Determining Hydrogel Porosity Through Dielectric Relaxation Intensity Ratios Between Water and Hydrogel

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Supplementary Information

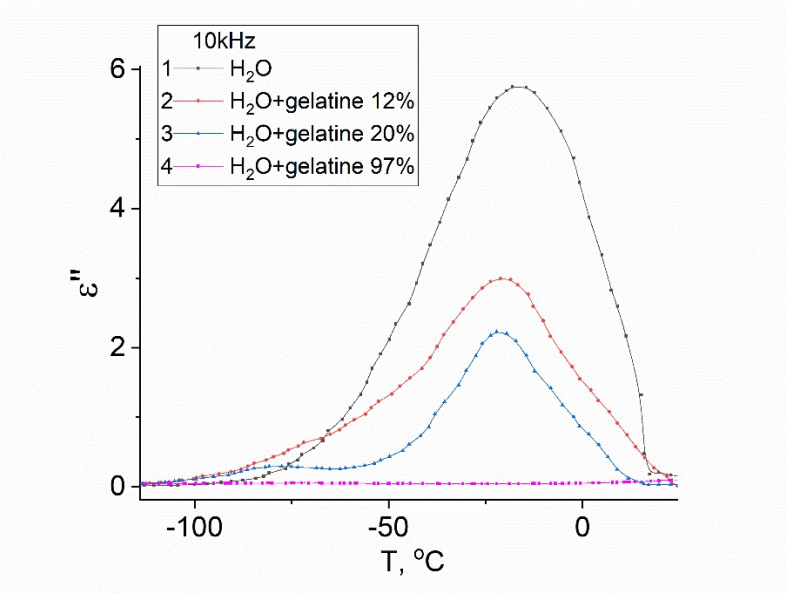

Fig.1. The thermal dependencies of the imaginary part of the complex dielectric permittivity ε'': 1- water, 2- 12% gelatine hydrogel, 3- 20% gelatine hydrogel, 4- 97% gelatine-water system.

Tabl.1 The thermal dependencies of the imaginary part of the complex dielectric permittivity.

water		12% gelatine hydrogel		20% gelatine hydrogel		97% gelatine-water system	
T, °C	ε''	T, °C	ε''	T, °C	ε''	T, °C	ε''
-178.7	0.00519	-195.3	0.00601	-195.3	0.00528	-195.7	0.0184
-177.3	0.0055	-194.6	0.00591	-192.3	0.00635	-192.3	0.0184
-176.9	0.00542	-192.5	0.00581	-190.4	0.00635	-189.6	0.0184
-175.5	0.00485	-191.8	0.00581	-187.7	0.00742	-187	0.0184
-173.2	0.00466	-193.9	0.00599	-185	0.00742	-184.4	0.0184
-172	0.00474	-191.8	0.00595	-183.1	0.00743	-182.5	0.0184
-171.4	0.00587	-189.7	0.00587	-181.1	0.00743	-178.1	0.01841
-170.2	0.00594	-189.7	0.00559	-180.6	0.00528	-176.9	0.0184
-168.9	0.00576	-187.7	0.00543	-180	0.00743	-175	0.01841
-167.3	0.00521	-186.3	0.00551	-179	0.00743	-174	0.01841
-166.7	0.00532	-188.4	0.00561	-176.9	0.00636	-172	0.01841
-164.4	0.00531	-188.4	0.00554	-175	0.00743	-169.6	0.01841
-162.4	0.00486	-186.3	0.00561	-172	0.00743	-167.9	0.0184
-161	0.00645	-184.3	0.00531	-171	0.00743	-165.5	0.01841
-159.9	0.01028	-183.6	0.00535	-169.6	0.00636	-163.4	0.0184
-157.7	0.01236	-181	0.00516	-167.3	0.00847	-157.7	0.01905
-156.1	0.00952	-177.1	0.00517	-166.8	0.00847	-155.9	0.01925
-152.8	0.00588	-179.1	0.00526	-165.5	0.00846	-153.3	0.01966
-151.3	0.00542	-178.4	0.00522	-164.4	0.00847	-149.7	0.02005
-149.2	0.00594	-174.6	0.00501	-159.2	0.00847	-148.1	0.02051
-144.6	0.00553	-174	0.00516	-158.2	0.00955	-147.6	0.02065
-142.1	0.00588	-171.5	0.00546	-156.6	0.00848	-146.1	0.02102
-140.1	0.00739	-170.9	0.00568	-157.7	0.00955	-144.6	0.02153
-137.6	0.00783	-170.2	0.0059	-155.9	0.00848	-142.1	0.0228
-135.7	0.00696	-166	0.00601	-153.9	0.00848	-141.6	0.023
-131	0.0065	-164.8	0.0063	-151.8	0.00955	-138.6	0.02416
-130.1	0.0065	-163.6	0.00642	-149.2	0.00956	-137.6	0.02472
-128.7	0.00707	-160.1	0.00635	-148.6	0.0106	-136.6	0.02532

