

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
1.	Features of commercial Supercapacitor and their manufacturers	3
2.	Report on carbon prepared from various biomass and its comparative electrochemical performance	17
3.	Reports on Zinc Cobaltite and its comparative electrochemical performances	27
4.	List of chemicals used	31
5.	List of electrode materials prepared	32
6.	List of assembled all solid-state supercapacitor	38
7.	Comparison of XRD and Raman results of the S-Carbon with various literature	46
8.	Elemental composition of carbon from the stick of <i>P. juliflora</i>	51
9.	Comparison of prepared carbon content with various literature	52
10.	Comparison of specific capacitance of prepared carbon with various literature	60
11.	Fitted parameters of electrochemical impedance spectra of S-Carbon	61
12.	Elemental composition of B-Carbon	68
13.	Fitted parameters of electrochemical impedance spectra of B-Carbon	75
14.	Elemental composition of PB-Carbon	82
15.	Fitted parameters of electrochemical impedance spectra of PB-Carbon	88
16.	Comparison of performances for all the three carbons prepared from <i>P. juliflora</i>	89
17.	Parameters obtained from the Rietveld refinements for ZnCo ₂ O ₄	92
18.	Parameters calculated from the X-ray diffractogram of ZnCo ₂ O ₄	93
19.	Assignments of Raman peaks of ZnCo ₂ O ₄	94
20.	Elemental composition of ZnCo ₂ O ₄	96
21.	Comparison of specific capacitance of ZnCo ₂ O ₄ value with various literature	100
22.	Fitted parameters of electrochemical impedance spectra of ZnCo ₂ O ₄	102
23.	Parameters obtained from the Rietveld refinements for Fe,Cr:ZnCo ₂ O ₄	107

TABLE NO.	TITLE	PAGE NO.
24.	Parameters calculated from the X-ray diffractogram of Fe,Cr:ZnCo ₂ O ₄	107
25.	Assignments of Raman peaks of Fe,Cr:ZnCo ₂ O ₄	108
26.	Elemental composition of Fe,Cr:ZnCo ₂ O ₄	110
27.	Fitted parameters of electrochemical impedance spectra of Fe,Cr:ZnCo ₂ O ₄	114
28.	Parameters obtained from the Rietveld refinements for Ni,Cr:ZnCo ₂ O ₄	118
29.	Parameters calculated from the X-ray diffractogram of Ni,Cr:ZnCo ₂ O ₄	118
30.	Assignments of Raman peaks of Ni,Cr:ZnCo ₂ O ₄	120
31.	Elemental composition of Ni,Cr:ZnCo ₂ O ₄	121
32.	Fitted parameters of electrochemical impedance spectra of Ni,Cr:ZnCo ₂ O ₄	126
33.	Comparison of performance of the prepared undoped and doped ZnCo ₂ O ₄	127
34.	Gravimetric and areal performance of symmetric supercapacitor devices with carbon electrodes	135
35.	Comparison of Energy and Power density of fabricated symmetric device using prepared carbon with various literature	136
36.	Fitted parameters of electrochemical impedance spectra of S-Carbon /PVA-KOH/ S-Carbon device	139
37.	Fitted parameters of electrochemical impedance spectra of B-Carbon/PVA-KOH/ B-Carbon device	140
38.	Fitted parameters of electrochemical impedance spectra of PB-Carbon /PVA-KOH/ PB-Carbon device	141
39.	Gravimetric and areal performance of symmetric supercapacitor device with doped and undoped ZnCo ₂ O ₄ electrodes	148
40.	Fitted parameters of electrochemical impedance spectra of ZnCo ₂ O ₄ /PVA-KOH/ZnCo ₂ O ₄ device	150
41.	Fitted parameters of electrochemical impedance spectra of Fe,Cr:ZnCo ₂ O ₄ /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	151
42.	Fitted parameters of electrochemical impedance spectra of Ni,Cr:ZnCo ₂ O ₄ /PVA-KOH/Ni,Cr:ZnCo ₂ O ₄ device	152

