

Temperature dependence of the far infrared optical constants of
polyethylene

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ABSTRACT

The optical constants of low density polyethylene in the spectral region from 30 to 120 cm^{-1} have been determined at a number of temperatures by the technique of dispersive Fourier transform spectroscopy. The temperatures were 6, 20, 40, 60, 80, 100 and 293 K. The results of these studies are presented in both graphical and tabular form.

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1 INTRODUCTION

In the far infrared region of the electromagnetic spectrum polyethylene ($(C_2H_4)_n$) is probably the most widely used material for the construction of low loss transmission optics such as lenses and windows. A consequence of this is that there have been extensive studies of its power transmission properties in this spectral region, including some studies of the spectral variation of its optical constants⁽¹⁾. These latter studies provide an unambiguous description of the optical constants of polyethylene in the spectral region between 3 and 500 cm^{-1} at ambient room temperature. If, however, information is required on the temperature dependence of the optical constants, the available data is more sparse. There have been a number of studies of the temperature variation of the absorption spectrum, particularly in the 70 to 80 cm^{-1} region of the B_{1u} lattice mode⁽²⁻⁶⁾, but there is much less information available on the temperature dependence of the refractive index spectrum. At near millimetre wavelengths, for example, dispersive Fourier transform spectrometry has been used to study the temperature dependence of the optical constants between 4.2 and 300 K,⁽⁷⁾ leading to a refractive index temperature gradient of $-2.5 \times 10^{-4} K^{-1}$ for temperatures close to 300 K. Stützel et al⁽⁸⁾ have used the Abbe method to determine the temperature dependence of the refractive index between 5 and 290 K at wavelengths of 118 and 570 μm . Their result of $-13 \times 10^{-4} K^{-1}$ for the gradient at 290 K was larger than that of the interferometric method, but this may reflect the finer temperature resolution of that study. Finally, Alvarez et al⁽⁹⁾ measured the refractive index of a Rigidex polyethylene between 50 and 200 cm^{-1} at 1.6 and 300 K. The present work was aimed at expanding this data base by providing a systematic study of the temperature dependence between 4.2 and 293 K of the optical constants of a specimen of low density polyethylene (LDPE) in the spectral region from 30 to 120 cm^{-1} .

2 EXPERIMENTAL

The refraction and absorption spectra of a 9.8 mm thick specimen of LDPE were determined using the techniques of dispersive Fourier transform spectroscopy⁽¹⁰⁾ (DFTS). These directly measure the phase shift and attenuation suffered by an electromagnetic wave as it propagates through a specimen. Once these are known, the refraction and absorption spectra of the specimen can be calculated from them without approximation. The measurements are made by introducing the specimen into one of the two active arms of a Michelson, or related, interferometer.

The interferometer used for these measurements was a polarising wire grid interferometer⁽⁷⁾. The beamdivider and polariser-analyser were wound from 10 μm diameter tungsten wire spaced 25 μm centre-to-centre. This was used with a quartz window Golay cell to cover the spectral region from 30 and 120 cm^{-1} . The specimen was mounted in a variable temperature cryostat which formed part of the fixed mirror arm of the interferometer. Its temperature could be adjusted to any value between 4.2 and 300 K. The specimen could be positioned in or out of the beam in the fixed mirror arm without removing it from the exchange gas volume of the cryostat.

The phase shift and attenuation due to the specimen were measured at seven temperatures, 6, 20, 40, 60, 80, 100 and 293 K. Typically, the temperature was

maintained to better than ± 1 K above 60 K, falling to around ± 0.3 K at the lower temperatures. All of the measurements were made with a nominal spectral resolution of 2 cm^{-1} .

