{-1}	6 M KOH	205.5 F g^{-1} at 20 mV s^{-1}	—	97.0% after 1500 cycles	93
Porous carbon microfibers	PVP + resin + TEOS + HCl + pluronic P123 + ethanol	Organic template	S_{BET} = 2092 m^2 g^{-1}, V_{total} = 1.370 cm^3 g^{-1}	6 M KOH	252.0 F g^{-1} at 0.5 A g^{-1}	—	97.0% after 4000 cycles	94
Nitrogen-doped PCNFs	PAN + PMMA + TEOS + TPU + DMF	Organic template + Nitrogen doping	S_{BET} = 1126 m^2 g^{-1}, V_{total} = 0.424 cm^3 g^{-1}	6 M KOH	207.0 F g^{-1} at 0.2 A g^{-1}	—	99.0% after 8000 cycles	95
PCNFs	PVP + resin + TEOS + HCl + pluronic F127 + ethanol	Organic template	S_{BET} = 1674 m^2 g^{-1}, V_{total} = 1.414 cm^3 g^{-1}, V_{micro} = 0.508 cm^3 g^{-1}	6 M KOH	210.0 F g^{-1} at 0.5 A g^{-1}	—	—	96

Materials	**Precursors and additives**	**Activation methods**	**Surface area, pores, and conductivity**	**Electrolyte**	**Specific capacitance**	**Energy/Power density**	**Cyclic Stability**	**Ref.**
Activated PCNFs	PAN + $Cu(Ac)_2$ + DMF	Organic template	S_{BET} = 395.6 m^2 g^{-1}, V_{total} = 0.242 cm^3 g^{-1}, V_{micro} = 0.149 cm^3 g^{-1}	3 M KOH	183.3 F g^{-1} at 1.0 A g^{-1}	—	—	98
Nitrogen-doped HPCNFs	PAN + $Mg(Ac)_2$ + DMF	Organic template + Nitrogen doping	S_{BET} = 684.3 m^2 g^{-1}, V_{total} = 0.560 cm^3 g^{-1}, V_{micro} = 0.260 cm^3 g^{-1}	6 M KOH	263.0 F g^{-1} at 1.0 A g^{-1}	9.15 Wh kg^{-1} at 500 W kg^{-1}	94.2% after 10000 cycles	101
Nitrogen-doped HPCNFs	PAN + ZIF-8 + DMF	Organic template + Nitrogen doping	S_{BET} = 417.9 m^2 g^{-1}, V_{total} = 0.680 cm^3 g^{-1}	2 M H_2SO_4	307.2 F g^{-1} at 1.0 A g^{-1}	10.96 Wh kg^{-1} at 250 W kg^{-1}	98.2% after 10000 cycles	102
Mesoporous CNFs	PVA + tin-citric aqueous solution + Triton X-100	Organic template	S_{BET} = 800.0 m^2 g^{-1}, V_{total} = 0.600 cm^3 g^{-1}, V_{micro} = 0.170 cm^3 g^{-1}	6 M KOH	103.0 F g^{-1} at 1.0 A g^{-1}	5.10 Wh kg^{-1} at 242.2 W kg^{-1}	~100% after 4250 cycles	104
Nitrogen-doped HPCNFs	PAN + ZIF-8 + DMF	Organic template + Nitrogen doping	S_{BET} =314.7 m^2 g^{-1}, V_{total} = 0.330 cm^3 g^{-1}	1 M H_2SO_4	332.0 F g^{-1} at 1.0 A g^{-1}	—	98.9% after 5000 cycles	105
Nitrogen-doped HPCNFs	PAN + ZIF-8 + DMF	Organic template + Nitrogen doping	S_{BET} = 559.6 m^2 g^{-1}, V_{total} = 0.789 cm^3 g^{-1}, V_{micro} = 0.137 cm^3 g^{-1}	6 M KOH	302.0 F g^{-1} at 0.5 A g^{-1}	—	84.0% after 12000 cycles	106
Boron/nitrogen *co*-doped PCNFs	PAN/ZIF-8 fibers treated by $NaBH_4$ and $NH_4HB_4O_7$	Organic template + Boron/nitrogen *co*-doping	S_{BET} =351.5 m^2 g^{-1}, V_{total} = 1.789 cm^3 g^{-1}	2 M KOH	295.0 F g^{-1} at 0.5 A g^{-1}	—	94.5% after 10000 cycles	107
Sulfur/nitrogen *co*-doped PCNFs	PAN + ZIF-67 + thiourea + DMF	Organic template + Sulfur/nitrogen *co*-doping	S_{BET} =512.0 m^2 g^{-1}, V_{micro} = 0.220 cm^3 g^{-1}	1 M H_2SO_4	396.0 F g^{-1} at 1.0 A g^{-1}	14.3 Wh kg^{-1} at 250 W kg^{-1}	107% after 3000 cycles	108

