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Design and development of proton exchange membrane (PEM) from synthetic rubber and carbon nanoballs for PEM fuel cell

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TABLE OF RESULTS

Table A1**:** Actual values of sulphur content, degree of sulphonation and ion exchange capacity on effect of stirring speed of PSBR sulphonation

	Stirring Speed (RPM)					
	250	**500**	**750**	**1000**	**1250**	**1500**
Sc (%)	2.83	3.25	3.34	3.68	3.68	4.98
DS (%)	15.03	17.42	18.03	20.07	23.53	28.19
IEC (mmol/g)	0.883	1.015	1.045	1.152	1.329	1.559

Table A2: Effects of Acid Concentration on the Degree of Sulphonation and Ion Exchange Capacity of PSBR

Acid Concentration (M/ml)	DS (%)	Ion Exchange Capacity (mmol/g)
0.4	6.73	0.412
0.6	9.13	0.552
0.8	11.92	0.711
1	12.34	0.735
1.2	13.13	0.779
1.4	15.39	0.903
1.6	20.04	1.15
1.8	18.35	1.062
2	16.76	0.977

Table A3: Effects of Acid Concentration on DS, IEC and Viscosity on PSBR

IEC (mmol/g)	DS (%)	Viscosity dl/g
0.412	6.73	0.58
0.552	9.13	0.63
0.711	11.92	0.68
0.735	12.34	0.68
0.779	13.13	0.69
0.903	15.39	0.74
1.15	20.04	0.8

Table A4: Effects of Stirring Speed on Degree of Sulphonation and Ion Exchange Capacity

Stirring Speed (rpm)	Degree of Sulphonation (%)	Ion Exchange Capacity (mmol/g)
250	4.76	0.3
500	5.37	0.3375
750	6.17	0.388
1000	6.77	0.425
1250	7.65	0.4625
1500	20.45	1.263

Table A5: Effects of Stirring Speed on Degree of Sulphonation and Ion Exchange Capacity

Stirring Speed (rpm)	Degree of Sulphonation (%)	Ion Exchange Capacity (mmol/g)
250	4.76	0.3
500	5.37	0.3375
750	6.17	0.388
1000	6.77	0.425
1250	7.65	0.4625
1500	20.45	1.263

Table A6: Effects of Temperature on Degree of Sulphonation

Sulphonation time (hrs)	Sulphonation temp=22^{o}C	Sulphonation temp=35^{o}C	Sulphonation temp=55^{o}C	Sulphonation temp =75^{o}C
3	9.78	11.09	17	20.04
6	11.02	14.97	22.96	25.95
9	14.24	18.32	26.37	32.65
12	15.34	23.95	32.86	42.3
15	19.08	25.96	37.93	46.83
18	21	29.67	44.9	55.38
21	25.15	34.82	48.54	59.89
24	27.59	39.75	58.01	66.82

Table A7: Effects of Temperature on Ion Exchange Capacity

Sulphonation time (hrs)	Sulphonation temp=22^{o}C	Sulphonation tempt=35^{o}C	Sulphonation tempt=55^{o}C	Sulphonation tempt=75^{o}C
3	0.59	0.71	0.99	1.15
6	0.66	0.88	1.3	1.45
9	0.84	1.06	1.47	1.77
12	0.9	1.35	1.78	2.2
15	1.1	1.45	2.01	2.39
18	1.2	1.63	2.31	2.73
21	1.41	1.87	2.46	2.9
24	1.53	2.09	2.83	3.15

Table A8: Effects of Time on Degree of Sulphonation and Ion exchange capacity of PSBR

Time (hrs)	Degree of Sulphonation (%)	Ion Exchange Capacity (mmol/g)
2	13.22	0.784
4	14.84	0.873
6	18.16	1.052
8	22.74	1.289
10	28.07	1.553
12	29.35	1.615
14	31.17	1.701
16	32.6	1.768
18	34.18	1.841
20	35.34	1.894
22	37.23	1.979
24	39.38	2.074
36	23.45	1.325
48	22.93	1.299

Table A9: Effects of Time on the Degree of Sulphonation and Viscosity of PSBR

Time (hrs)	Degree of Sulphonation (mmol/g)	(Viscosity dl/g)
2	13.22	0.69
4	14.84	0.72
6	18.16	0.78
8	22.74	0.83
10	28.07	0.97
12	29.35	1.09
14	31.17	1.13
16	32.6	1.19
18	34.18	1.37
20	35.34	1.4
22	37.23	1.53
24	39.38	1.61
36	23.45	0.95
48	22.93	0.84

