SUPPORTING MATERIALS

Recent progress in energy conversion and storage of agricultural waste-derived (carbon/nano)materials: a review

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Table S1. Agricultural waste-derived materials for energy applications.

Entry	Agriculture waste	Electrocatalyst	Application	BET surface area (m^2 g^{-1})	Highlights	Ref.
1	Fresh banana peels	N-carbon nanoparticles (NPs) and N-carbon NPs-NH_3[a]	ORR	734.8 and 941.2	N-CNPs-NH_3 showed high performance in ORR	[1]
2	Pomelo peel	N-D hierarchical porous carbon/reduced graphene oxide (rGO)	ORR	1194	-	[2]
3	Grapefruit peel	Porous carbon	OER/ORR	1037 to 1194	Porous carbon showed high performance as an OER/ORR catalyst in seawater	[3]
4	Pomelo peel	Fe_2N/N-PPC[b]	ORR	1103.90	-	[4]
5	Mangosteen peel	Nitrogen self-doped porous graphitic carbon	ORR	1168	Mangosteen peel was applied as both N and C source	[5]
6	Sweet potato vines	N and S self-doped porous carbon	ORR	884.9	-	[6]
7	Pomegranate peel	Pt_3Ni/rGO and Pt_3Co/rGO	ORR	-	Pt_3Ni/rGO showed better catalytic performance than Pt_3Co/rGO	[7]
8	Bagasse	N-D nanoporous carbon sheets	ORR	1284	-	[8]
9	Pomelo peel	N-D nanoporous carbon	ORR	Up to 1444.9	The catalyst had porous structure and high graphitic N content	[9]
10	Rice husks	Si-GQD nanocomposites[c]	ORR	-	-	[10]
11	Kidney bean	N-D porous nanocarbon	ORR	-	-	[11]
12	Pomelo peel	Metal-free N-D porous carbons	ORR	1165	-	[12]

13	Banana peels	$Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ on N-D mesoporous carbon	ORR and OER	372.3	-	[13]
14	Lignin (L), straw (S) and shaddock peel (SP)	Ru-based composites synthesized from nitrogen doped lignin, straw and shaddock peel (Ru@o-NL, Ru@o-NS and Ru@o-NSP)	HER	680.4 (for o-NL)	Ru@o-NL presented better HER activity than Ru@o-NS and Ru@o-NSP	[14]
15	Bean sprout (BS)	BS-800	HER and high specific capacitance for supercapacitors	397.15	-	[15]
16	Pomelo peel	NiFe@N-D carbon/carbonized pomelo peel	ORR/OER	367.5	-	[16]
17	Watermelon peels	Carbon-based nanocomposites	OER/HER	724-1331 (in different temperatures)	Overpotential and Tafel slope of 237 mV at 10 mA cm^{-2} and 69.8 mV dec^{-1}, respectively for OER, overpotential of 111 mV for HER	[17]
18	Grapefruit peel	Ni NPs embedded in nitrogen self-doped graphene-like carbon	OER/HER	43	Overpotential of 350 and 165 mV and moderate Tafel slope OER and HER of 20 and 10 mA cm^{-2}, respectively	[18]
19	Sugarcane bagasse	Sugarcane bagasse-based porous carbon nanofiber-supported the CoP/Co_2P heterostructure	OER/HER	233.45	-	[19]
20	Pomegranate	Pd NPs supported	CO_2RR and	-	-	[20]

	peel	NiO/C	alkaline direct ethanol fuel cell			

[a] Ammonia-activated N-D carbon NPs

[b] Fe_2N NPs in situ immobilized over N-D porous carbon derived from pomelo peel

[c] Hybrid silicon nanosheets-graphene quantum dot nanocomposites.

Table S2. Carbonaceous compounds from agricultural waste resources, their properties, and applications for supercapacitors.

Entry	Agricultural resource	Carbonaceous material	Surface area ($m^2\ g^{-1}$)	Other properties	Ref.
1	Pomelo peel	Two-dimensional lamellar carbon	1927	Rich in surface oxygen functional groups with a very high capacitance (398 F g^{-1} at 1 A g^{-1}) and a high energy density (21 Wh kg^{-1} at a power density of 180 W kg^{-1})	21
2	Sapindus Mukorossi peel (SMP)	SMP-based activated carbon	1254.5	Specific capacitance of 314.5 F g^{-1} at 1 A g^{-1}	22
3	Watermelon peel	Heteroatom-doped hierarchical porous carbon	1660	High specific capacitances of up to 278 F g^{-1} in 1 M H_2SO_4 electrolyte	23
4	Pomelo peel	N, O-co-doped hierarchical porous carbon	1582	Specific capacitance of 180 F g^{-1} at 0.5 A g^{-1}	24
5	Orange peel	Porous carbon	912.4	Specific capacitance of 375.7 F g^{-1} at 1 A g^{-1} and good rate retention of 50.9% from 1 to 100 A g^{-1}	25
6	Wheat straw cellulosic foam	Hierarchical Porous carbon	772	Specific capacitance of 226.2 F g^{-1} at a current density of 0.5 A g^{-1}	26
7	Rice straw	N-D porous carbon	2786.5	Capacitance of 317 F g^{-1} at 1 A g^{-1}	27
8	Durian peel	Activated N/P co-doped carbon with a hierarchical porous structure (84 vol % micropores)	3416	N (2.17 at. %) and P (0.48 at. %) doping amounts with specific capacitance (383.4 F g^{-1} at 0.5 A g^{-1}), ideal rate performance (255.6 F g^{-1} at 20 A g^{-1}), and superior cyclic performance (98.3% capacitance retention after 10 000 cycles at 5 A g^{-1})	28
9	Rice husk	Activated graphene-based carbon (AGC)	3292	AGC was modified with $Ni(OH)_2$ with 9 wt.% loading and used for supercapacitor applications with a	29