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
Nitrogen-doped HPCNFs	PAN nanofibers + ZIF-8 (polarity-assisted growth)	Organic template + Nitrogen doping	S_{BET} =277.2 m^2 g^{-1}	1 M H_2SO_4	387.3 F g^{-1} at 1.0 A g^{-1}	7.9 Wh kg^{-1} at 219 W kg^{-1}	90.0% after 10000 cycles	109
PCNFs	PAN/IAA/DMF (outer) + PAN/DMF (inner)	Organic template	S_{BET} =563.0 m^2 g^{-1}, V_{micro} = 0.240 cm^3 g^{-1}	1 M H_2SO_4	272.7 F g^{-1} at 1.0 A g^{-1}	11.1 Wh kg^{-1} at 250 W kg^{-1}	96.7% after 3000 cycles	110
Nitrogen-doped PCNFs	PAN + PVP + DMF	Organic template + Nitrogen doping	S_{BET} =452.5 m^2 g^{-1}, V_{total} = 0.210 cm^3 g^{-1}	6 M KOH	198.0 F g^{-1} at 1.0 A g^{-1}	—	104.8% after 5000 cycles	113
Fluorine/nitrogen *co*-doped PCNFs	PAN/PVP fibers + water + Carbonization + Vacuum plasma treatment by C_4F_8	Organic template + Fluorine/nitrogen *co*-doping	S_{BET} =596.1 m^2 g^{-1}	1 M H_2SO_4	252.6 F g^{-1} at 0.5 A g^{-1}	8.07 Wh kg^{-1} at 248 W kg^{-1}	92.0% after 20000 cycles	114
PCNFs	PAN/PVP fibers + water	Organic template + Physical activation by CO_2	S_{BET} = 1232 m^2 g^{-1}, V_{total} = 0.786 cm^3 g^{-1}, V_{micro} = 0.441 cm^3 g^{-1}	6 M KOH	202.0 F g^{-1} at 2 mV s^{-1}	—	100% after 10000 cycles	115
Nitrogen-doped arch CNFs	PAN (outer)/PVP (inner) fibers + water	Organic template + Nitrogen doping	S_{BET} = 619.0 m^2 g^{-1}, V_{total} = 0.659 cm^3 g^{-1}, σ = 4.50 S cm^{-1}	1 M H_2SO_4	421.0 F g^{-1} at 0.5 A g^{-1}	8.4 Wh kg^{-1} at 50 W kg^{-1}	98.0% after 5000 cycles	117
Microporous CNFs	PAN/PVP fibers + water	Organic template	—	2 M KOH	200.0 F g^{-1} at 0.5 A g^{-1}	—	93.0% after 1000 cycles	119
Nitrogen-doped hollow CNFs	PAN (outer)/PVP (inner) fibers + water	Organic template + Nitrogen doping by NH_3 activation	S_{BET} = 701.0 m^2 g^{-1}, V_{total} = 0.497 cm^3 g^{-1}	6 M KOH	197.0 F g^{-1} at 0.2 A g^{-1}	—	98.6% after 1000 cycles	120

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
Mesoporous CNFs	PAN + PMMA + graphene + DMF	Organic template + Integration with graphene	S_{BET} = 551.3 m^2 g^{-1}, σ = 1.16 S cm^{-1}	6 M KOH	~160.0 F g^{-1} at 1 mA cm^{-2}	21.4 Wh kg^{-1} at 400 W kg^{-1}	83.0% after 100 cycles	121
Hollow PCNFs	PAN/PMMA/DMF (outer) + PMMA/DMF (inner)	Organic template + Chemical activation by KOH	S_{BET} = 1753.9 m^2 g^{-1}, V_{total} = 2.150 cm^3 g^{-1}	6 M KOH	191.3 F g^{-1} at 2 mV s^{-1}	—	91.0% after 4000 cycles	122
PCNFs	PAN + PMMA + DMF	Organic template	S_{BET} = 683.5 m^2 g^{-1}, V_{total} = 0.241 cm^3 g^{-1}	6 M KOH	140.8 F g^{-1} at 0.5 A g^{-1}	19.5 Wh kg^{-1} at 250 W kg^{-1}	95.4% after 10000 cycles	123