3 RESULTS

The absorption and refraction spectra of the LDPE specimen, at all 7 measurement temperatures, are shown in figures 1 and 2, respectively. Each spectrum represents the average of 4 independent determinations. The reproducibility of these was such as to suggest a level of random uncertainty in the refraction spectra of about 0.0001, or better, and of about 0.1 cm^{-1} in the absorption spectra. In the absorption spectra of figure 1 the ordinate scale refers to the 293 K spectrum. The other spectra are each offset by a progressive 0.5 cm^{-1} for clarity of presentation. These refraction and absorption spectra are all tabulated in tables 1 to 7, together with corresponding parameters, using the notation ν (wavenumber), f (frequency), n (refractive index), α (absorption coefficient), ϵ' (relative permittivity) and ϵ'' (loss).

There were two possible sources of major systematic errors in the refraction spectra derived from these measurements. First, the thickness of the specimen was only known at room temperature. Thus, in order to correctly calculate the optical constants from the measured phase and attenuation it was necessary to correct for thermal contraction using literature values⁽¹¹⁾ at each measurement temperature. The effect of the correction could only be seen in the refraction spectrum, due to the high signal-to-noise ratio in the phase spectrum. The lower signal-to-noise ratio of the attenuation measurements masked the correction. Second, in the calculation of refractive index spectra from the results of DFTS measurements made in transmission, it is usual to assume that the specimen is immersed in vacuum of refractive index unity. As the specimen was immersed in helium with a refractive index that was neither unity nor temperature independent, a further correction was necessary to allow for this. The effect that this has, if ignored, is to reduce the derived value of the refractive index from its true value. This can be avoided if the temperature dependence of the refractive index of helium gas is known. This has been determined with the present interferometer in previous measurements⁽¹²⁾. The correction factor, which is additive, decreased from 0.0026 at 6 K to 0.00008 at 100 K. In the corrected refraction spectra of figure 2 residual systematic errors are expected to be dominated by effects due to off axis rays⁽¹³⁾. Calculations based on the geometry of the interferometer used for these measurements indicate that such errors occur below the 10^{-4} level.

In the absorption spectra a possible source of significant systematic errors was pseudocoherence effects, which are due to non-uniformities in the optical thickness of a specimen. Such errors lead to a loss of interferometric modulation and, hence, to an absorption spectrum which is more intense than the real, intrinsic spectrum of the material⁽¹⁴⁾. Conventional FTS absorption measurements are not susceptible to this type of error, so a comparison of DFTS and FTS measurements on the same specimen reveals the presence of such errors. These were not present for this specimen. Other sources of systematic absorption error such as focussing/defocussing effects of off axis rays are expected to be less than the random absorption errors.