				specific capacitance of up to 300 F g^{-1} at a current density of 50 mA g^{-1}	
10	Wheat straw	Porous carbon	1905	Pore distribution of 0.62 cm^3 g^{-1} and meso-/macropores content of 0.53 cm^3 g^{-1} with the oxygen content of up to 21.6% and high specific capacitance of 268.5 F g^{-1} at 0.5 A g^{-1}	30
11	Orange peel	Nitrogen and oxygen co-doped carbon	917.66	Specific capacitance of 282.3 F g^{-1} at 1 A g^{-1}	31
12	Rice husk	Nitrogen and phosphorus co-doped porous carbon	2188	Pore volume of 3.025 cm^3 g^{-1}, pore diameter (PD) of 5.537 nm and specific capacitance of 236 F g^{-1} at a current density of 0.5 A g^{-1}	32
13	Orange peel	Orange peel carbon (OPC800)	2004	Pore volume of 1.24 cm^3 g^{-1} and maximum specific capacitance of 306.6 F g^{-1} at 0.5 A g^{-1}	33
14	Mangosteen peel	Porous carbon	2623	Specific capacitance of 357 F g^{-1} at 1 A g^{-1}	34
15	Coconut husk	Activated carbon	From 823 to 1033.20	Specific capacitance of 184 F g^{-1}	35
16	Rice husk	Activated carbon/polyaniline	2265	Specific capacitance of 465 F g^{-1} in 1 M H_2SO_4 at discharge current density 0.2 A g^{-1} with polyaniline content 60 wt.%	36
17	Rice husk	Graphene nanosheets	~1225	Specific capacitance of 115 F g^{-1} at 0.5 mA cm^{-2}	37
18	Pomegranate husk	N-D porous nanosheets carbon	1754.8	Pore volume of 1.05 cm^3 g^{-1}, nitrogen doping content of 4.51 wt% and a high specific capacitance of 254 F g^{-1} at a current density of 0.5 A g^{-1}	38
19	Rice husk	Mesoporous carbons	1737	Specific capacitance and energy density of 157 F g^{-1} and 84 Wh kg^{-1} at 0.05 A g^{-1}, respectively	39
20	Banana peel	Nitrogen-doped banana peel-derived porous carbon foam	1357.6	Pore volume of 0.77 cm^3 g^{-1}, mesopore size distributions around 3.9 nm and specific capacitance of 185.8 F g^{-1} at 5 mV s^{-1} and 210.6 F g^{-1} at 0.5 A g^{-1} in 6	40

				M KOH aqueous electrolyte	
21	Rice husk	Activated carbon	2516	Average pore diameter of 3.02 nm	[41]
22	Rice husk	Mesoporous carbon	2009	Mesoporosity of 90.8% with a specific capacitance of 176 F g^{-1} at a current density of 50 mA g^{-1}	[42]
23	Rice husk	Nanoporous activated carbon	2523.4	Specific capacitance of 250 F g^{-1} at the current density of 1 A g^{-1}	[43]

Table S3. Supercapacitors from agricultural wastes and their properties.

Entry	**Agricultural precursor**	**Prepared material**	**Specific capacitances (F g^{-1})/ current density (A g^{-1})**	**Capacitance retention / cycles**	**Energy density (Wh kg^{-1})**	**Ref.**
1	*Citrus bergamia* peel	Activated carbon-H_3PO_4	142/ 0.1	101%/ 5000	-	44
		Activated carbon-Mn_3O_4	289/ 0.1	88%/ 5000	50.8 at a power density of 240 W kg^{-1}	
2	Dragon fruit peel	N-D mesoporous dominated hierarchical activated carbon	427/ -	109%/ 5000	112 Wh kg^{-1} at a power of 3214 W kg^{-1}	45
3	Mangosteen peels	Liquefied bio-carbon nanofibers	365.5/ 0.5	97.7%/ 10000	18 at a power density of 348.9 W kg^{-1} at 1 A g^{-1} current density	46
4	Potato peel	Sulfur and phosphorus co-doped porous activated carbon	323/ 1	94.3%/ 10000	45.5 at a power density of 800 W kg^{-1}	47
5	Buckwheat husk	Nitrogen, sulfur and oxygen-co-doped porous carbon	285/ 1	96%/ 30	6.60 at a power density of 250 W kg^{-1}	48
6	*Areca catechu* Husk (ACH)	Carbon nanofiber	181.96/ -	-	25.27 for power density of 91.07 W kg^{-1}	49
7	Potato peel	Copper phthalocyanine/activated carbon	237/ 0.1	80%/ 1000	-	50
8	Orange peel	Boroncarbonitride	209/ 2.5	-	-	51
9	Corn husk	Hierarchical porous carbon	314.83 at 1 mV s^{-1} and 297.81 at 5 mA cm^{-2} in 0.5 M H_2SO_4 electrolyte	-	9.85 at a high-power density of 7185 W kg^{-1}	52
10	Garlic peel	3D hierarchical porous carbon	426/ 1	-	59.57 and 49.18 at power density	53

					of 190.06 W kg^{-1} and 16.24 KW kg^{-1}, respectively	
11	Rice husk	Porous rice husk-based activated carbon	147/ 0.5	92%/ 10000 at 1 A g^{-1}	-	54
12	Mung bean husk	Original bio-structured porous carbon (PC_{3-600})	390/ 1	73.5% at a high current density of 50 A g^{-1}	-	55
		3D architecture porous carbon (HPC_{2-700})	353/ 1	76.48% at a high current density of 50 A g^{-1}	Energy density of 20.4 at 872 W kg^{-1} in 1 M Na_2SO_4 electrolyte	
		Porous carbon block ($HPPC_{2-700}$)	304/ 1	77.3% at a high current density of 50 A g^{-1}	-	
13	Corn straw	Hierarchical porous carbon based on corn straw carbon nanofiber	376.5/ 0.5	94.18%/ 5000 at the current density of 2 A g^{-1}	-	56
14	Buckwheat husk	Nitrogen doped 3D hierarchical porous carbon	326/ 1	95% of the initial capacitance at 5 A g^{-1}/ 5000	20.4 at a power density of 699 W kg^{-1}	57
15	Durian peel	Activated carbon/CDs	60/ -	-	-	58
16	Orange peel	N-D porous carbon	268/ -	92%/ up to 6000	32.08 at a power density of 700.43 W kg^{-1}	59
17	Pomelo peel	Nitrogen/sulfur dual-doped sponge-like porous carbon (NSC-600)	310/ 0.5	98.8%/ 10000	21.4 at a power density of 259.9 W kg^{-1}	60
18	Rice husk	Activated carbon	315/ 0.5	-	-	61
19	Pomelo peel	CuS nanosheets-based	954/ 1	81.99% at 7	-	62