TABLE NO.	TITLE	PAGE NO.
43.	Gravimetric and areal performance of asymmetric supercapacitor devices of S-Carbon with undoped and doped ZnCo ₂ O ₄	162
44.	Comparison of Energy and Power density of fabricated asymmetric device using prepared carbon with various literature	164
45.	Fitted parameters of electrochemical impedance Spectra of S-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	166
46.	Fitted parameters of electrochemical impedance spectra of S-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	167
47.	Fitted parameters of electrochemical impedance spectra of S-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	168
48.	Gravimetric and areal performance of asymmetric supercapacitor devices of B-carbon with undoped and doped ZnCo ₂ O ₄ device	175
49.	Fitted parameters of electrochemical impedance spectra of B-Carbon/PVA-KOH/ ZnCo ₂ O ₄ device	177
50.	Fitted parameters of electrochemical impedance spectra of B-Carbon/PVA-KOH/Fe,Cr :ZnCo ₂ O ₄ device	178
51.	Fitted parameters of electrochemical impedance spectra of B-Carbon/PVA-KOH/Ni,Cr:ZnCo ₂ O ₄ device	179
52.	Gravimetric and areal performance of asymmetric supercapacitor devices of PB-carbon with undoped and doped ZnCo ₂ O ₄	186
53.	Fitted parameters of electrochemical impedance spectra of PB-Carbon/PVA-KOH/ ZnCo ₂ O ₄ device	188
54.	Fitted parameters of electrochemical impedance spectra of PB-Carbon/PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	189
55.	Fitted parameters of electrochemical impedance spectra of PB-Carbon/PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	190
56.	Gravimetric and areal performance of B-Carbon/PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device at various angles of bending at 2 Ag ⁻¹	194
57.	Fitted parameters of electrochemical impedance spectra of B-Carbon/PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device - before bending	195
58.	Fitted parameters of electrochemical impedance spectra of B-Carbon/PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device - after cycling	197

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE NO.
1.	Configuration of Supercapacitor	2
2.	Classification of Supercapacitors	4
3.	Atomic arrangements of Spinel structured metal oxides	8
4.	Pictorial flowchart for the preparation of carbon	33
5.	Pictorial flowchart for the preparation of Zinc cobaltite	35
6.	Pictorial flowchart for the preparation of working electrodes	37
7.	Pictorial flowchart for the device assembly	38
8.	The schematic of electrode setup: (a) Three electrode configuration and (b) two electrode configuration	39
9.	X-ray Diffractogram of S-Carbon	44
10.	Raman spectra of S-Carbon	45
11.	A_{1g} and E_{2g} vibrational modes of the six-membered rings of the two-dimensional graphite plane	46
12a.	FESEM micrograph of S-Carbon at lower magnification	48
12b.	FESEM micrograph of S-Carbon at higher magnification	48
13a.	HRTEM images of S-carbon at lower magnification	49
13b.	HRTEM images of S-carbon at higher magnification	50
13c.	FFT processed HRTEM image of S-carbon at higher magnification	50
14.	EDX spectrum of S-Carbon	51
15.	BET analysis of S-Carbon	53
16.	Pore size distribution of S-Carbon	54
17.	Cyclic voltammogram of S-Carbon	55
18.	Galvanostatic Charge-Discharge curves of S-Carbon	56
19.	Plot of current density vs specific capacitance of S-Carbon	57
20.	Cyclic stability of S-Carbon	58
21.	Electrochemical impedance spectra of S-Carbon before and after cycling	59

FIGURE NO.	TITLE	PAGE NO.
22.	Equivalent circuit obtained from electrochemical impedance spectra S-Carbon	59
23.	X-ray Diffractogram of B-Carbon	63
24.	Raman spectra of B-Carbon	63
25a.	FESEM micrograph of B-Carbon at lower magnification	65
25b.	FFT processed FESEM micrograph of B-Carbon at higher magnification	65
26a.	HRTEM images of B-Carbon at lower magnification	66
26b.	HRTEM images of B-Carbon at higher magnification	66
26c.	FFT processed HRTEM image of B-Carbon at higher magnification	67
27.	EDX spectrum of B-Carbon	68
28.	BET analysis of B-Carbon	69
29.	Pore size distribution of B-Carbon	70
30.	Cyclic voltammogram of B-Carbon	72
31.	Galvanostatic Charge-Discharge curves of B-Carbon	72
32.	Plot of current density vs specific capacitance of B-Carbon	73
33.	Cyclic stability of B-Carbon	73
34.	Electrochemical impedance spectra of B-Carbon before and after cycling	74
35.	X-ray Diffractogram of PB-Carbon	76
36a.	Raman spectra of PB-Carbon	77
36b.	Raman spectra of PB-Carbon – Deconvoluted 2D band	77
37a.	FESEM micrograph of PB-Carbon at lower magnification	79
37b.	FESEM micrograph of PB-Carbon at higher magnification	79
38a.	HRTEM images of PB-Carbon at lower magnification	80
38b.	HRTEM images of PB-Carbon at higher magnification	80
38c.	FFT processed HRTEM image of PB-Carbon at higher magnification	81
39.	EDX spectrum of PB-Carbon	82
40.	BET analysis of PB-Carbon	83