PCNFs	PAN + PMMA + DMF	Organic template + Physical activation by CO_2	S_{BET} = 2419 m^2 g^{-1}, V_{total} = 1.313 cm^3 g^{-1}, V_{micro} = 0.638 cm^3 g^{-1}	EMITFSI ionic liquid	140.2 F g^{-1} at 10 mV s^{-1}	67.4 Wh kg^{-1} at 1715 W kg^{-1}	85.0% after 1000 cycles	124
Ultrathin CNFs	PAN + PMMA + DMF	Organic template	S_{BET} = 620.0 m^2 g^{-1}, V_{total} = 0.403 cm^3 g^{-1}, V_{micro} = 0.217 cm^3 g^{-1}	1 M H_2SO_4	243.0 F g^{-1} at 1.0 A g^{-1}	—	100.5% after 1000 cycles	125
Hollowed multi-channel CNFs	PAN/l-PMMA/DMF (shell) + h-PMMA/DMF (core)	Organic template	S_{BET} = 549.2 m^2 g^{-1}, V_{total} = 0.463 cm^3 g^{-1}	1 M H_2SO_4	129.0 F g^{-1} at 2 mV s^{-1}	—	~82.0% after 1000 cycles	126
Multi-channel CNFs	PAN + PS + DMF	Organic template	S_{BET} = 750.0 m^2 g^{-1}	6 M KOH	270.0 F g^{-1} at 0.5 A g^{-1}	9.0 Wh kg^{-1} at 120 W kg^{-1}	~100% after 5000 cycles	127
Nitrogen-doped multi-channel PCNFs	PAN + PS + DMF	Organic template + Nitrogen doping	S_{BET} = 840.8 m^2 g^{-1}, V_{total} = 0.462 cm^3 g^{-1}, V_{micro} = 0.250 cm^3 g^{-1}	1 M H_2SO_4	461.0 F g^{-1} at 0.25 A g^{-1}	11.2 Wh kg^{-1} at 118.7 W kg^{-1}	92.6% after 50000 cycles	128

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
Activated PCNFs	PAN + CA + DMF	Organic template + Physical activation by steam	S_{BET} = 1160 m^2 g^{-1}, V_{total} = 0.807 cm^3 g^{-1}, σ = 7.50 S cm^{-1}	6 M KOH	245.0 F g^{-1} at 1 mA cm^{-2}	—	95.9% after 1000 cycles	130
Interconnected PCNFs	PAN + PSF + DMF	Organic template	S_{BET} = 687.0 m^2 g^{-1}, V_{total} = 0.520 cm^3 g^{-1}, σ = 13.85 S cm^{-1}	6 M KOH	257.0 F g^{-1} at 0.25 A g^{-1}	36.0 Wh kg^{-1} at 125 W kg^{-1}	100% after 6000 cycles	131
Nitrogen-doped PCNFs	PAN + APEG + DMF	Organic template + Nitrogen doping	S_{BET} = 753.0 m^2 g^{-1}	6 M KOH	302.0 F g^{-1} at 0.2 A g^{-1}	10.5 Wh kg^{-1} at 50 W kg^{-1}	94.6% after 2000 cycles	133
PCNFs	PAN/DMF + pitch/THF	Organic template	S_{BET} = 966.3 m^2 g^{-1}, V_{total} = 0.379 cm^3 g^{-1}, σ = 3.96 S cm^{-1}	6 M KOH	130.7 F g^{-1} at 1 mA cm^{-2}	15.0 Wh kg^{-1} at 400 W kg^{-1}	—	134
Nitrogen-doped PCNFs	PAN + PmAP + DMSO	Organic template + Nitrogen doping	S_{BET} = 1031.4 m^2 g^{-1}, V_{total} = 1.343 cm^3 g^{-1}, V_{micro} = 0.708 cm^3 g^{-1}	6 M KOH	347.5 F g^{-1} at 0.5 mA cm^{-2}	12.1 Wh kg^{-1} at 93 W kg^{-1}	90.5% after 10000 cycles	135
Activated PCNFs	PAN + Nafion + DMF	Organic template + Chemical activation by KOH	S_{BET} = 2282 m^2 g^{-1}, V_{total} = 1.240 cm^3 g^{-1}	Sol-gel/ionic liquid	144.0 F g^{-1} at 0.5 A g^{-1}	61.0 Wh kg^{-1} (5 mV s^{-1})	—	137
Microporous CNFs	PVP + PMDA + ODA + DMF	Organic template	S_{BET} = 804.0 m^2 g^{-1}, V_{total} = 0.344 cm^3 g^{-1}	6 M KOH	215.0 F g^{-1} at 0.2 A g^{-1}	7.5 Wh kg^{-1} at 50 W kg^{-1}	92.0% after 1000 cycles	139