-125.1	0.00704	-159.5	0.00655	-147.6	0.0106	-134.3	0.02647
-122.9	0.00799	-158.4	0.00682	-144.6	0.0106	-133.8	0.02678
-119.8	0.00746	-153.3	0.00682	-142.6	0.01272	-131	0.02808
-116.9	0.00846	-152.8	0.00692	-141.6	0.0117	-130.1	0.02876
-115.9	0.00937	-151.7	0.0072	-140.6	0.01273	-129.6	0.02899
-113	0.01287	-149.9	0.0077	-137.6	0.01274	-128.3	0.02951
-110.5	0.01492	-147.9	0.00816	-136.7	0.01381	-128.1	0.02973
-106	0.01807	-145.2	0.00835	-135.2	0.01594	-127.8	0.02991
-104.4	0.02224	-144.7	0.00863	-133.8	0.01698	-122.1	0.03338
-100.1	0.02959	-143.7	0.00895	-131	0.017	-120.2	0.03451
-96.6	0.03822	-142.7	0.00923	-130.1	0.01912	-117.6	0.03681
-95.1	0.04754	-141.6	0.00978	-129.2	0.02125	-116.8	0.03797
-93.2	0.05944	-139.6	0.01059	-126.4	0.02123	-115.2	0.03912
-90.6	0.07515	-136.1	0.01143	-123.9	0.02442	-114.7	0.04027
-87.6	0.09381	-135.6	0.01209	-122.9	0.02653	-112.6	0.04143
-84.2	0.11964	-132.6	0.01301	-119.8	0.03082	-110.3	0.04257
-82.2	0.14833	-131.6	0.01445	-118.9	0.03398	-107.8	0.04409
-80.8	0.1993	-130.7	0.01601	-115.1	0.03716	-106.4	0.04489
-76.5	0.25615	-129.7	0.01755	-113.4	0.04353	-104	0.04603
-75.8	0.32296	-127.8	0.01917	-112.6	0.0478	-102.8	0.04634
-73.4	0.38191	-125	0.02128	-109.3	0.05536	-101.4	0.04702
-72.4	0.46072	-124.1	0.02351	-107.6	0.06493	-99.7	0.04732
-69.3	0.55247	-122.7	0.02607	-105.2	0.07664	-98.4	0.04777
-66.9	0.66356	-120.4	0.02912	-104	0.09264	-97.8	0.04803
-65.6	0.80298	-119.1	0.03274	-99.7	0.10749	-96.8	0.04832
-61.9	0.96422	-116.9	0.03678	-97.8	0.12452	-95.1	0.04863
-59.9	1.13671	-115.5	0.04122	-95.1	0.1458	-93.3	0.04905
-57.2	1.32384	-113.4	0.04688	-91.3	0.16688	-92.1	0.04949
-55.6	1.50295	-111.6	0.05356	-89.8	0.19025	-91.7	0.04955
-54.3	1.70318	-108.7	0.06043	-88.1	0.21568	-90.6	0.04965
-52.1	1.90533	-106.6	0.06896	-86.5	0.24113	-89.1	0.04995
-49.8	2.11549	-104.1	0.07982	-84.7	0.26229	-86.9	0.05083
-48.2	2.33902	-103.3	0.09342	-81.8	0.27806	-85.4	0.05106
-44.7	2.62784	-100.4	0.1103	-80.8	0.28959	-82.5	0.05162