Table 10: Water uptake at different degree of sulphonation and constant membrane thickness of 350µm

Time (Days)	DS=5.85	DS=9.4	DS=18.16	DS=28.07	DS=37.23	DS=39.38
0	0	0	0	0	0	0
1	9.7356	12.81	19.215	26.901	33.306	39.711
2	13.3456	17.56	26.34	36.876	45.656	54.436
3	15.6712	20.62	30.93	43.302	53.612	63.922
4	17.1304	22.54	33.81	47.334	58.604	69.874
5	17.1304	22.54	33.81	47.334	58.604	69.874
6	17.1304	22.54	33.81	47.334	58.604	69.874
7	17.1304	22.54	33.81	47.334	58.604	69.874
8	17.1304	22.54	33.81	47.334	58.604	69.874

Table A11: Water uptake at different membrane thickness and constant degree of sulphonation (9.4%)

Time (Days)	Membrane Thickness (120µm)	Membrane Thickness (160µm)	Membrane Thickness (220µm)	Membrane Thickness (330µm)	Membrane Thickness (350µm)	Membrane Thickness (420µm)
0	0	0	0	0	0	0
1	16.75	18.57	32.39	27.86	12.81	7.33
2	24.18	27.14	34.66	30.96	17.56	10
3	35.24	37.14	39.21	32.2	20.62	12.67
4	48.45	50	45.46	33.13	22.54	16.67
5	55.78	52.86	46.59	38.08	22.54	16.67
6	60.33	54.29	46.59	41.49	22.54	16.67
7	60.33	54.29	46.59	41.49	22.54	16.67
8	60.33	54.29	46.59	41.49	22.54	16.67

Table A12: Effect of carbon nanoballs on the water uptake

Time (Days)	Mass of CNBs=0g	Mass of CNBs=0.1g	Mass of CNBs=0.2g	Mass of CNBs=0.3g	Mass of CNBs=0.4g
0	0	0	0	0	0
1	39.711	43.6821	46.06476	48.05031	55.5954
2	54.436	59.8796	63.14576	65.86756	76.2104
3	63.922	70.3142	74.14952	77.34562	89.4908
4	69.874	75.1267	79.51265	81.67995	94.73459
5	69.874	75.895	80.97652	83.78566	96.55897
6	69.874	76.8614	81.05384	84.54754	97.8236
7	69.874	76.814	81.05384	84.54754	97.8236
8	69.874	76.814	81.05384	84.54754	97.8236

Table A13: Effects of hydration and temperature on proton conductivity at different degrees of sulphonation

Degree of Sulphonation (%)	Partially hydrated (20°C)	Fully hydrated (20°C)	Fully Hydrated (35°C)	Fully hydrated (50°C)
2.2	0.001461	0.002283	0.002427	0.00265
3.76	0.002655	0.00347	0.003792	0.003973
3.96	0.002712	0.00357	0.003821	0.004139
4.75	0.003014	0.003601	0.004171	0.004218
5.85	0.00315	0.003687	0.004314	0.004536
8.23	0.003451	0.003714	0.004817	0.005279
11.92	0.003589	0.003798	0.005016	0.005745
12.34	0.00371	0.003877	0.005213	0.00618
28.07	0.004586	0.004791	0.006288	0.00815
34.18	0.004714	0.005493	0.006714	0.009346
37.23	0.005019	0.006312	0.008076	0.01287
39.38	0.005213	0.008154	0.009449	0.016076

Table A14: Effects of membrane thickness on the proton conductivity of the membrane at different degrees of sulphonation

Membrane Thickness (µm)	DS =2.2	DS =3.76	DS =3.96	DS =4.75	DS =9.4	DS =12.23	DS =25.49	DS =39.38
170	0.003632	0.0040663	0.00457126	0.0048743	0.00773332	0.0095125	0.009817	0.015839
190	0.003531	0.0039169	0.00429489	0.004544715	0.00742887	0.0093416	0.009716	0.013474
200	0.003433	0.0038082	0.00410792	0.004436695	0.00739656	0.0088775	0.00941	0.01332
220	0.003218	0.0036034	0.00400206	0.004274426	0.00707421	0.0081335	0.009086	0.013275
290	0.002942	0.0033701	0.00395628	0.004121	0.00693632	0.0074182	0.008716	0.013076
300	0.00285	0.0032299	0.00391534	0.004009	0.00676791	0.007319	0.008513	0.012928
320	0.002831	0.0031483	0.00385387	0.003917	0.00658318	0.007216	0.008218	0.012654
340	0.002789	0.003105	0.00381363	0.003894	0.00647464	0.007016	0.007914	0.012234
360	0.002714	0.0030547	0.00377255	0.003827	0.00625721	0.006917	0.007612	0.012195
380	0.002673	0.0028624	0.0036142	0.003732	0.00616228	0.006413	0.007432	0.011355
390	0.002595	0.0028216	0.0035846	0.003692	0.00615621	0.006298	0.007009	0.010688
450	0.002332	0.0026819	0.00344433	0.003584	0.00567058	0.005987	0.006985	0.009379