FIGURE NO.	TITLE	PAGE NO.
41.	Pore size distribution of PB-Carbon	84
42.	Cyclic voltammogram of PB-Carbon	85
43.	Galvanostatic Charge-Discharge curves of PB-Carbon	86
44.	Plot of current density vs specific capacitance of PB Carbon	86
45.	Cyclic stability of PB-Carbon	87
46.	Electrochemical impedance spectra of PB-Carbon before and after cycling	88
47.	Rietveld refined X-ray Diffractogram of ZnCo ₂ O ₄	91
48.	Rietveld refined crystal structure of ZnCo ₂ O ₄ ; inset shows the position of oxygen	92
49.	Raman spectra of ZnCo ₂ O ₄	93
50.	Vibration modes of ZnCo ₂ O ₄	94
51.	FESEM micrographs of ZnCo ₂ O ₄	95
52.	EDX spectrum of ZnCo ₂ O ₄	95
53.	Cyclic voltammogram of ZnCo ₂ O ₄	97
54.	Plot of scan rate vs specific capacitance of ZnCo ₂ O ₄	97
55.	Galvanostatic Charge-Discharge curves of ZnCo ₂ O ₄	99
56.	Cyclic stability of ZnCo ₂ O ₄	99
57.	Electrochemical impedance spectra of ZnCo ₂ O ₄	101
58.	Rietveld refined X-ray Diffractogram of Fe,Cr:ZnCo ₂ O ₄	105
59.	Rietveld refined crystal structure of Fe,Cr:ZnCo ₂ O ₄ ; inset shows the position of oxygen	106
60.	Raman spectra of Fe,Cr:ZnCo ₂ O ₄	108
61.	FESEM micrographs of Fe,Cr:ZnCo ₂ O ₄	109
62.	EDX spectrum of Fe,Cr:ZnCo ₂ O ₄	110
63.	Cyclic voltammogram of Fe,Cr:ZnCo ₂ O ₄	111
64.	Plot of scan rate vs specific capacitance of Fe,Cr:ZnCo ₂ O ₄	111
65.	Galvanostatic Charge-Discharge curves of Fe,Cr:ZnCo ₂ O ₄	112
66.	Cyclic stability of Fe,Cr:ZnCo ₂ O ₄	113

FIGURE NO.	TITLE	PAGE NO.
67.	Electrochemical impedance spectra of Fe,Cr:ZnCo ₂ O ₄	114
68.	Rietveld refined X-ray Diffractogram of Ni,Cr:ZnCo ₂ O ₄	117
69.	Rietveld refined crystal structure of Ni,Cr:ZnCo ₂ O ₄ ; inset shows the position of oxygen	117
70.	Raman spectra of Ni,Cr:ZnCo ₂ O ₄	119
71.	FESEM micrographs of Ni,Cr:ZnCo ₂ O ₄	120
72.	EDX spectrum of Ni,Cr:ZnCo ₂ O ₄	121
73.	Cyclic voltammogram of Ni,Cr:ZnCo ₂ O ₄	122
74.	Plot of scan rate vs specific capacitance of Ni,Cr:ZnCo ₂ O ₄	123
75.	Galvanostatic Charge-Discharge curves of Ni,Cr:ZnCo ₂ O ₄	124
76.	Cyclic stability of Ni,Cr:ZnCo ₂ O ₄	124
77.	Electrochemical impedance spectra of Ni,Cr:ZnCo ₂ O ₄	125
78a.	Cyclic voltammogram of S-Carbon/PVA-KOH/S-Carbon	129
78b.	Cyclic voltammogram of B-Carbon/PVA-KOH/B-Carbon	129
78c.	Cyclic voltammogram of PB-Carbon/PVA-KOH/PB-Carbon	129
79a.	Power law dependence of charge storage mechanism for S-Carbon/PVA-KOH/S-Carbon	131
79b.	Power law dependence of charge storage mechanism for B-Carbon/PVA-KOH/B-Carbon	131
79c.	Power law dependence of charge storage mechanism for PB-Carbon/PVA-KOH/PB-Carbon	131
80a.	Capacitive contribution of S-Carbon/PVA-KOH/S-Carbon device	132
80b.	Capacitive contribution of B-Carbon/PVA-KOH/B-Carbon device	132
80c.	Capacitive contribution of PB-Carbon/PVA-KOH/ PB-Carbon device	132
81a.	Galvanostatic Charge-Discharge curves of S-Carbon/PVA-KOH/ S-Carbon device	133
81b.	Galvanostatic Charge-Discharge curves of B-Carbon/PVA-KOH/ B-Carbon device	133