Nitrogen-doped HPCNFs	PAN + PMMA + TPU + DMF	Organic template + Nitrogen doping	S_{BET} = 2216.8 m^2 g^{-1}, V_{total} = 1.443 cm^3 g^{-1}	6 M KOH	255.0 F g^{-1} at 0.2 A g^{-1}	—	~100% after 8000 cycles	140

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
Mesoporous CNFs	PAN + PAA-*b*-PAN-*b*-PAA + DMAc	Organic template	S_{BET} = 249.8 m^2 g^{-1}, V_{total} = 0.186 cm^3 g^{-1}, V_{micro} = 0.097 cm^3 g^{-1}	4 M KOH	256.3 F g^{-1} at 0.5 A g^{-1}	3.1 Wh kg^{-1} at ~250 W kg^{-1}	90.0% after 80000 cycles	141
Mesoporous CNFs	PAN + poly(ST-*co*-DVB-*co*-NaSS) +NWCNTs + DMF	Organic template + Integration with CNTs	S_{BET} = 535.0 m^2 g^{-1}, V_{total} = 0.437 cm^3 g^{-1}, σ = 2.36 S cm^{-1}	1 M H_2SO_4	262.0 F g^{-1} at 0.2 A g^{-1}	–	–	142
PCNFs	PAN + POSS + DMF	Organic template + Chemical activation by KOH	S_{BET} = 335.4 m^2 g^{-1}, V_{total} = 0.330 cm^3 g^{-1}, V_{micro} = 0.040 cm^3 g^{-1}	PVA/H_3PO_4 gel	138.7 F g^{-1} at 0.2 A g^{-1}	12.2 Wh kg^{-1} at 79.6 W kg^{-1}	~100% after 1000 cycles	143
PCNFs	PAN + lignin + DMF	Organic template	S_{BET} = 675.0 m^2 g^{-1}, V_{total} = 0.290 cm^3 g^{-1}, V_{micro} = 0.240 cm^3 g^{-1}	6 M KOH	216.8 F g^{-1} at 1.0 A g^{-1}	–	88.8% after 2000 cycles	144
Microporous CNFs	Phenolic resin/PVA + KOH + H_2O	Organic template + Chemical activation by KOH	S_{BET} = 597.0 m^2 g^{-1}, V_{total} = 0.270 cm^3 g^{-1}, V_{micro} = 0.260 cm^3 g^{-1}	6 M KOH	256.0 F g^{-1} at 0.2 A g^{-1}	–	95.0% after 1000 cycles	145
PCNFs	Lignin + PVA + H_2O	Organic template	S_{BET} = 583.0 m^2 g^{-1}, V_{total} = 0.289 cm^3 g^{-1}	6 M KOH	64.0 F g^{-1} at 0.4 A g^{-1}	5.67 Wh kg^{-1} at 94.2 W kg^{-1}	90.0% after 6000 cycles	146
PCNFs	Acid treated coal + PVA + SDBS +H_2O	Organic template	S_{BET} = 691.0 m^2 g^{-1}, V_{total} = 0.526 cm^3 g^{-1}, V_{micro} = 0.226 cm^3 g^{-1}	6 M KOH	170.0 F g^{-1} at 1.0 A g^{-1}	–	~105% after 20000 cycles	147

Materials	**Precursors and additives**	**Activation methods**	**Surface area, pores, and conductivity**	**Electrolyte**	**Specific capacitance**	**Energy/Power density**	**Cyclic Stability**	**Ref.**
Hollow CNFs	PAN/PMMA/DMF (shell) + PMMA/DMF (core)	Organic template	S_{BET} = 812.6 m^2 g^{-1}, V_{total} = 0.946 cm^3 g^{-1}, V_{micro} = 0.282 cm^3 g^{-1}	6 M KOH	192.0 F g^{-1} at 0.5 A g^{-1}	26.7 Wh kg^{-1} at 249.9 W kg^{-1}	~80.0% after 3000 cycles	148
PCNFs	PBI + PLLA + DMAc + NMP	Organic template + Activation by NH_3	S_{BET} = 1114 m^2 g^{-1}, V_{total} = 0.606 cm^3 g^{-1}, V_{micro} = 0.443 cm^3 g^{-1}	EMITFSI ionic liquid	111.9 F g^{-1}	36.9 Wh kg^{-1} at 700 W kg^{-1}	—	149
PCNFs	PAN + high-amylose starch + DMSO	Organic template	S_{BET} = 637.0 m^2 g^{-1}, V_{total} = 0.420 cm^3 g^{-1}, σ = 9.32 S cm^{-1}	6 M KOH	282.0 F g^{-1} at 1.0 A g^{-1}	9.1 Wh kg^{-1}	~100% after 10000 cycles	151