-42.8	2.92736	-99.6	0.13042	-77.6	0.29259	-81.1	0.05162
-41.18	3.20622	-98	0.15424	-75.1	0.28819	-80.8	0.05179
-39.3	3.479	-93.7	0.18233	-73.4	0.28053	-80	0.05162
-36.8	3.80146	-90.6	0.21465	-68.6	0.27094	-76.5	0.05162
-34.6	4.135	-88	0.25117	-67.2	0.26135	-75.1	0.05162
-31.9	4.44799	-86.3	0.29183	-65.2	0.25484	-74.4	0.05162
-29.7	4.70694	-84.7	0.33538	-62.5	0.25698	-72.4	0.05146
-28.3	4.97316	-81.6	0.38047	-61.2	0.26631	-70.6	0.05135
-26.3	5.23656	-79.7	0.42859	-58.9	0.27894	-67.9	0.05081
-23.9	5.4492	-77	0.4785	-56.2	0.30428	-67.2	0.05063
-22.1	5.5915	-75.8	0.52929	-53.7	0.33495	-64.5	0.04995
-19.6	5.69258	-73.3	0.582	-52.1	0.37803	-62.5	0.04947
-18.1	5.75146	-71.9	0.63547	-49.8	0.43705	-61.5	0.04905
-14.5	5.74371	-67.4	0.69205	-46.3	0.51817	-59.9	0.04871
-12.4	5.66761	-65	0.75293	-44.7	0.61172	-58.6	0.04831
-9.1	5.44568	-62.6	0.81613	-41.8	0.72746	-56.2	0.0478
-5.5	5.11152	-61.2	0.88585	-39.6	0.8564	-55.2	0.04747
-2.3	4.7253	-58.9	0.96235	-38.1	1.04169	-53.7	0.0471
-0.8	4.37216	-55.9	1.04498	-35.6	1.21755	-52.7	0.04697
1.6	3.87277	-54.5	1.13416	-31.9	1.46099	-51.7	0.04686
5	3.33229	-52.6	1.22924	-30	1.66876	-50.1	0.04657
7.4	2.82229	-49.2	1.332	-27.5	1.88096	-49.8	0.0464
9	2.59348	-47.1	1.44363	-25.9	2.05568	-47.6	0.04596
11.2	2.16563	-44.4	1.56645	-23.7	2.1778	-46.3	0.04579
15.2	1.31782	-41.4	1.69913	-22.1	2.23046	-44.4	0.04546
15.8	0.47782	-39.3	1.84871	-19.6	2.20146	-41.2	0.04487
17.3	0.17889	-37.5	2.01109	-17.2	2.09429	-37.4	0.04409
19.6	0.20677	-35.8	2.18535	-14.5	1.89069	-36.8	0.04387
22.7	0.16836	-33.3	2.36926	-12.4	1.66242	-34.3	0.04371
25	0.14577	-30.8	2.55103	-8.2	1.41769	-30.9	0.04373
26.1	0.13311	-28.3	2.71842	-5.2	1.17626	-28.5	0.04373
28.4	0.12051	-25.9	2.85602	-2.3	1.00609	-27.9	0.04373
31.8	0.11117	-23.7	2.95014	-0.8	0.86735	-26	0.04372
32	0.10788	-21.2	2.99289	1.6	0.75519	-24.5	0.04374

36	0.10343	-18.5	2.97851	4.2	0.60018	-22.1	0.04372
38.5	0.09823	-16.7	2.90189	6.5	0.42947	-19	0.04373
40.4	0.0937	-14	2.7688	8.9	0.24749	-18.7	0.04374
42.9	0.08903	-12.7	2.59493	11.8	0.12225	-16.6	0.04372
45.3	0.08333	-10.1	2.38493	15.2	0.06171	-13	0.04459
49.2	0.07971	-8.28	2.15972	15.8	0.03712	-12.4	0.04487
50.2	0.07748	-5.5	1.93391	17	0.02706	-11.2	0.04506
53.2	0.077	-2.7	1.72465	19.6	0.02698	-8.2	0.04602
55.6	0.07646	-0.7	1.54783	22.7	0.02697	-7	0.04604
59.6	0.07939	2.1	1.39016	25	0.03521	-5.2	0.04719
61.9	0.08386	4.1	1.2381	28.9	0.03791	-3.5	0.04834
63.5	0.09124	6.9	1.07969	31.8	0.04871	-1.7	0.04948
67.9	0.09688	9	0.91289	34.6	0.05406	-0.5	0.05063
69.2	0.10101	11.5	0.74222	36	0.05412	2.7	0.05294
71.2	0.10375	13.7	0.57394	38.5	0.05128	5.82	0.05639
		16	0.41483	40.7	0.03774	7.7	0.05868
		18.4	0.26809			8.9	0.06098
		21.8	0.14636			10.6	0.06444
		23	0.05813			11.2	0.06675
		24.4	0.0121			12.1	0.06676
		25.6	0.00606			13.5	0.07021
		31	0.01648			17.6	0.07825
		32.4	0.02968			18.8	0.08286
		34.7	0.02792			21	0.08891
		37.5	0.02998			22.4	0.09206
		40.6	0.03585			24	0.09668
		43.9	0.04553			26.7	0.10588
		45.3	0.05903			28.9	0.11509
		48.9	0.07633			30.1	0.12659
						31.8	0.13697