		3D micro-flowers grown on pomelo peel -derived porous activated carbon		A g^{-1}/ 5000		
20	Ginger straw	Ginger straw-based porous carbon	274/ 0.1	88%/ 6000 at a current density of 5 A g^{-1}	34.06 at a power density of 4.35 kW kg^{-1}	63
21	Pineapple peel	Carbon/$ZnMn_2O_4$ composite	104.89/ 300 mA g^{-1}	97.06%/ 5000	-	64
22	Rice husk	Rice husk activated carbon/$NiCo_2S_4$	133.3/ 0.2 A	86%/ 5000 at a current density of 1 A g^{-1}	41.6 at power density of 150 W kg^{-1}	65
23	Rice husk	Poly(3,4-ethylenedioxythiophene)-CO_2@C hybrid	458/ 1	~98%/ 5000	280 at power density of ~1 kW kg^{-1}	66
24	Rice husk	Hierarchical micro-/mesoporous carbon	302.2/ 1	88.5%/ 5000	-	67
25	Pomelo peel	Nitrogen-doped hierarchical porous carbon600 (Porous carbon at 600 °C)	208.7/ 1	-	7.3 at a current density of 1 A g^{-1} in 1 M H_2SO_4 electrolyte	68
26	Banana peel	Porous carbon electrode	258-273/ 0.1	90%/ 1000	-	69
27	Rice husk	Activated carbon	168/ 250 mA g^{-1}	-	-	70
28	Banana peel	MnO_2/biomass-derived porous carbon	139.6/ 300 mA g^{-1}	92.3%/ 1000 at 1 A g^{-1}	-	71
29	Wheat husk	NiO@porous carbon	500/ 10	92%/ 8000	-	72
30	Rice straw	Graphene-like activated carbon	255/ 0.5	98%/ 10000	-	73
31	Rice husk	Rice husk porous carbon	260/ 1	86%/ 10000	-	74
32	Shaddock peel	N-doped activated shaddock peel carbon/graphene/bacterial cellulose	250.5/ -	97%/ 10000	-	75

33	Pomelo peel	Oxygen-rich hierarchical porous carbon	222.6/ 0.5	99%/ 5000	-	[76]
34	Rice husk	Silica-free rice husk-derived porous carbon	220/ 0.5	98%/ 10000	-	[77]
35	Pomelo peel	Cobalt nickel aluminum layered double hydroxide@carbonaceous aerogel	1134/ 1 902/ 10	-	-	[78]
36	Grapefruit Peel	Hierarchically porous N-doped carbon nanosheets	Up to 311/-	94.1%/ 10000	17.7 at a power density of 1100 W kg^{-1} in 1 M H_2SO_4 electrolyte	[79]
37	Pomelo peel	3D porous framework-like N-D carbon	260/ 1	84.2%/ 10000 at 10 A g^{-1}	-	[80]

Table S4. Agricultural wastes-derived carbon for lithium-ion batteries (LIBs).

Entry	Source	Prepared material	Electrolyte	Highlights	Ref.
1	Rice husk	Nanoporous silicon@graphitized carbon composites	$LiPF_6$ solution (1 M) in a mixture of ethylene carbonate/dimethyl carbonate/fluoroethylene carbonate (EC/DMC/FEC, 3:6:1 v/v/v)	Initial coulombic efficiency of 41% and the reversible specific capacity of 681.8 mAh g^{-1} after 100 times at 0.2 A g^{-1}	[81]
2	Rice husk and lignin	Si/C as an anode material	1 M $LiPF_6$ in a mixture of EC:ethyl methyl carbonate (EMC):DMC (1:1:1, v/v/v)	High specific capacity retention of 572 mAh g^{-1} at 1 A g^{-1} after 1000 cycles	[82]
3	Rice husk	Si/C as an anode material	1 M $LiPF_6$ in a mixture of EC and DMC (1:1 vol%)	Reversible capacity of up to 1247.8 mAh g^{-1} with 92.4% capacity retention over 50 cycles	[83]
4	Rice husk	$Si@SiO_2@C$ as an anode material	1 M $LiPF_6$ in a 1:1 mixture of EC and diethyl carbonate (DEC)	After 200 cycles at 1 A g^{-1}, the anode delivered a reversible capacity of 973.1 mAh g^{-1}, showing a capacity retention of 93.1% and a Coulumbic efficiency of above 99.7%	[84]
5	Rice husk	Si/C composite as an anode material	-	Capacity retention rate above 90% after 150 cycles at the charge/discharge rate of 0.5 C (1 C = 600 mAh g^{-1})	[85]
6	Rice husk	Pitaya-like SiO_x/nitrogen-doped carbon superstructures prepared as an anode	1 M $LiPF_6$ in EC and DMC (volume ratio of 1:1) with 5% FEC	Specific capacity of 622.8 mAh g^{-1} after 100 cycles at 0.1 A g^{-1} and an excellent long cycle performance of 190.1 mAh g^{-1} after 5000	[86]