Hollow PCNFs	PMDA/ODA/PVP/DMF (shell) + SAN/DMF (core)	Organic template	—	6 M KOH	221.0 F g^{-1} at 0.2 A g^{-1}	—	95.0% after 5000 cycles	152
Cross-linked HPCNFs	PAN + TPA + DMF	Organic template	S_{BET} = 1144 m^2 g^{-1}	1 M H_2SO_4	257.6 F g^{-1} at 0.5 A g^{-1}	10.18 Wh kg^{-1}	95.0% after 20000 cycles	153
Cross-linked PCNFs	PAN + melamine + DMF	Organic template	S_{BET} = 428.0 m^2 g^{-1}	6 M KOH	194.0 F g^{-1} at 0.05 A g^{-1}	—	99.2% after 1000 cycles	154
PCNFs	P(AN-*co*-IA) + DMF	Organic template	S_{BET} = 1427 m^2 g^{-1}, V_{total} = 0.782 cm^3 g^{-1}, V_{micro} = 0.442 cm^3 g^{-1}	EMITFSI ionic liquid	92.9 F g^{-1} at 10 mV s^{-1}	45.9 Wh kg^{-1} at 1700 W kg^{-1}	77.0% after 2500 cycles	155
Cross-linked NCNFs	PAN + PVP + TPA + DMF	Organic template + Nitrogen doping	S_{BET} = 582.0 m^2 g^{-1}, σ = 19.0 S cm^{-1}	1 M H_2SO_4	223.8 F g^{-1} at 0.5 A g^{-1}	5.9 Wh kg^{-1} at 1200 W kg^{-1}	106% after 20000 cycles	156

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
Ultrafine hollow PCNFs	PAN/PVP (shell)/silicone oil (core) fibers + water	Organic template + Chemical activation by KOH	S_{BET} = 1120.3 m^2 g^{-1}, V_{total} = 0.307 cm^3 g^{-1}	Organic electrolyte	231.6 F g^{-1}	11.2 Wh kg^{-1} at 15131.2 W kg^{-1}	—	157
Mesoporous CNFs	Phenolic resin + pluronic F127 + $Mg(NO_3)_2$ + PVP + ethanol	Inorganic and organic template	S_{BET} = 674.0 m^2 g^{-1}, V_{total} = 0.880 cm^3 g^{-1}, V_{micro} = 0.045 cm^3 g^{-1}, σ = 1.2 S cm^{-1}	6 M KOH	270.0 F g^{-1} at 0.2 A g^{-1}	—	95.0% after 5000 cycles	158
PCNFs	PBI + 6FDD + DMAc	Organic template + Physical activation by CO_2	S_{BET} = 3010 m^2 g^{-1}, V_{total} = 1.608 cm^3 g^{-1}, V_{micro} = 0.921 cm^3 g^{-1}	Ionic liquid	142.8 F g^{-1} at 10 mV s^{-1}	67.5 Wh kg^{-1} at 1713.8 W kg^{-1}	86.3% after 1000 cycles	162
Interconnected CNFs	PAN + oxidized coal + DMF	Organic template + Physical activation by CO_2	S_{BET} = 877.0 m^2 g^{-1}, V_{total} = 0.354 cm^3 g^{-1}, V_{micro} = 0.308 cm^3 g^{-1}	6 M KOH	259.7 F g^{-1} at 1.0 A g^{-1}	—	135.5% after 7000 cycles	163
Mesoporous CNFs	PAN + lignin + DMF	Organic template + Physical activation by CO_2	S_{BET} = 2543 m^2 g^{-1}, V_{micro} = 0.547 cm^3 g^{-1}, σ = 5.3 S cm^{-1}	Ionic liquid	128.0 F g^{-1} at 10 mV s^{-1}	50.0 Wh kg^{-1} at 15000 W kg^{-1}	75.0% after 1000 cycles	164
Inter-bonded CNFs	CA nanofibers + hydrolysis	Physical activation by CO_2	S_{BET} = 520.0 m^2 g^{-1}, V_{total} = 0.300 cm^3 g^{-1}	6 M KOH	241.4 F g^{-1} at 1.0 A g^{-1}	4.2 Wh kg^{-1} at 12500 W kg^{-1}	99.9% after 10000 cycles	165
Aligned ACNFs	PAN + DMF	Physical activation by CO_2	S_{BET} = 1097 m^2 g^{-1}, V_{total} = 0.620 cm^3 g^{-1}, V_{micro} = 0.240 cm^3 g^{-1}, σ = 1.42 S cm^{-1}	1 M H_2SO_4	230.0 F g^{-1} at 10 mV s^{-1}	—	96.5% after 1000 cycles	167