						33.7	0.15422
						36.2	0.17262
						38.6	0.19564
						40.7	0.21867
						43.4	0.26584
						45.1	0.31653
						47.4	0.37291
						50	0.44886
						52.2	0.58702
						53.5	0.68599
						54.5	0.7389
						55.6	0.86791
						57.5	1.03246
						59.6	1.25687
						60.9	1.75187
						62.2	1.92219
						63.2	2.02571

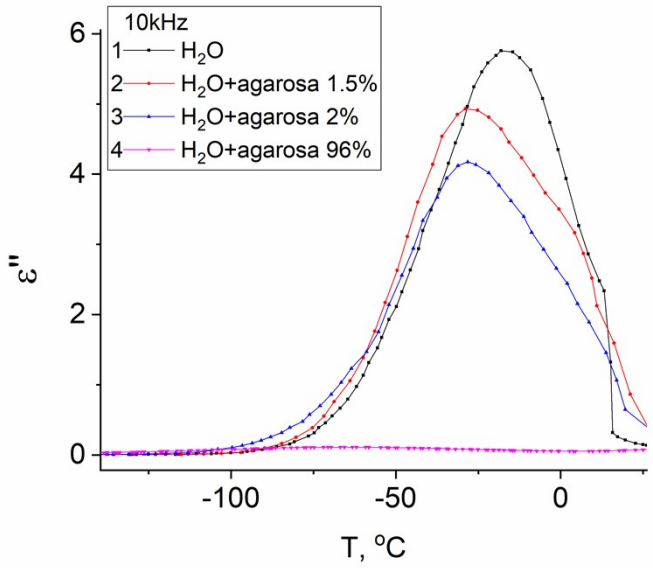

Fig.2. The thermal dependencies of the imaginary part of the complex dielectric permittivity ε'': 1- water, 2- 1.5% agarose hydrogel, 3- 2% agarose hydrogel, 4 - 96% agarose-water system.

Tabl.2. The thermal dependencies of the imaginary part of the complex dielectric permittivity

water		1.5% agarose hydrogel		2% agarose hydrogel		96% agarose-water system	
T, °C	ε''	T, °C	ε''	T, °C	ε''	T, °C	ε''
-178.7	0.00519	-189.3	0.00498	-193.7	0.00557	-194.4	0.01832
-177.3	0.0055	-188.3	0.00371	-192.3	0.00557	-191	0.01832
-176.9	0.00542	-187.3	0.00498	-189.6	0.00443	-187	0.01832
-175.5	0.00485	-186	0.0037	-190.3	0.00557	-183.1	0.01832
-173.2	0.00466	-176.3	0.00498	-190.3	0.00443	-180.6	0.01832
-172	0.00474	-164.3	0.00498	-184.4	0.00666	-178.7	0.01832
-171.4	0.00587	-155.2	0.00371	-180.6	0.00557	-176.2	0.01831
-170.2	0.00594	-146.7	0.00498	-179.3	0.00557	-173.8	0.01831
-168.9	0.00576	-135.6	0.00499	-176.9	0.00443	-172	0.01832
-167.3	0.00521	-130.8	0.00371	-172	0.00443	-170.2	0.01832
-166.7	0.00532	-123	0.00627	-169.6	0.00557	-166.1	0.01923
-164.4	0.00531	-115.1	0.00499	-168	0.00557	-164.4	0.01925
-162.4	0.00486	-108.3	0.01128	-165.5	0.00443	-161	0.02016
-161	0.00645	-103	0.02124	-163.3	0.00443	-158.2	0.02108
-159.9	0.01028	-97.1	0.03499	-158.8	0.00557	-156.6	0.02198
-157.7	0.01236	-93.6	0.05749	-157.7	0.00557	-155	0.02299
-156.1	0.00952	-89.8	0.099	-155.5	0.00557	-153.8	0.02383
-152.8	0.00588	-84.6	0.1602	-151.8	0.00557	-152.3	0.0244
-151.3	0.00542	-80.3	0.24916	-150.3	0.00558	-148.7	0.02567
-149.2	0.00594	-75.3	0.38559	-147.6	0.00557	-147.6	0.02565
-144.6	0.00553	-71.8	0.55306	-144.1	0.00668	-145.6	0.02657
-142.1	0.00588	-68.7	0.75647	-143.1	0.00667	-141.6	0.02841