				cycles at 5 A g^{-1}	
7	Rice husk	C/SiO_2 composite as an anode material	1 M $LiPF_6$ in EC:EMC:DEC (1:1:1, v/v/v)	Reversible specific capacity of 553 mAh g^{-1} after 100 cycles at 0.1 A g^{-1}	[87]
8	Rice husk	Porous N-D carbon/SiO_x composite as an anode material	1 M $LiPF_6$ in EC:EMC:DEC (1:1:1, v/v/v)	Reversible capacity up to 1018.5 mAh g^{-1} at 0.1 A g^{-1}	[88]
9	Rice husk	Hierarchically porous SiO_2/N-D carbon composites as anode materials	1 M $LiPF_6$ in DMC/EC (1:1 v/v)	Reversible capacity of 556 mAh g^{-1} over 1000 cycles at 1 A g^{-1}	[89]
10	Rice husk	Rice husk-derived silicon-tin/N-D graphene composite nanostructure as anode materials	1 M $LiPF_6$ in the DMC/EC (1:1 v/v)	The composite with 10% Sn and 10% Si on N-D graphene delivered a capacity of 480 mAh g^{-1} after 100 cycles	[90]
11	Rice husk	SiO_2/C and Si/C composites as anode materials	1 M $LiPF_6$ in EC/DEC (1:1 vol%)	-	[91]
12	Rice husk	Rice husk-derived SiO_x@carbon nanocomposites	1 M $LiPF_6$ in EC/DMC (1:1)	The anode showed a reversible capacity of 1315 mAh g^{-1} after 100 cycles at 100 mA g^{-1}	[92]
13	Rice husk	Rice husk-derived carbon@SnO_2@rGO composite as an anode electrode	1 M $LiPF_6$	The anode showed a reversible capacity of 1206.9 mAhg^{-1} at a current density of 0.2 C after 100 cycles	[93]
14	Rice husk	Rice husk lignin-based porous carbon and ZnO composite as an anode material	-	The anode showed a discharge capacity of 898.1 mAh g^{-1} at 0.2 C after 110 cycles	[94]
15	Rice husk	Rice husk-based C/SiO_2 composites as anode materials	1 M $LiPF_6$ in EC:DEC:DMC (1:1:1, v/v/v)	Good cycling performance under a current density of 100 mA g^{-1}	[95]

16	Rice husk	C/SnO_2 composite anode	1 M $LiPF_6$ in a mixture of propylene carbonate, EC and DMC (1:1:1 in volume)	The results showed the fifty-discharge capacity of 550 mAh g^{-1} at current density of 100 mA g^{-1} (180 mAh g^{-1} for SnO_2 anodes)	96
17	Rice husk	P-doped porous carbon/SiO_x composites as anode materials	1 M $LiPF_6$ in EC:DMC:EMC (1:1:1, v/v/v) with 5% FEC	Capacity of 1151.8 mAh g^{-1} at 0.1 A g^{-1}	97
18	Rice husk	N-D carbon/SiO_x composites as anode materials	1 M $LiPF_6$ in EC, DMC and DEC (1:1:1 in volume)	The composite displayed high reversible capacity (at a current density of 100 mA g^{-1}, after 100 cycles the discharge capacity as high as 1110 mAh g^{-1})	98
19	Rice husk	SiO_2/C as anode materials	1 M $LiPF_6$ dissolved in an equal volume mixture of EC and DMC	Capacity of 756.9 mAhg^{-1} after 150 charge-discharge cycles at 0.2 C and 620 mAh g^{-1} after 600 cycles at 2 C	99
20	Rice husk ash	SiO_2/C composite as an anode material	1 M $LiPF_6$ in EC:EMC:DMC (1:1:1, v/v/v)	Reversible specific capacity of 404 mAh g^{-1} over 500 cycles at 0.25 C	100
21	Rice husk	Rice husk-nano Si@C/CNT as anode materials	1 M $LiPF_6$ and 6 vol% of vinylene carbonate in a solution of EC and DEC (volume ratio of 1:1)	Reversible capacity of 989.5 mAh g^{-1} at 0.5 C (1 C = 4.2 A g^{-1}) and 345 mAh g^{-1} at 3 C	101
22	Rice husk	ZnO/CoO@rice husk-Cellulose nanocomposites as anode materials	-	Capacity of 972 mAh g^{-1} over 150 cycles at 100 mA g^{-1}	102
23	Rice husk	SiO_2 as an anode	1 M $LiPF_6$ in a mixture of	Initial discharge	103

		material	EC/DEC/DMC (1:1:1, v/v/v)	capacity of 1049 mAhg^{-1}	
24	Rice husk	Rice husk-based 3D porous silicon/carbon nanocomposites as anode materials	1 M $LiPF_6$ in a mixture of EC/DEC/DMC (1:1:1, v/v/v)	Reversible capacity of 345 mAh g^{-1} after 100 cycles at 50 mA g^{-1}	[104]
25	Rice husk	Rice husk lignin-derived porous carbon as an anode material	1 M $LiPF_6$ in EC and DMC (1:1, v/v)	Specific capacity of 469 mAh g^{-1} after 100 cycles	[105]
26	Rice husk	MoS_2@rice husk carbon composite anode	1 M $LiPF_6$ in a mixture of EC and DMC (1:1 w/w)	The composite delivered average discharge capacities of 280, 260, 234 and 186 mAh g^{-1} at current density of 40, 60, 80, and 100 mA g^{-1}, respectively	[106]
27	Rice husk	Activated carbon-decorated spherical silicon nanocrystal composites as anode materials	1 M $LiPF_6$ in 1:1 mixture of $OC(OCH_3)_2$ and $(CH_2O)_2CO$	Reversible specific capacity of 429 mAh g^{-1} after 100 cycles	[107]
28	Rice husk	Silicon derived from Rice husks	1 M $LiPF_6$ in a mixture of EC and DEC (1:1, w/w) with 10 w% EFC	The material delivered initial discharge and charge capacities of 3844.7 and 3144.4 mAh g^{-1} at the current density of 100 mA g^{-1}	[108]
29	Rice husk	Rice husk-derived Si-Sn/nitrogen-doped rGO nanocomposites as anode materials	1 M $LiPF_6$ in EC/DMC (1:1 v/v)	The composite delivered an initial capacity of 1600 mAh g^{-1}	[109]
30	Rice husk	Rice husk-derived activated carbon as an anode material	1 M $LiPF_6$ in a 1:1 (V/V) mixture of EC and DMC	The anode delivered reversible specific capacity of 448 mAh g^{-1} after 100 cycles at a rate of 0.2 C	[110]