Table A15: Effects of carbon nanoballs on the proton conductivity of the membrane

Membrane Thickness (mm)	Mass of CNBs=0g	Mass of CNBs=0.1g	Mass of CNBs=0.2g	Mass of CNBs=0.3g	Mass of CNBs=0.4g
170	0.015839	0.016324	0.019165	0.022589	0.026748
190	0.013474	0.014821	0.016407	0.018365	0.020211
200	0.01332	0.014742	0.016117	0.018155	0.02001
220	0.013275	0.014602	0.016062	0.018093	0.019912
290	0.013076	0.014383	0.015821	0.017822	0.019613
300	0.012928	0.014221	0.015643	0.017621	0.019392
320	0.012654	0.013919	0.015311	0.017247	0.018981
340	0.012234	0.013457	0.014803	0.016674	0.01835
360	0.012195	0.013414	0.014755	0.016621	0.018292
380	0.011355	0.01249	0.013739	0.015477	0.017032
390	0.010688	0.011957	0.012933	0.014568	0.016033
450	0.009379	0.010418	0.011038	0.012783	0.014063

Table A16: Methanol molecule uptake per sulphonic group at different concentrations of methanol

Methanol Concentration (mol/dm^3)	DS= 3.86	DS =5.85	DS =10.48	DS =11.92	DS =12.34	DS =15.39	DS =29.45	DS =39.38
0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.50	5.1398	3.0839	2.4043	1.6220	1.5157	1.2980	0.7390	0.4894
1.00	10.0694	6.0417	4.7103	3.1776	2.9694	2.5428	1.4477	0.9588
2.00	19.4384	11.6631	9.0929	6.1342	5.7322	4.9088	2.7947	1.8510
4.00	37.6620	22.5973	17.6174	11.8850	11.1062	9.5107	5.4148	3.5862
6.00	56.0599	33.6360	26.2236	17.6909	16.5316	14.1567	8.0599	5.3381
8.00	72.7127	43.6277	34.0134	22.9460	21.4424	18.3620	10.4542	6.9239
10.00	89.5724	53.7436	41.9000	28.2665	26.4142	22.6196	12.8782	8.5293
12.00	105.0249	63.0152	49.1284	33.1429	30.9711	26.5219	15.0999	10.0008
24.63	115.5975	69.3590	54.0743	36.4797	34.0892	29.1922	16.6205	11.0081

Table A17: Effects of membrane thickness on the porosity of the membrane at different concentrations of methanol

Methanol concentration (mol/dm3)	Membrane thickness =120µm	Membrane Thickness =350µm	Membrane thickness =420µm
0	0.076356	0.0601132	0.048337
0.5	0.088663679	0.067029051	0.052224476
1	0.093280682	0.076316171	0.052810627
2	0.106368665	0.086842255	0.05583182
4	0.106857702	0.094534219	0.061504716
6	0.12218445	0.106189076	0.070628831
8	0.128650031	0.112710566	0.074434512
10	0.144161253	0.124128014	0.078209697
12	0.163187455	0.130270188	0.08146747
24	0.172151978	0.132897537	0.082340744

Table A18: Effects of carbon nanoballs on the porosity of the membrane

Methanol Concentration (M)	Mass of CNBs=0g	Mass of CNBs=0.1g	Mass of CNBs=0.2	Mass of CNBs=0.3g	Mass of CNBs=0.4g
0	0.076356	0.0559763	0.0496314	0.0475772	0.03894156
0.5	0.0886637	0.0668378	0.0596314	0.0560848	0.04821848
1	0.0932807	0.0691621	0.0616324	0.0639012	0.05357315
2	0.1063687	0.0765854	0.0701396	0.0668849	0.05524802
4	0.1168577	0.0789375	0.0734575	0.0681832	0.05849743
6	0.1221845	0.0879728	0.0814199	0.0745325	0.06231407
8	0.12865	0.092628	0.0836225	0.0784765	0.06561152
10	0.1441613	0.1137961	0.0937048	0.0879384	0.07352224
12	0.1631875	0.117495	0.1060718	0.0995443	0.087798
24	0.172152	0.1239494	0.1118988	0.1050127	0.091134