-140.1	0.00739	-63.9	1.05707	-137.6	0.00667	-139.6	0.03029
-137.6	0.00783	-59.9	1.38318	-135.7	0.00777	-138.6	0.03129
-135.7	0.00696	-56.4	1.76282	-131	0.00892	-137.6	0.03207
-131	0.0065	-53.2	2.16971	-129.2	0.01116	-136.6	0.0339
-130.1	0.0065	-49.6	2.62685	-126.4	0.01226	-135.7	0.03391
-128.7	0.00707	-46.5	3.11029	-125.1	0.0145	-134.8	0.03483
-125.1	0.00704	-43.3	3.59909	-122.9	0.01785	-134.3	0.03484
-122.9	0.00799	-38.8	4.14102	-119.8	0.02229	-133.8	0.03575
-119.8	0.00746	-36.03	4.53651	-116.8	0.02563	-132.3	0.03665
-116.9	0.00846	-31.3	4.84832	-113	0.0346	-130.1	0.0394
-115.9	0.00937	-28.9	4.93132	-110.1	0.04243	-129.7	0.03985
-113	0.01287	-25.2	4.90867	-108	0.05137	-129.1	0.04031
-110.5	0.01492	-21.8	4.81146	-106	0.06477	-128.6	0.04123
-106	0.01807	-18.1	4.64495	-104	0.08043	-127.3	0.04308
-104.4	0.02224	-15.7	4.4549	-99.7	0.105	-126.4	0.04399
-100.1	0.02959	-11.8	4.23306	-96.6	0.13407	-125.4	0.04491
-96.6	0.03822	-8.2	3.98186	-93.6	0.16756	-122.5	0.04857
-95.1	0.04754	-4.6	3.73094	-90.9	0.20675	-121.1	0.05132
-93.2	0.05944	-0.5	3.49976	-88	0.25698	-119.7	0.05316
-90.6	0.07515	4.3	3.1634	-84.7	0.31626	-118.4	0.05407
-87.6	0.09381	6.9	2.86749	-82.2	0.39025	-116.4	0.0559
-84.2	0.11964	9.5	2.51883	-78.3	0.47733	-115.4	0.05681
-82.2	0.14833	11	2.12328	-76.2	0.57459	-114.1	0.05768
-80.8	0.1993	16.2	1.592	-73	0.69883	-112.6	0.06049
-76.5	0.25615	21.1	0.86289	-69.6	0.86376	-111.2	0.06232
-75.8	0.32296	27.4	0.31949	-66.6	1.03266	-110.8	0.06324
-73.4	0.38191	33.1	0.55654	-63.5	1.23308	-110.1	0.06432
-72.4	0.46072	37	0.73577	-58.9	1.46793	-108	0.0676
-69.3	0.55247	43.4	1.0302	-55.3	1.75194	-105.6	0.0724
-66.9	0.66356			-52.1	2.1383	-102.8	0.07607
-65.6	0.80298			-48.2	2.55719	-101	0.07806
-61.9	0.96422			-44.7	2.94322	-99.7	0.08066
-59.9	1.13671			-41.8	3.33784	-98.9	0.08157