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
ACNFs	PAN + DMF	Physical activation by steam	S_{BET} = 1230 m^2 g^{-1}, V_{total} = 0.550 cm^3 g^{-1}	30 wt.% KOH	173.0 F g^{-1} at 0.01 A g^{-1}	—	—	168
ACNFs	PBI + DMAc	Physical activation by steam	S_{BET} = 1220 m^2 g^{-1}, V_{micro} = 0.710 cm^3 g^{-1}	1 M H_2SO_4	202.0 F g^{-1} at 1 mA cm^{-2}	—	—	169
ACNFs	PMDA + ODA + THF + methanol	Physical activation by steam	S_{BET} = 1453 m^2 g^{-1}, V_{micro} = 0.563 cm^3 g^{-1}	30 wt.% KOH	175.0 F g^{-1} at 0.02 A g^{-1}	—	—	172
ACNFs	PIM-1 + tetrachloroethane	Physical activation by steam	S_{BET} = 1162 m^2 g^{-1}, V_{total} = 0.611 cm^3 g^{-1}, V_{micro} = 0.469 cm^3 g^{-1}	Ionic liquid	149.0 F g^{-1} at 1.0 A g^{-1}	60.0 Wh kg^{-1} at 1715 W kg^{-1}	—	173
ACNFs	PAN + acid treated coal + DMF	Organic template + Physical activation by steam	S_{BET} = 902.0 m^2 g^{-1}, V_{total} = 0.405 cm^3 g^{-1}, V_{micro} = 0.352 cm^3 g^{-1}	6 M KOH	230.0 F g^{-1} at 1.0 A g^{-1}	—	97.0% after 1000 cycles	174
Activated PCNFs	PAN + DMF	Chemical activation by KOH	S_{BET} = 1886 m^2 g^{-1}, V_{total} = 1.196 cm^3 g^{-1}, V_{micro} = 0.940 cm^3 g^{-1}	1 M Na_2SO_4	103.0 F g^{-1} at 1.0 A g^{-1}	—	94.0% after 3000 cycles	177
CNF aerogels	Pre-oxidized PAN fibers + PAA-TEA (freeze-drying)	Organic template + Chemical activation by KOH	—	6 M KOH	307.2 F g^{-1} at 2 mV s^{-1}	—	96.3% after 5000 cycles	178
Activated PCNFs	Phenolic resin + PVA + H_2O	Organic template + Chemical activation by KOH	S_{BET} = 1317 m^2 g^{-1}, V_{total} = 0.699 cm^3 g^{-1}, V_{micro} = 0.540 cm^3 g^{-1}	6 M KOH	362.0 F g^{-1} at 0.2 A g^{-1}	7.1 Wh kg^{-1} at 90 W kg^{-1}	98.0% after 1000 cycles	179

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
ACNFs	PAN + carbonized wheat straw + DMF	Integration with biomass carbon + Chemical activation by KOH	—	6 M KOH	249.0 F g^{-1} at 0.4 A g^{-1}	—	96.4% after 1000 cycles	180
ACNFs	PAN + H_3PO_4 + DMF	Chemical activation by H_3PO_4	S_{BET} = 709.0 m^2 g^{-1}, V_{total} = 0.356 cm^3 g^{-1}, V_{micro} = 0.278 cm^3 g^{-1}	6 M KOH	156.0 F g^{-1} at 0.5 A g^{-1}	21.46 Wh kg^{-1} at 500 W kg^{-1}	96.5% after 1000 cycles	181
Activated PCNFs	CA + DMAc + acetone	Chemical activation by $ZnCl_2$	S_{BET} = 1188 m^2 g^{-1}, V_{total} = 0.575 cm^3 g^{-1}, V_{micro} = 0.406 cm^3 g^{-1}	6 M KOH	202.0 F g^{-1} at 0.1 A g^{-1}	—	92.0% after 5000 cycles	182
NCNFs	PVP-derived CNFs + *g*-C_3N_4	Nitrogen doping	S_{BET} = 309.0 m^2 g^{-1}	1 M H_2SO_4	264.4 F g^{-1} at 1.0 A g^{-1}	—	>100% after 5000 cycles	192
Mesoporous NCNFs	PAN + *g*-C_3N_4 + DMF	Nitrogen doping + Physical activation by steam	S_{BET} = 554.0 m^2 g^{-1}, V_{total} = 0.900 cm^3 g^{-1}	2 M Li_2SO_4	220.0 F g^{-1} at 0.2 A g^{-1}	12.5 Wh kg^{-1} at 72 W kg^{-1}	97.0% after 1000 cycles	193