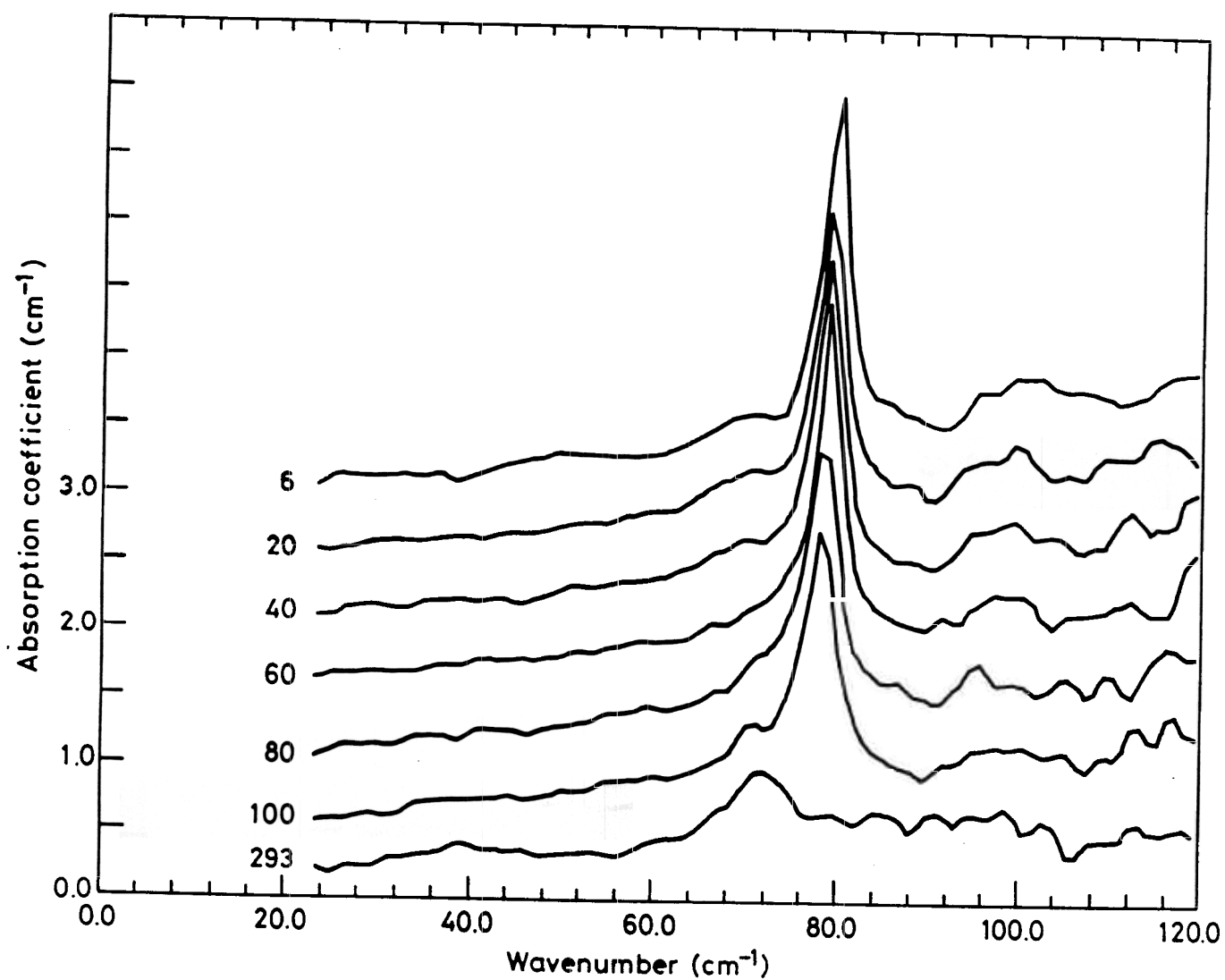


Figure 1. The absorption spectra of the low density polyethylene specimen at temperatures from 6 to 293 K. The ordinate scale is for the 293 K spectrum. The other spectra are each offset by a progressive 0.5cm^{-1} for clarity.