-57.2	1.32384			-37.4	3.66984	-95.8	0.08524
-55.6	1.50295			-34.6	3.94119	-93.6	0.08798
-54.3	1.70318			-31.2	4.11858	-92.4	0.08983
-52.1	1.90533			-28.2	4.17348	-91.1	0.09165
-49.8	2.11549			-25.7	4.13542	-89.8	0.09258
-48.2	2.33902			-21.8	4.01852	-88.9	0.09348
-44.7	2.62784			-18.7	3.83925	-88.1	0.09439
-42.8	2.92736			-15.1	3.62054	-87.9	0.09525
-41.18	3.20622			-11.2	3.39555	-87.3	0.09616
-39.3	3.479			-8.8	3.16957	-86.5	0.09807
-36.8	3.80146			-5.2	2.92722	-84	0.10085
-34.6	4.135			-1.3	2.65795	-81.8	0.10267
-31.9	4.44799			2	2.44084	-80	0.10449
-29.7	4.70694			5.1	2.15297	-78.9	0.10606
-28.3	4.97316			8.6	1.89242	-77.2	0.10782
-26.3	5.23656			13.8	1.45436	-75.8	0.10862
-23.9	5.4492			17	1.06486	-74.8	0.10936
-22.1	5.5915			19.6	0.64732	-72	0.11
-19.6	5.69258			27	0.36825	-70.6	0.11001
-18.1	5.75146			30.4	2.75148	-70.6	0.11
-14.5	5.74371			35.1	3.233	-69.6	0.11
-12.4	5.66761			38.5	3.64874	-66.9	0.1102
-9.1	5.44568			45.1	4.27667	-65.6	0.11039
-5.5	5.11152			44	4.63202	-63.2	0.10999
-2.3	4.7253			42.9	4.78013	-61.9	0.10999
-0.8	4.37216			41.5	4.96667	-59.2	0.11
1.6	3.87277			40.4	5.13725	-58.2	0.10906

5	3.33229			37.4	5.32644	-56.2	0.10816
7.4	2.82229			37.1	5.40477	-55.2	0.10781
9	2.59348					-54.6	0.10723
11.2	2.16563					-53.6	0.10672
15.2	1.31782					-52.7	0.10567
15.8	0.47782					-51.1	0.10449
17.3	0.17889					-50.1	0.10357
19.6	0.20677					-49.5	0.10267
22.7	0.16836					-48.5	0.10174
25	0.14577					-47.5	0.10082
26.1	0.13311					-46.8	0.10008
28.4	0.12051					-46	0.09899
31.8	0.11117					-44.4	0.09681
32	0.10788					-42.5	0.09532
36	0.10343					-41.8	0.09453
38.5	0.09823					-40	0.09341
40.4	0.0937					-38.4	0.09168
42.9	0.08903					-37.8	0.0909
45.3	0.08333					-36.8	0.08983
49.2	0.07971					-34.6	0.08709
50.2	0.07748					-33	0.08523
53.2	0.077					-31.9	0.08432
55.6	0.07646					-29.7	0.08249
59.6	0.07939					-27.5	0.08066
61.9	0.08386					-26.9	0.07975
63.5	0.09124					-25.1	0.0779
67.9	0.09688					-23.5	0.07607

69.2	0.10101					-22.7	0.07515
71.2	0.10375					-22.1	0.07433
						-20.2	0.07241
						-19.5	0.07149
						-18.7	0.07056
						-16.5	0.06784
						-15.4	0.0669
						-14.8	0.06601
						-13.9	0.06507
						-12.9	0.06415
						-11.2	0.06232
						-10	0.06142
						-9.1	0.0605
						-7.3	0.05866
						-5.2	0.05773
						-2.9	0.05683
						-1.9	0.05648
						-0.8	0.05592
						-0.5	0.0559
						2.7	0.05498
						3.9	0.05498
						4.5	0.05499
						8.6	0.05499
						9.7	0.05497
						11.8	0.05589
						13.5	0.05774
						14.4	0.05865

						16.8	0.0614
						19	0.06417
						19.6	0.06597
						22.7	0.07059
						23.5	0.07242
						25	0.07423
						27.3	0.07975
						28.4	0.08249
						29.4	0.08433
						31.8	0.09073
						33.4	0.09347
						34	0.09622
						35.1	0.10172
						37.9	0.10907
						40.1	0.11734
						41.7	0.12559
						42.9	0.13567
						44	0.14115
						45.3	0.15123
						47.9	0.165
						49.4	0.1815
						52.1	0.20167
						53.7	0.21723