NCNFs	Regenerated cellulose fibers + NH_4Cl	Nitrogen doping	S_{BET} = 29.0 m^2 g^{-1}, σ = 10.2 S cm^{-1}	1 M KOH	26.0 F g^{-1}	—	138.3% after 1000 cycles	195
NCNFs	Regenerated cellulose fibers + PPy coating	Nitrogen doping + Physical activation by CO_2	S_{BET} = 281.8 m^2 g^{-1}, V_{total} = 0.187 cm^3 g^{-1}	6 M KOH	236.0 F g^{-1} at 0.2 A g^{-1}	—	98.0% after 10000 cycles	197
Nitrogen-doped PCNFs	PAN fibers + PANi coating	Nitrogen doping	S_{BET} = 410.0 m^2 g^{-1}, V_{total} = 0.209 cm^3 g^{-1}	1 M H_2SO_4	335.0 F g^{-1} at 0.5 A g^{-1}	9.2 Wh kg^{-1} at 250 W kg^{-1}	86.0% after 10000 cycles	198
NCNFs	PAN fibers + bPEI coating	Nitrogen doping	—	3 M KOH	192.5 F g^{-1} at 1.0 A g^{-1}	8.0 Wh kg^{-1} at 300 W kg^{-1}	84.5% after 1000 cycles	200

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
NCNFs	Pre-oxidized PAN fibers (carbonization in NH_3)	Nitrogen doping	—	1 M Na_2SO_4	—	29.1 Wh kg^{-1} at 450 W kg^{-1}	93.7% after 5000 cycles	201
NCNFs	Phenolic resin/PVA-derived CNFs (NH_3 treatment)	Organic template + Nitrogen doping	S_{BET} = 763.0 m^2 g^{-1}, V_{total} = 0.360 cm^3 g^{-1}, V_{micro} = 0.280 cm^3 g^{-1}, σ = 0.833 S cm^{-1}	6 M KOH	251.2 F g^{-1} at 0.1 A g^{-1}	21.7 Wh kg^{-1} at 10000 W kg^{-1}	99.0% after 2000 cycles	203
Boron/nitrogen *co*-doped PCNFs	PAN + H_3BO_3 + urea + DMF	Boron/nitrogen *co*-doping	S_{BET} = 560.0 m^2 g^{-1}, V_{total} = 0.270 cm^3 g^{-1}, V_{micro} = 0.186 cm^3 g^{-1}	6 M KOH	180.0 F g^{-1} at 1 mA cm^{-2}	23.5 Wh kg^{-1} at 400 W kg^{-1}	—	207
Oxygen/nitrogen *co*-doped PCNFs	PAN/PVP fibers + water (HNO_3 activation)	Organic template + Oxygen/nitrogen *co*-doping	S_{BET} = 692.0 m^2 g^{-1}, V_{total} = 0.450 cm^3 g^{-1}, V_{micro} = 0.252 cm^3 g^{-1}	6 M KOH	207.0 F g^{-1} at 0.2 A g^{-1}	24.8 Wh kg^{-1} at 349 W kg^{-1}	91.0% after 3000 cycles	208
Oxygen/nitrogen *co*-doped CNFs	PAN + DMF (HNO_3 oxidation)	Oxygen/nitrogen *co*-doping	S_{BET} = 165.0 m^2 g^{-1}, V_{total} = 0.117 cm^3 g^{-1}, V_{micro} = 0.073 cm^3 g^{-1}	2 M KOH	365.0 F g^{-1} at 2 mV s^{-1}	—	~100% after 2000 cycles	209
Oxygen/nitrogen *co*-doped CNFs	PAN + DMF (microwave-assisted oxidation)	Oxygen/nitrogen *co*-doping	S_{BET} = 670.0 m^2 g^{-1}, V_{total} = 0.534 cm^3 g^{-1}, V_{micro} = 0.397 cm^3 g^{-1}	1 M H_2SO_4	338.0 F g^{-1} at 1.0 A g^{-1}	46.9 Wh kg^{-1} at 10000 W kg^{-1}	98.0% after 10000 cycles	210
Oxygen/nitrogen *co*-doped CNFs	PAN + DMF (plasma oxidation)	Oxygen/nitrogen *co*-doping	S_{BET} = 274.0 m^2 g^{-1}, V_{total} = 0.181 cm^3 g^{-1}, V_{micro} = 0.099 cm^3 g^{-1}	2 M KOH	377.0 F g^{-1} at 2 mV s^{-1}	—	~120% after 2000 cycles	212

Materials	Precursors and additives	Activation methods	Surface area, pores, and conductivity	Electrolyte	Specific capacitance	Energy/Power density	Cyclic Stability	Ref.