FIGURE NO.	TITLE	PAGE NO.
81c.	Galvanostatic Charge-Discharge curves of PB-Carbon/PVA-KOH/ PB-Carbon device	134
82a.	Cyclic stability of S-Carbon /PVA-KOH/ S-Carbon device at 3 Ag^{-1}	137
82b.	Cyclic stability of B-Carbon /PVA-KOH/B-Carbon device at 3 Ag^{-1}	137
82c.	Cyclic stability of PB-Carbon /PVA-KOH/PB-Carbon device at 3 Ag^{-1}	137
83a.	Electrochemical impedance spectra of S-Carbon /PVA-KOH/ S-Carbon device	139
83b.	Electrochemical impedance spectra of B-Carbon /PVA-KOH/ B-Carbon device	140
83c.	Electrochemical impedance spectra of PB-Carbon /PVA-KOH/ PB-Carbon device	141
84a.	Cyclic voltammogram of ZnCo_2O_4 /PVA-KOH/ ZnCo_2O_4 device	143
84b.	Cyclic voltammogram of Fe,Cr: ZnCo_2O_4 /PVA-KOH/ Fe,Cr: ZnCo_2O_4 device	143
84c.	Cyclic voltammogram of Ni,Cr: ZnCo_2O_4 /PVA-KOH/ Ni,Cr: ZnCo_2O_4 device	143
85a.	Power law dependence of charge storage mechanism for ZnCo_2O_4 /PVA-KOH/ ZnCo_2O_4 device	145
85b.	Power law dependence of charge storage mechanism for Fe,Cr: ZnCo_2O_4 /PVA-KOH/ Fe,Cr: ZnCo_2O_4 device	145
85c.	Power law dependence of charge storage mechanism for Ni,Cr: ZnCo_2O_4 /PVA-KOH/ Ni,Cr: ZnCo_2O_4 device	145
86a.	Capacitive contribution of ZnCo_2O_4 /PVA-KOH/ ZnCo_2O_4 device	146
86b.	Capacitive contribution of Fe,Cr: ZnCo_2O_4 /PVA-KOH/Fe,Cr: ZnCo_2O_4 device	146
86c.	Capacitive contribution of Ni,Cr: ZnCo_2O_4 /PVA-KOH/Ni,Cr: ZnCo_2O_4 device	146
87a.	Galvanostatic Charge-Discharge curves of ZnCo_2O_4 /PVA-KOH/ ZnCo_2O_4 device	147
87b.	Galvanostatic Charge-Discharge curves of Fe,Cr: ZnCo_2O_4 /PVA-KOH/ Fe,Cr: ZnCo_2O_4 device	147