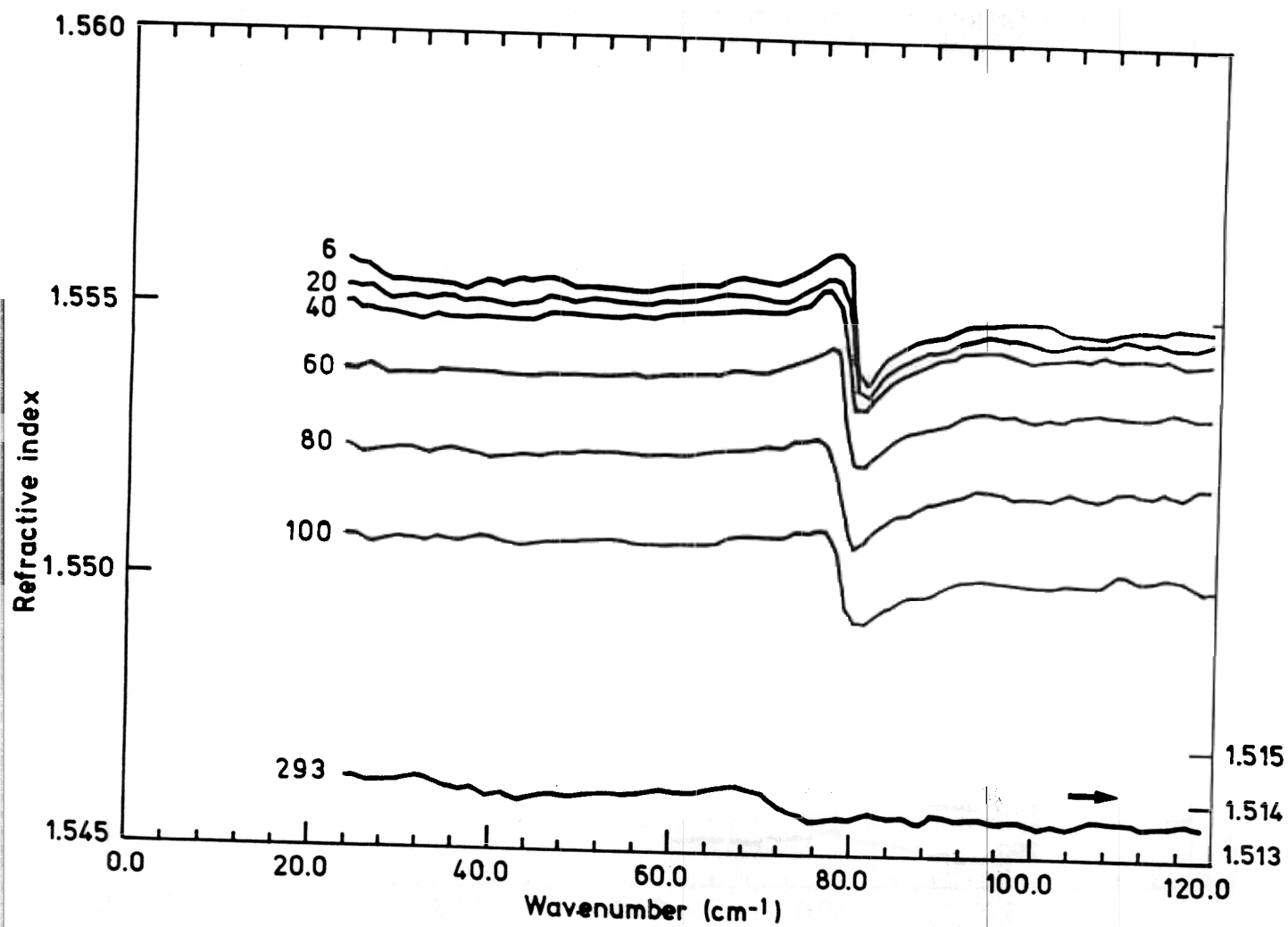


Figure 2. The refractive index spectra of the low density polyethylene specimen at temperatures from 6 to 293 K.

The absorption spectra of this LDPE specimen show the B_{1u} lattice mode superimposed on a broad feature-less background absorption that increases with increasing wavenumber, and is largely independent of temperature. This absorption is associated with amorphous regions in the material, and, at room temperature, has been fitted to a quadratic form by Chantry et al⁽¹⁵⁾. The spectra clearly show the temperature evolution of the B_{1u} lattice mode, which shifts from a peak position of about 72 cm^{-1} at 293 K to one of 80 cm^{-1} by 6 K , with corresponding increases in peak intensity from 1 to 3 cm^{-1} . Such behaviour is similar to that reported by other authors in both low and high density polyethylene^(16,17).

The corresponding refraction spectra of figure 2 show the classical behaviour of the refractive index in the region of an isolated narrow absorption feature. At each temperature there is a region of strong dispersion in the immediate vicinity of the band. This is such that the overall level of the spectrum has higher values at wavenumbers below the line centre than above it. The dispersion across the band increases with decreasing temperature to reflect its causal relationship with the intensity of the line. Away from line centre the spectrum is independent of wavenumber.