Table A19: Uptake of solution per sulphonic group

Methanol Concentration (M)	Total uptake of solution molecule	Total uptake of water molecule	Methanol molecule uptake
0	26.1013	26.1013	0
0.5	24.11007322	23.62063874	0.489434486
1	23.61641358	22.65758719	0.958826391
2	22.79510162	20.94413937	1.850962252
4	22.08273879	18.49650201	3.586236779
6	21.67330371	16.33516901	5.338134705
8	21.31730825	14.39344653	6.923861721
10	21.00816944	12.47885265	8.529316793
12	20.52703337	10.52626271	10.00077066
24.63	11.00805917	0	11.00805917

Table A20: Methanol crossover concentration at different degrees of sulphonation

Time	DS=3.37	DS=5.97	DS=15.17	DS=25.45	DS=39.2
0	0	0	0	0	0
1800	0.224455	0.17808	0.1827	0.1596	0.1134
3600	0.450765	0.350595	0.2772	0.2373	0.2016
5400	0.573195	0.532385	0.3654	0.3045	0.2772
7200	0.717885	0.654815	0.4263	0.3402	0.3318
9000	0.86814	0.754985	0.5061	0.3864	0.3696
10800	1.007265	0.855155	0.6006	0.4368	0.4053
12600	1.088885	0.93492	0.6594	0.5061	0.4641
14400	1.151955	1.06106	0.7413	0.6153	0.5502
16200	1.233575	1.118565	0.7875	0.7266	0.6321
18000	1.307775	1.21317	0.8337	0.8001	0.7182
19800	1.34673	1.266965	0.9261	0.8862	0.7812
21600	1.367135	1.30963	1.0122	0.9807	0.8421
23400	1.456175	1.385685	1.1298	1.0773	0.9282
25200	1.508115	1.41351	1.2222	1.1823	1.0143
27000	1.567475	1.459885	1.2516	1.2096	1.0206
28800	1.59901	1.49884	1.3503	1.2453	1.071
30600	1.623125	1.50997	1.3776	1.2432	1.1052
30660	1.63141	1.51114	1.3776	1.2432	1.1052
30720	1.63162	1.51119	1.3776	1.2432	1.1052
30780	1.63165	1.51201	1.3776	1.2432	1.1052
30840	1.63164	1.51203	1.3776	1.2432	1.1052
30900	1.63164	1.51203	1.3776	1.2432	1.1052

Table 21: Effects of carbon nanoballs on methanol crossover concentration

Time (Sec)	CNBs =0	CNBs=0.1	CNBs=0.2	CNBs=0.3	CNBs=0.4
0	0	0	0	0	0
1800	0.1134	0.114122	0.098452	0.0796316	0.0674112
3600	0.2016	0.187328	0.157248	0.1478784	0.1245088
5400	0.2772	0.230076	0.266216	0.1938328	0.1674496
7200	0.3318	0.294394	0.298804	0.2536332	0.1884624
9000	0.3696	0.317768	0.308288	0.2691104	0.2399328
10800	0.4053	0.336399	0.336134	0.2931722	0.2612104
12600	0.4641	0.385203	0.361998	0.3228034	0.2836088
14400	0.5502	0.473666	0.434156	0.3708348	0.3125136
16200	0.6321	0.534643	0.513038	0.4510354	0.3590328
18000	0.7182	0.616106	0.570196	0.4840668	0.4469376
19800	0.7812	0.668396	0.629336	0.5435288	0.4787216
21600	0.8421	0.718943	0.666838	0.5875754	0.5183128
23400	0.9282	0.770406	0.723996	0.6456068	0.5472176
25200	1.0143	0.851869	0.791154	0.6836382	0.5761224
27000	1.0206	0.878098	0.796068	0.6878844	0.5797008
28800	1.071	0.90893	0.83538	0.721854	0.608328
30600	1.1052	0.947316	0.892056	0.7849048	0.6477536
30660	1.1052	0.947316	0.892056	0.7849048	0.6477536
30720	1.1052	0.947316	0.892056	0.7849048	0.6477536
30780	1.1052	0.947316	0.892056	0.7849048	0.6477536
30840	1.1052	0.947316	0.892056	0.7849048	0.6477536
30900	1.1052	0.947316	0.892056	0.7849048	0.6477536

Table A22: Performance of MEA at different weight of catalyst, constant membrane DS (39.38%) and Nafion 112.