31	Rice husk	Si-Co/Nitrogen-doped rGO as an anode material	$LiPF_6$ solution in EC/DMC (1:1 V/V)	Initial capacity of 975 mAh g^{-1}	[111]
32	Rice husk	Rice husk-Porous-Si/C/rGO as anode materials	1 M $LiPF_6$ solution (mixed EC:DEC as solvent 50:50)	Capacity of 760 mAh g^{-1} after 100 cycles at the current density of 100 mA g^{-1}	[112]
33	Rice husk	ZnO/rice husk-based hollow carbonaceous nanosphere composite as an anode material	-	Specific charge capacity of 920 mAh g^{-1} at 0.2 C after 100 cycles	[113]
34	Rice husk ash	Nano-silica materials	-	-	[114]
35	Rice husk	SiO_2/C composite as anode materials	1 M $LiPF_6$ in EC, EMC and DEC (1 :1 :1, v/v/v)	Reversible capacity of 827 mAh g^{-1} over 300 cycles at the current density of 100 mA g^{-1}	[115]
36	Rice husk	Nanostructured silicon/carbon and silica/carbon nanocomposites as anode materials	1 M $LiPF_6$ in a 1:1:1 (v/v/v) mixture of EC, EMC and DMC	Reversible capacity of 560 mAh g^{-1} at a current density of 100 mA g^{-1} over 180 cycles with good structural stability for silicon/carbon and 650 mAh g^{-1} at 100 mA g^{-1} after 150 cycles for silica/carbon nanocomposite	[116]
37	Rice husk	Silicon/Carbon as an anode material	1 M $LiPF_6$ (mixed EC:DEC as the solvent, 50:50)	Si/C composite displayed good cycling stability (537 mAh g^{-1} after 200 cycles at a current density of 0.1 A g^{-1})	[117]
38	Rice husk	Porous Li_2MnSiO_4/C nanocomposite as a cathode material	1 M $LiPF_6$ in a 1:1 (v/v) mixture of EC and DMC	Discharge specific capacity of 163.2 mAh g^{-1} at 1 C	[118]

39	Rice husk	Nano-$Co_{1-x}S$/biomass derived activated carbon as a cathode material	1 M $LiPF_6$/EC + DMC (1:1 in volume)	Capacity of 630 mAh g^{-1} after 120 cycles at a current density of 0.1 A g^{-1}	[119]
40	Rice husk	Si-graphite composites as anode materials	1 M $LiPF_6$ solution in a mixture of EC and DEC (1:1, v/v) with 5 wt% FEC	-	[120]
41	Rice husk	C/SiO_2 composite as a cathode material	1 M $LiPF_6$/EC + DMC (1:1 in volume) solution	Discharge specific capacity of 1105 mAh g^{-1} at 0.1 A g^{-1}	[121]
42	Rice husk	Fe_3O_4/rice husk-based maco-/mesoporous carbon bone nanocomposite as a cathode material	1 M $LiPF_6$ dissolved in EC, DMC, and DEC (1:1:1 by volume)	The anode delivered an initial reversible capacity of 918 mAh g^{-1} at 0.2 A g^{-1} and a reversible capacity of 681 mAh g^{-1} remained after 200 cycles at 1 A g^{-1}	[122]
43	Rice husk	Phosphorus-carbon composite as an anode material	1 M $LiPF_6$ dissolved in EC, DMC, and EMC (1:1:1, v:v:v)	After over 100 cycles, the composite delivered a capacity of about 1293 mAh g^{-1}	[123]
44	Rice husk	Cellulose-derived hollow carbonaceous nanospheres as anode materials	1 M $LiPF_6$ in a 1:1 (v/v) mixture of EC and DMC	The first discharge specific capacity of 1040 mAh g^{-1} at a rate of 0.2 C and the reversible specific capacity stabilized at 489 mAh g^{-1} after 100 cycles	[124]
45	Rice husk	SiO_x/C composite as an anode material	1 M $LiPF_6$ in a mixed solvent of EC, DMC, and EMC (1:1:8 in weight)	Specific capacity of nearly 600 mAh g^{-1} at 100 mA g^{-1} after 100 cycles	[125]
46	Rice husk	Rice husk-derived hierarchical silicon/N-D carbon/CNT spheres	1 M $LiPF_6$ in a mixed solvent of EC and DMC (1:1, v:v) containing 10 vol% FEC	Reversible specific capacity of 1380 mAh g^{-1} at a current density	[126]