N/P *co*-doped CNFs	PAN + H_3PO_4 + DMF	Phosphorus/nitrogen *co*-doping	S_{BET} = 12.15 m^2 g^{-1}	1 M H_2SO_4	224.9 F g^{-1} at 0.5 A g^{-1}	—	105.2% after 8000 cycles	216
N/P *co*-doped CNFs	PAN + PEG + PPA + DMF	Organic template + Phosphorus/nitrogen *co*-doping	S_{BET} = 462.8 m^2 g^{-1}, V_{total} = 0.250 cm^3 g^{-1}, V_{micro} = 0.150 cm^3 g^{-1}	1 M H_2SO_4	228.7 F g^{-1} at 0.5 A g^{-1}	—	107.5% after 5000 cycles	217
Sulfur/nitrogen *co*-doped CNFs	PAN + lignin + graphene + DMF	Organic template + Integration with graphene + Sulfur/nitrogen *co*-doping + Chemical activation by KOH	S_{BET} = 2439 m^2 g^{-1}, V_{total} = 1.288 cm^3 g^{-1}	6 M KOH	267.3 F g^{-1} at 5 mV s^{-1}	9.28 Wh kg^{-1} at 493 W kg^{-1}	96.7% after 5000 cycles	220
B-F-N triply doped PCNFs	PVA + PTFE + H_3BO_3 + H_2O (carbonization in N_2)	Boron/fluorine/nitrogen *co*-doping + Organic template	S_{BET} = 633.6 m^2 g^{-1}, V_{total} = 0.540 cm^3 g^{-1}	1 M $LiPF_6$	163.6 F g^{-1} at 5 mV s^{-1}	42.77 Wh kg^{-1} at 1750 W kg^{-1}	88.5% after 9000 cycles	223
Reinforced CNFs	PAN + graphene QDs + DMF	Integration with graphene + Chemical activation by KOH	S_{BET} = 2032 m^2 g^{-1}, V_{total} = 1.091 cm^3 g^{-1}, V_{micro} = 0.550 cm^3 g^{-1}, σ = 0.650 S cm^{-1}	6 M KOH	358.4 F g^{-1} at 1.0 A g^{-1}	3.73 Wh kg^{-1} at 34020 W kg^{-1}	~100% after 10000 cycles	245

PCNFs: porous CNFs, HPCNFs: hierarchical PCNFs, ACNFs: activated CNFs, NCNFs: nitrogen-doped CNFs, S_{BET}: BET specfic suface area, V_{total}: total pore volume, V_{micro}: micropore volume, σ: conductivity, THF: tetrahydrofuran, rGO: reduced graphene oxide, SDS: sodium dodecyl sulfate, MWCNTs: Multiwalled carbon nanotubes, DMAc: dimethylacetamide, CVD: chemical vapor deposition, PFA: poly(furfuryl alcohol), C_4F_8: octafluorocyclobutane, l-PMMA: low-molecular weight PMMA, h-PMMA: high-molecular weight PMMA, PMDA: pyromellitic dianhydride, ODA: 4,4'-oxydianiline, PAA-b-PAN-b-PAA: polyacrylic acid-*b*-

polyacrylonitrile-*b*-polyacrylic acid, poly(ST-co-DVB-co-NaSS): poly(styrene-*co*-divinylbenzene-*co*-styrene sulfonate), POSS: polyhedral oligomeric silsesquioxane, SDBS: sodium dodecyl benzene sulfonate, PLLA: poly-L-lactic acid, NMP: 1-methyl-2-pyrrolidinone, DMSO: dimethyl sulfone, SAN: styrene-acrylonitrile copolymer, P(AN-*co*-IA): poly(acrylonitrile-co-itaconic acid), PAA-TEA: poly(amide acid)-triethylamine salt, $EMIMBF_4$: 1-ethyl-3-methylimidazolium tetrafluoroborate, EMITFSI: ethylmethylimidazolium bis (trifluoromethylsulfonyl) imide.