FIGURE NO.	TITLE	PAGE NO.
87c.	Galvanostatic Charge-Discharge curves of Ni,Cr:ZnCo ₂ O ₄ /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	147
88a.	Cyclic stability of ZnCo ₂ O ₄ /PVA-KOH/ZnCo ₂ O ₄ device	149
88b.	Cyclic stability of Fe,Cr:ZnCo ₂ O ₄ /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	149
88c.	Cyclic stability of Ni,Cr:ZnCo ₂ O ₄ /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	149
89a.	Electrochemical impedance spectra of ZnCo ₂ O ₄ /PVA-KOH/ZnCo ₂ O ₄ device	150
89b.	Electrochemical impedance spectra of Fe,Cr:ZnCo ₂ O ₄ /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	151
89c.	Electrochemical impedance spectra of Ni,Cr:ZnCo ₂ O ₄ /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	152
90.	Comparison of Energy and Power density of all fabricated symmetric supercapacitor devices – Ragone plot	154
91a.	Cyclic voltammogram of S-Carbon/PVA-KOH/ZnCo ₂ O ₄ device	156
91b.	Cyclic voltammogram of S-Carbon/PVA-KOH/Fe,Cr:ZnCo ₂ O ₄ device	156
91c.	Cyclic voltammogram of S-Carbon/PVA-KOH/Fe,Cr:ZnCo ₂ O ₄ device	156
92a.	Power law dependence of charge storage mechanism for S-Carbon/PVA-KOH/ZnCo ₂ O ₄ device	158
92b.	Power law dependence of charge storage mechanism for S-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	158
92c.	Power law dependence of charge storage mechanism for S-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	158
93a.	Capacitive contribution of S-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	160
93b.	Capacitive contribution of S-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	160
93c.	Capacitive contribution of S-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	160
94a.	Galvanostatic Charge-Discharge curves of S-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	161

FIGURE NO.	TITLE	PAGE NO.
94b.	Galvanostatic Charge-Discharge curves of S-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	161
94c.	Galvanostatic Charge-Discharge curves of S-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	161
95a.	Cyclic stability of S-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	163
95b.	Cyclic stability of S-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	163
95c.	Cyclic stability of S-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	163
96a.	Electrochemical impedance spectra of S-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	166
96b.	Electrochemical impedance spectra of S-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	167
96c.	Electrochemical impedance spectra of S-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	168
97a.	Cyclic voltammogram of B-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	170
97b.	Cyclic voltammogram of B-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	170
97c.	Cyclic voltammogram of B-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	170
98a.	Power law dependence of charge storage mechanism for B-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	171
98b.	Power law dependence of charge storage mechanism for B-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	172
98c.	Power law dependence of charge storage mechanism for B-Carbon /PVA-KOH/ Ni,Cr: ZnCo ₂ O ₄ device	172
99a.	Capacitive contribution of B-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	173
99b.	Capacitive contribution of B-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	173
99c.	Capacitive contribution of B-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	173
100a.	Galvanostatic Charge-Discharge curves of B-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	174
100b.	Galvanostatic Charge-Discharge curves of B-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	174

FIGURE NO.	TITLE	PAGE NO.
100c.	Galvanostatic Charge-Discharge curves of B-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	174
101a.	Cyclic stability of B-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	176
101b.	Cyclic stability of B-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	176
101c.	Cyclic stability of B-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	176
102a.	Electrochemical impedance spectra of B-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	177
102b.	Electrochemical impedance spectra of B-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	178
102c.	Electrochemical impedance spectra of B-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	179
103a.	Cyclic voltammogram of PB-Carbon /PVA-KOH/ ZnCo ₂ O ₄ device	182
103b.	Cyclic voltammogram of PB-Carbon /PVA-KOH/ Fe,Cr:ZnCo ₂ O ₄ device	182
103c.	Cyclic voltammogram of PB-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	182
104a.	Power law dependence of charge storage mechanism for PB-Carbon/PVA-KOH/ZnCo ₂ O ₄ device	183
104b.	Power law dependence of charge storage mechanism for PB-Carbon/PVA-KOH/Fe,Cr:ZnCo ₂ O ₄ device	183
104c.	Power law dependence of charge storage mechanism for PB-Carbon/PVA-KOH/Ni,Cr:ZnCo ₂ O ₄ device	183
105a.	Capacitive contribution of PB-Carbon /PVA-KOH/ZnCo ₂ O ₄ device	184
105b.	Capacitive contribution of PB-Carbon/PVA-KOH/Fe,Cr:ZnCo ₂ O ₄ device	184
105c.	Capacitive contribution of PB-Carbon/PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device	184
106a.	Galvanostatic Charge-Discharge curves of PB-Carbon/PVA-KOH/ZnCo ₂ O ₄ device	185
106b.	Galvanostatic Charge-Discharge curves of PB-Carbon/PVA-KOH/Fe,Cr:ZnCo ₂ O ₄ device	185