		as anode materials		of 0.5 A g^{-1}	
47	Rice husk	Disordered carbon	1 M LiPF6 in a 1:1 (v/v) mixture of EC-DEC	Reversible capacity of 502 mAh g^{-1} after 100 cycles at 0.2 C	[127]
48	Rice husk	Microsized porous SiO_x@C composites as anode materials	1 M $LiPF_6$/EC + DMC (1:1 in volume)	Specific capacity of 1230 mAh g^{-1} at a current density of 0.1 A g^{-1}	[128]
49	Rice husk	rGO-porous silicon composite as an anode material	1 M $LiPF_6$ EC/DEC (1:1 v/v) plus 1 wt% vinylene carbonate	Capacity of 907 mAh g^{-1} at a rate of 16 A g^{-1}	[129]
50	Rice husk	Porous silicon as anode materials	1 M $LiPF_6$ in a mixture of EC:DMC:EMC (vol ratio 1:1:1) and 1.5 wt% vinylene carbonate additive	Reversible capacity of 1 400.7 mAh g^{-1}	[130]
51	Rice husk	Phosphorus-doped porous carbon as an anode material	1 M $LiPF_6$ in a 50:50 (v/v) mixture of EC and DEC	Reversible capacity of 757 mAh g^{-1} after 100 cycles at 100 mA g^{-1}	[131]
52	Rice husk	Nb_2O_5/graphene nanocomposites as anode materials	1 M $LiPF_6$ in a mixture of EC and DMC (1:1 v/v)	Reversible capacity of 192 mAh g^{-1} under 0.1 C rate over 50 cycles	[132]
53	Rice husk	V_2O_5 NPs as cathode material	1 M $LiPF_6$ in EC, DMC and EMC (1: 1: 8 by volume ratio)	Discharge capacity of 229 mAh g^{-1} after 50 cycles	[133]
54	Rice husk	Fe/Fe_3O_4/N-carbon composite as an anode material	1 M $LiPF_6$ in a mixture of EC and DEC with a volume ratio of 1:1	Reversible capacity of about 610 mAh g^{-1} at a current density of 200 mA g^{-1} after 100 cycles	[134]
55	Rice husk	Activated carbon as an anode material	1 M $LiPF_6$ in a mixture of EC and DMC (1:1 by volume)	Reversible specific capacity of 730 mAh g^{-1} at a current density of 0.2 C	[135]
56	Rice husk	Carbon-silica composites as anode materials	1 M $LiPF_6$ in a mixture of EC and DMC (1:1 by volume)	It showed an initial discharge capacity of 325 mAh g^{-1}, increasing to 485 mAh g^{-1} after 84 cycles	[136]

57	Rice husk	Rice husk-based silicon-graphene composite as an anode material	1 M $LiPF_6$ in EC/DMC (1:1 v/v)	Initial capacity of 1000 mAh g^{-1} at current density of 1000 mA g^{-1}	137
58	Rice husk	Rice husk-derived carbon as anode materials	1 M $LiPF_6$ in a mixture of EC and DMC (1:1 v/v)	It delivered superior electrochemical behavior; especially rate performance (137 mAh g^{-1} at 10 C)	138
59	Rice husk	Mesoporous silicon as an anode material	1 M $LiPF_6$ in a mixture of carbonate-containing vinylene carbonate	Reversible capacity of 1220.2 mAh g^{-1} at a specific discharge-charge current of 1000 mA g^{-1} after 100 cycles	139
60	Rice husk	Pyrolytic carbons as anode materials	-	The highest insertion and deinsertion capacities were observed with the carbon obtained from Rice husk treated with 0.3 M NaOH, at 819 and 463 mAh g^{-1}, respectively	140
61	Rice husk	Carbon anode	1 M $LiPF_6$ in a 50/50 v/v% mixture of EC and DEC	Reversible capacity of 1055 mA g^{-1}	141
62	Bagasse	Carbon-coated Na_2FePO_4F as a cathode material	1 M $LiPF_6$ in a mixture of EC and DMC (1:1 v/v)	The coulombic efficiency of the cathode remained above 97.8% after 30 cycles at 0.1 C	142
63	Bagasse	$xNa_3V_2(PO_4)_2F_3\cdot(1-x)$ $Na_2MnPO_4F@C$ as a cathode material	1 M $LiPF_6$ in a mixture of EC and DMC (1:1 v/v)	The coulombic efficiency of the cathode remained 95% after 35 cycles at 0.1 C	143
64	Sugarcane bagasse	HAPC/MoS_2/rGO[a] as an anode material	1 M $LiPF_6$ in EC, DMC and EMC (1: 1: 1 by volume ratio)	Reversible discharge capacity of 952 mAh g^{-1} after 200 cycles at a	144

				current density of 0.2 A g^{-1}	
65	Bagasse	Sulfur-doped honeycomb-like carbon as an anode material	1.25 M MPF_6 (M: Li/Na) in a mixture of DEC and EC (1:1 by volume)	Reversible specific capacity of 690.9 mAh g^{-1} at 0.1 A g^{-1} after 100 cycles	[145]
66	Bagasse and starch	Carbon-coated $LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ as a cathode material	1 M $LiPF_6$ in a mixture of EC/DEC (1:1 by volume)	The initial discharge capacity of the $LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ was 147.8 mAh g^{-1}, which increased to 152.4 and 153.3 mAh g^{-1} for 2% starch and bagasse, respectively	[146]
67	Bagasse	Hierarchically functionalized porous carbon/β-FeOOH composite as an anode material	1 M $LiPF_6$ in EC, DMC and EMC (1: 1: 1 by volume ratio)	Discharge capacity of 898.8 mAh g^{-1} at 0.2 A g^{-1} after 350 times	[147]
68	Bagasse	$Li_4Ti_5O_{12}$ as an anode material	1 M $LiPF_6$ in a mixture of 1:1 volume of EC and DEC	Reversible capacity of 170.7 mAh g^{-1} at 1 A g^{-1} after 1000 cycles and an excellent rate performance of 91.2 mAh g^{-1} at 10 A g^{-1} even after 3000 cycles	[148]
69	Sugarcane bagasse	N-D porous carbon as an anode material	1 M $LiPF_6$ in a mixture of EC and DEC (1:1 v/v)	Reversible capacity of 1148 mAh g^{-1} at 0.1 A g^{-1}	[149]
70	Sugarcane bagasse	Functionalized bioinspired porous carbon with graphene sheets as anode materials	1 M $LiPF_6$ in a mixture of EC and DEC (1:1 v/v)	Reversible discharging capacity of 617.3 mAh g^{-1} after 600 cycles at 200 mA g^{-1}	[150]
71	Sugarcane bagasse	Alkali activated carbons as anode materials	-	-	[151]