Current density (mA/Cm^2)	10Wt% PSBR	20Wt% PSBR	30Wt% PSBR	40Wt% PSBR	40wt% Nafion
0	0.30745	0.52048	0.68979	0.71875	0.70089
5.72	0.25976	0.46924	0.64754	0.7045	0.69889
12.688	0.22045	0.39856	0.56987	0.6789	0.66998
29.952	0.191545	0.322575	0.48999	0.64515	0.588634
47.84	0.18561	0.30078	0.43309	0.6187	0.55683
87.984	0.178914	0.291525	0.40056	0.58305	0.524745
108.316	0.16047	0.25856	0.37443	0.5349	0.48245
125.32	0.14835	0.24725	0.35565	0.4945	0.44505
160.576	0.136023	0.21978	0.31073	0.4439	0.39951
182.52	0.119098	0.201825	0.28055	0.40365	0.366286
199.68	0.1158	0.18078	0.2583	0.369	0.3321
211.848	0.100395	0.167325	0.234255	0.33465	0.29425
221.312	0.08978	0.15095	0.21067	0.3059	0.27531
232.96	0.076845	0.128075	0.179305	0.25615	0.23454
250.64	0.06989	0.112567	0.161805	0.23115	0.208035
256.8	0.058955	0.114925	0.15689	0.22985	0.20987

Table A23: Power density at different weight of catalyst, constant membrane DS (39.38%) and Nafion 112.

Current density (mA/cm^2)	Power density (10Wt% +PSBR)	Power density (20wt% +PSBR)	Power density (30Wt% +PSBR)	Power density (30Wt% +PSBR)2	Power density (40Wt% +PSBR)
0	0	0	0	0	0
5.72	0.001485827	0.002684053	0.003703929	0.00402974	0.003997651
12.688	0.00279707	0.005056929	0.007230511	0.008613883	0.008500706
29.952	0.005737156	0.009661766	0.01467618	0.019323533	0.017630766
47.84	0.008879582	0.014389315	0.020719026	0.029598608	0.026638747
87.984	0.015741569	0.025649536	0.035242871	0.051299071	0.046169164
108.316	0.017381469	0.028006185	0.04055676	0.057938228	0.052257054
125.32	0.018591222	0.03098537	0.044570058	0.06197074	0.055773666
160.576	0.021842029	0.035291393	0.04989578	0.071279686	0.064151718
182.52	0.021737767	0.036837099	0.051205986	0.073674198	0.066854521
199.68	0.023122944	0.03609815	0.051577344	0.07368192	0.066313728
211.848	0.02126848	0.035447467	0.049626453	0.070894933	0.062336274
221.312	0.019869391	0.033407046	0.046623799	0.067699341	0.060929407
232.96	0.017901811	0.029836352	0.041770893	0.059672704	0.054638438
250.64	0.01751723	0.028213793	0.040554805	0.057935436	0.052141892
256.8	0.015139644	0.02951274	0.040289352	0.05902548	0.053894616

Table A24: Performance of MEA at different degrees of sulphonation

Current Density (mA/cm^2)	DS =8.25%	DS =11.92	DS =18.16	DS =28.17	DS =39.38
0	0.18434	0.30167	0.4025	0.50632	0.71875
5.72	0.17944	0.29589	0.39452	0.49315	0.7045
12.688	0.17264	0.285138	0.380184	0.47523	0.6789
29.952	0.167739	0.270963	0.361284	0.44637	0.64515
47.84	0.160862	0.259854	0.346472	0.43309	0.6187
87.984	0.14834	0.244881	0.326508	0.40532	0.58305
108.316	0.13506	0.224658	0.299544	0.37043	0.5349
125.32	0.12857	0.20769	0.27692	0.34615	0.4945
160.576	0.115414	0.186438	0.248584	0.31073	0.4439
182.52	0.104949	0.169533	0.226044	0.28056	0.40365
199.68	0.09594	0.15498	0.20664	0.2583	0.369
211.848	0.08434	0.140553	0.187404	0.23225	0.33465
221.312		0.128478	0.171304	0.21413	0.3059
232.96			0.143444	0.179305	0.25615
250.64			0.129444	0.1648	0.23115
256.8			0.128716	0.16078	0.22985