FIGURE NO.	TITLE	PAGE NO.
106c.	Galvanostatic Charge-Discharge curves of PB-Carbon/PVA-KOH/Ni,Cr:ZnCo ₂ O ₄ device	185
107a.	Cyclic stability of PB-Carbon/PVA-KOH/ZnCo ₂ O ₄ device	187
107b.	Cyclic stability of PB-Carbon/PVA-KOH/Fe,Cr:ZnCo ₂ O ₄ device	187
107c.	Cyclic stability of PB-Carbon/PVA-KOH/Ni,Cr:ZnCo ₂ O ₄ device	187
108a.	Electrochemical impedance spectra of PB-Carbon/PVA-KOH/ZnCo ₂ O ₄ device	188
108b.	Electrochemical impedance spectra of PB-Carbon/PVA-KOH/Fe,Cr:ZnCo ₂ O ₄ device	189
108c.	Electrochemical impedance spectra of PB-Carbon/PVA-KOH/Ni,Cr:ZnCo ₂ O ₄ device	190
109a.	Performance Comparison of all devices at a current density of 1 Ag ⁻¹	191
109b.	Performance Comparison of all devices at a current density of 2 Ag ⁻¹	192
110.	Flexibility of B-Carbon/PVA-KOH/Ni,Cr:ZnCo ₂ O ₄ device	193
111.	Cyclic voltammogram of B-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device at various angles of bending at 100mV/s	193
112.	Galvanostatic Charge-Discharge curves of B-Carbon /PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device at various bending states at 2 Ag ⁻¹	194
113.	Electrochemical impedance spectra of B-Carbon/PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device before bending	195
114.	Cyclic stability of B-Carbon/PVA-KOH/Ni,Cr:ZnCo ₂ O ₄ device after bending	196
115.	Electrochemical impedance spectra of B-Carbon/PVA-KOH/ Ni,Cr:ZnCo ₂ O ₄ device – before and after cycling	196
116.	Comparison of Energy and Power density of all fabricated asymmetric supercapacitor devices – Ragone plot	198

Abbreviations

SCs	-	Supercapacitors
EDLCs	-	Electric Double Layer Capacitors
ASSS	-	All Solid State Supercapacitors
TMOs	-	Transition Metal Oxides
AC	-	Activated Carbon
FWHM	-	Full Width Half Maximum
COD	-	Crystallographic Open Database
GOF	-	Goodness of Fit
CE	-	Counter Electrode
CV	-	Cyclic Voltammetry
GCD	-	Galvanostatic Charge-Discharge
Pt	-	Platinum
RE	-	Reference Electrode
SEI	-	Solid Electrolyte Interface
FESEM	-	Field Emission Scanning Electron Microscopy
SHE	-	Standard Hydrogen electrode
HRTEM	-	High Resolution Transmission Electron Microscopy
XRD	-	X-ray Diffractogram
BET	-	Brunauer-Emmett-Teller
EIS	-	Electrochemical Impedance Spectroscopy
BJH	-	Barrett, Joyner, and Halenda

Symbols, Constants and Units

(h,k,l)	-	Miller indices
$^{\circ}$ (C)	-	Degree Celsius
2θ	-	Diffraction Angle ($^{\circ}$)
\AA	-	Angstrom
a, c	-	Lattice parameters
a.u.	-	Arbitrary units
CPE	-	Constant Phase Element
C_{sp}	-	Specific capacitance
d	-	Interplanar spacing
E_{we-}	-	Potential of working electrode
Fg^{-1}	-	Farad per gram
F	-	Farad
Hz	-	Hertz
E	-	Energy density
P	-	Power density
C_A	-	Areal capacitance
E_A	-	Areal energy density
P_A	-	Areal power density
nm	-	nanometer
R	-	Resistance (Ω)
R_{ct}	-	Charge transfer resistance
Wh/Kg	-	Watt hour per kilogram
W/Kg	-	Watt per kilogram

W_R	-	Weighed R factor
mF/cm^2	-	milli farad centimeter square
V	-	Volume of the unit cell
wt %	-	Weight percentage
Z	-	Impedance
$Re (Z)$	-	Real impedance
$- Im (Z)$	-	Imaginary impedance
α, β, γ	-	Crystallographic angles
ΔE (in CV)	-	Potential difference
ε	-	Strain
λ	-	Wavelength (nm)
μm	-	micrometer
Ω	-	Ohm