72	Sugarcane bagasse	Activated porous carbon as an anode material	1 M $LiPF_6$ in a mixture (1:1, in vol %) of EC and DMC	Reversible capacity of 757 mAh g^{-1} at a current density of 100 mA g^{-1}	152
73	Sugarcane bagasse	Single-crystalline α-MoO_3 microbelts as anode materials	1 M $LiPF_6$ in EC and DEC (1:1, v/v ratio)	-	153
74	Bamboo culm, rice husk and sugarcane bagasse	3D nanoporous Si and its nanohybrids as anode materials	1 M $LiPF_6$ in EC and DMC (1:1 v/v) with 2wt% vinylene carbonate	Si decorated with dimensionally modulated carbon-based materials such as carbon, graphene nanosheets, and multiwall CNTs, exhibited higher delithiation capacities (1997, 1290, and 1166 mAh g^{-1}, respectively) compared to pristine Si (956 mAh g^{-1}) extracted from rice husk	154
75	Sugarcane bagasse	Germanium-graphene nanocomposites as anode materials	1 M $LiPF_6$ in EC, DMC and DEC (1: 1: 1 by volume ratio)	The nanocomposites exhibited high specific capacity and superior capacity retention of 90% after 15 cycles	155
76	Sugarcane bagasse	Carbonaceous materials	1 M $LiPF_6$ in EC, DMC and DEC (Selectipur-1:1:1 m/m/m)	Reversible specific capacity of 310 mAh g^{-1}	156
77	Waste mango-peel	Porous hard carbon	1 M $LiPF_6$ in EC:EMC:DMC (1:1:1 wt.%) with 1% of vinylene carbonate	Reversible discharge capacity of 801 mAh g^{-1} at 100 mA g^{-1}	157
78	Shaddock peel	N-D porous hard carbons as anode materials	1 M $LiPF_6$ in a mixture of EC, EMC and DMC (1:1:1 in volume)	Reversible capacity of 673 mAh g^{-1} at 50 mA g^{-1} after 100 cycles	158
79	Lemon juice and	Nanosized MnO_2 as a cathode material	1 M $LiPF_6$ in a 1:1 mixture of EC and DMC	Reversible capacity of 160 mAh g^{-1} (initial	159

	citrus peel			capacity of 212 mAh g^{-1}) at a current density of 10 mA g^{-1}	
80	Shaddock peel	Graphene-Co/CoO shaddock peel-derived carbon foam hybrid as anode materials	1 M $LiPF_6$ in a mixture of EC, DEC, and DMC	Capacity of 600 mAh g^{-1} at 0.2 A g^{-1} after 80 times	160
81	Banana peel	Banana peel pseudographite as anode materials	1 M $LiPF_6$ in a 1:1:1 volume ratio of EC, DEC and DMC	Capacity of 1090 mAh g^{-1} at 50 mA g^{-1}	161
82	Spongy pomelo peel	Carbonaceous material as an anode material	1 M $LiPF_6$ in a mixture of EC, DMC and EMC (in a volume ratio of 1:1:1)	Capacity of 452 mAh g^{-1} at a current density of 90 mAg^{-1} after 200 cycles	162
83	Wheat bran	Carbon anode	1 M $LiPF_6$ in EC, EMC, and DMC (1:1:1, v/v)	Reversible capacity of 515 mAh g^{-1} and corresponding retention of 92% after 1000 charge/discharge cycles	163
84	Rice husk	Silicon/carbon as anode materials	1 M $LiPF_6$ in 1:1 (v/v) EC and DMC with 5 % FEC as an additive	Reversible capacity of 1309 mAh g^{-1} after 300 cycles	164
85	Barley husk ash	Porous silicon composite as anode material	1 M $LiPF_6$ in (1:1 v/v) EC:DMC	Average discharge capacity of 2049 mAh g^{-1} and 472 mAh g^{-1} at the rate of 0.1 C and 1 C, respectively	165
86	Sunfower stalk and walnut shell	Porous carbon microsphere as anode materials	1 M $LiPF_6$ in EC and DEC (1:1 vol%)	The capacity of the carbon microsphere originating from Sunflower stalk and walnut shell are 145.9 and 235.3 mAh g^{-1} after 50 cycles, respectively	166
87	Shaddock peel	SiO_x-modified porous biocarbon as an anode material	1 M $LiPF_6$ in a mixture of EC, DMC and EMC (1:1:1 w/w)	Reversible capacity of 740 mAh g^{-1} at a current density of 0.358	167

				A·g^{-1} after 100 cycles	
88	Coffee beans	α-Fe_2O_3 nano coffee beans as anode materials	1 M $LiPF_6$ in EC/DMC (1:1 v%)	Reversible capacity of 810 mAh g^{-1} (0.2 C)	[168]
89	Broad bean shells	Sulfur and nitrogen dual-doping porous carbon materials as anode materials	1 M $LiPF_6$ in EC and DMC with a volume ratio of 1:1	-	[169]
90	Soya bean seed (*Glysin maze*), Bagasse fibers (*Sacharum officinarum*) and Semer Cotton (*Bombax ceiba*)	Carbon anode	$LiPF_6$ (1 wt.%) in EC:DMC (1:20 solution)	Bagasse is the best precursor	[170]
91	Coffee bean	Carbon anodes	1 M $LiPF_6$ in 1:1 EC and DMC for mesocarbon microbead cells and in 1:1 propylene carbonate and DMC for non-graphitizable carbon cells	-	[171]
92	Wheat straw	Hierarchical nitrogen-rich porous carbon (HNPC) as an anode material	-	Initial reversible capacity of 792.41 mAh g^{-1} with coulombic efficiency of 88.61%	[172]
93	Wheat straw	SnO_2/C as an anode material	1 M $LiPF_6$/EC:DMC:EMC (1:1:1 in volume)	Initial capacity of 517.6 mAh g^{-1} and a capacity ratio of 52.9% at 0.05 C (80 mA g^{-1}) after 100 cycles	[173]
94	Wheat	Few-layer graphene as	1 M $LiPF_6$ in EC/DMC (1:1	Reversible capacity of	[174]

	straw	an anode material	by volume)	502 mAh g^{-1} at 0.1 C, rate capability of 463.5, 431.4, and 306.8 mAh g^{-1} at 1, 2, and 5 C, respectively, and cycling performance of 392.8 mAh g^{-1} at 1 C after 300 cycles	
95	Wheat straw	Hierarchically porous nitrogen-rich carbon as an anode material	-	Specific capacity of 1470 mAh g^{-1} at 0.037 A g^{-1}	[175]
96	Rice husk	Hierarchically porous carbons	1 M $LiPF_6$ in EC and DEC (1:1, v/v)	Specific capacity of 541 mAh g^{-1} after 800 cycles at 1 A g^{-1}	[176]

[a] 3D aerogels based on the in-situ growth of tetragonal molybdenum disulfide (1T-MoS_2) on hydrothermally acid-treated porous carbon (HAPC) derived from sugarcane bagasse and rGO composites.