Table A25: Power density at different at different degrees of sulphonation

Current Density (w/cm2)	DS =8.25%	DS =11.92%	DS =18.16%	DS =28.17%	DS =39.38%
0	0	0	0	0	0
5.72	0.001026397	0.001692491	0.002256654	0.002820818	0.00402974
12.688	0.002190456	0.003617831	0.004823775	0.006029718	0.008613883
29.952	0.005024119	0.008115884	0.010821178	0.013369674	0.019323533
47.84	0.007695638	0.012431415	0.01657522	0.020719026	0.029598608
87.984	0.013051547	0.02154561	0.02872748	0.035661675	0.051299071
108.316	0.014629159	0.024334056	0.032445408	0.040123496	0.057938228
125.32	0.016112392	0.026027711	0.034703614	0.043379518	0.06197074
160.576	0.018532718	0.029937468	0.039916624	0.04989578	0.071279686
182.52	0.019155291	0.030943163	0.041257551	0.051207811	0.073674198
199.68	0.019157299	0.030946406	0.041261875	0.051577344	0.07368192
211.848	0.01786726	0.029775872	0.039701163	0.049201698	0.070894933
221.312		0.028433723	0.037911631	0.047389539	0.067699341
232.96			0.033416714	0.041770893	0.059672704
250.64			0.032443844	0.041305472	0.057935436
256.8			0.033054269	0.041288304	0.05902548

Table A26: Effects of carbon nanoballs on the performance of the membrane in a single fuel cell stack

Current density (mA/cm^2)	Mass of CNBs=0g	Mass of CNBs=0.1g	Mass of CNBs=0.2g	Mass of CNBs=0.3g	Mass of CNBs=0.4g
0	0.71875	0.74907	0.77572	0.79781	0.82656
5.72	0.7045	0.74382	0.75721	0.782	0.81018
12.688	0.6789	0.72642	0.73932	0.75358	0.78074
29.952	0.64515	0.68731	0.70257	0.71612	0.74192
47.84	0.6187	0.66201	0.67376	0.68676	0.71151
87.984	0.58305	0.63384	0.65216	0.66719	0.68051
108.316	0.5349	0.57134	0.59252	0.62574	0.63514
125.32	0.4945	0.54912	0.56851	0.6009	0.61068
160.576	0.4439	0.46497	0.50741	0.56373	0.58049
182.52	0.40365	0.43191	0.45958	0.51005	0.5322
199.68	0.369	0.39483	0.41184	0.43959	0.46035
211.848	0.33465	0.35808	0.36443	0.39246	0.40785
221.312	0.3059	0.32731	0.33313	0.35955	0.38179
232.96	0.25615	0.26408	0.27895	0.29733	0.31557
250.64	0.23115	0.24733	0.25172	0.26558	0.28582
256.8	0.22985	0.24594	0.25031	0.26013	0.27833

Table A27: Effect of carbon nanoballs on the power density o the membrane in a single fuel cell stack

Current density (mA/cm^2)	Power density (Mass of CNBs=0g)	Power density (Mass of CNBs=0.1g)	Power density (Mass of CNBs=0.2g)	Power density (Mass of CNBs=0.3g)	Power density (Mass of CNBs=0.4g)
0	0	0	0	0	0
5.72	0.0040297	0.0042547	0.0043312	0.004473	0.0046342
12.688	0.0086139	0.0092169	0.0093805	0.0095614	0.009906
29.952	0.0193235	0.0205863	0.0210434	0.0214491	0.0222221
47.84	0.0295986	0.0316705	0.0322327	0.0328545	0.0340384
87.984	0.0512991	0.0557678	0.0573796	0.0587016	0.0598738
108.316	0.0579382	0.0618853	0.0641794	0.0677775	0.0687953
125.32	0.0619707	0.0688151	0.0712457	0.0753042	0.0765298
160.576	0.0712797	0.0746635	0.0814779	0.0905213	0.093212
182.52	0.0736742	0.0788314	0.0838825	0.0930946	0.0971367
199.68	0.0736819	0.0788397	0.0822362	0.0877773	0.0919227
211.848	0.0708949	0.0758576	0.0772046	0.0831422	0.0864017
221.312	0.0676993	0.0724383	0.0737246	0.0795725	0.0844936
232.96	0.0596727	0.0615202	0.0649836	0.0692652	0.0735158
250.64	0.0579354	0.0619909	0.0630917	0.0665641	0.0716386
256.8	0.0590255	0.0631573	0.0642787	0.0668023	0.0714745