Table S5. Agricultural wastes-derived carbon for lithium-sulfur batteries (Li-SBs).

Entry	Source	Li-SBs applications	Highlights	Ref.
1	Snake skin fruit peel (SFP)	The synthesized porous carbon using SFP applied as cathode along with sulfur (Carbon-S)	Carbon-sulfur electrodes demonstrated initial specific capacity of 945 mAh g^{-1} and good capacity retention until the 100th cycle at 0.1 C rate	177
2	Bagasse	S/Bagasse-based 3D carbon matrix (BC) used as a cathode	S/BC cathode delivered specific capacity of 1360 mAh g^{-1} at 0.2 C and remained at 790 mAh g^{-1} after 200 cycles	178
3	Pomelo peel	N-D porous carbon-derived pomelo peel used as an advanced sulfur host for the improvement of Li-SBs performance	The sulfur composite electrodes displayed an ultrahigh initial capacity of 1534.6 mAh g^{-1}, high coulombic efficiency of over 98% upon 300 cycles, and decent rate capability of up to 2 C	179
4	Rice husk	Rice husks-derived hierarchical porous SiO_2@C-2.5S used as a cathode	SiO_2@C-2.5S cathode delivered high reversible capacity of 1218 mAh g^{-1} at 0.2 C, superior rate capability of 553 mAh g^{-1} at 2 C and outstanding cycling stability with a low capacity fading of 0.104% after 300 cycles at 0.5 C	180
5	Garlic peel	The porous carbon synthesized using hydrothermal treatment (GPC/HT) applied as cathode along with sulfur (GPC/HT-S)	The GPC/HT-S with a sulfur content of 87.6 wt.% demonstrated high initial specific capacity of 1087 mAh g^{-1} at 0.1 C and good cycle retention of 72.2% after 400 cycles at 0.5 C	181
6	Corn husk	Co/3D carbon/rGO decorated pomelo peel separator applied in Li-SBs with 3DC/S as a cathode	Stable reversible capacity of 516.3 mAh g^{-1} after 500 cycles	182
7	Rice husk	Rice husk-derived SiO_x@carbon nanocomposites used as cathodes	The composite showed high capacity and good stability (675 mAh g^{-1} after 100 cycles at 0.1 C	183

Table S6. Different agriculture wastes for DSSCs applications.

Entry	Source	DSSCs applications	Highlights	Ref.
1	Spinach, pitaya pericarp, orange peel, ginkgo leaf, purple cabbage and carrot	Dyes sensitizers	Higher and lower conversion efficiencies of 0.157 and 0.01% were obtained using purple cabbage and carrot, respectively	184
2	*Acanthus sennii chiovenda* flower and *Euphorbia cotinifolia* leaf	Light harvesting pigments	-	185
3	Red dragon fruit peel	Natural sensitizer	Open Circuit-Voltage = 0.47 V, Jsc = 23.46 μAcm^{-2}, fill factor = 0.480 and efficiency of 0.029%	186
4	Cochineal, papaya peel, and the microalga Scenedesmus obliquus	Natural sensitizer	The high efficiencies of 0.228, 0.093 and 0.064% were achieved using cochineal, papaya peel extract and Scenedesmus obliquus extract, respectively	187
5	Pomelo peel	Counter electrode catalyst	-	188
6	Guar Gum	Polymer gel electrolyte	Power conversion efficiency of 4.96%	189
7	Peels of *Musa paradisiaca*, *Mangifera indica*, *Punica granatum*, and *Ananas comosus*	Photosensitizer	Solar to electrical energy efficiencies of natural dye-based on ZnO DSSCs for *Musa paradisiaca*, *Mangifera indica*, *Punica granatum*, and *Ananas comosus* were 0.009, 0.024, 0.010, and 0.002%, respectively	190
8	Red grape peel (*Vitis Vinifera*), jengkol peel (*Pithecellobium jiringa*), senduduk fruit (*Melastoma malabathricum L*), and mangosteen peel (*Garcinia Mangostana L*)	Natural dye co-pigmented	The highest efficiency in DSSC was obtained using TiO_2-Ag and mangosteen peel as the dye source	191
9	Onion peel	Natural sensitizer	η = 0.0413%, Jsc = 0.6031 $mAcm^{-2}$	192

			and fill factor of 0.2764	
10	A mixture of waste orange-apple peels	Counter electrode (Se@activated carbon)	The DSSC with a Se@activated carbon-based composite (synthesized *via* Se incorporation on the porous activated carbon derived from fruit peel wastes) counter electrode of 5.67% PCE with long stability	[193]
11	Limonene extracted from orange peel	Additive	η = 4.4%, Jsc = 8.94 mAcm^{-2}, Open Circuit-Voltage = 887 mV, fill factor of 0.55% and efficiency of 4.4%	[194]
12	Cornelian cherry, black pomegranate, ruby grape, and tangerine peel	Photosensitizer	-	[195]
13	*Rhamnus tinctoria* seed, *Rubia fruticosa* fruits, and *Pinus pinea* bark	Natural sensitizer	-	[196]
14	*Mussaenda erythrophylla*	Natural sensitizer	-	[197]

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