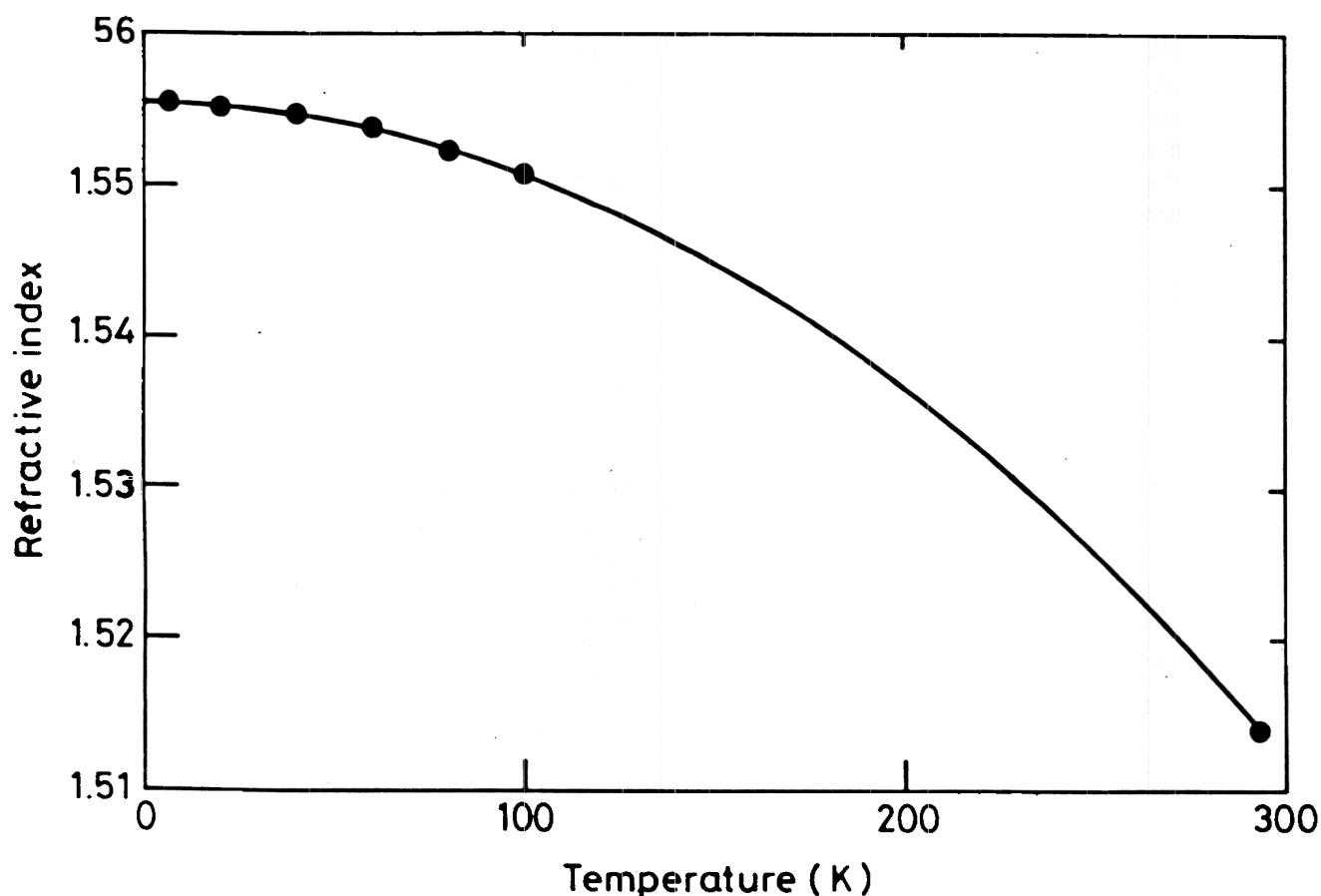


Figure 3. The temperature dependence of the refractive index of the low density polyethylene specimen at 40 cm^{-1} .

As the temperature of the specimen is decreased, the overall level of the refraction spectrum increases to follow the increase in density of the specimen. This can be seen in figure 3, which shows the temperature dependence of the refractive index at 40 cm^{-1} . The largest changes are seen at temperatures between 100 and 293 K. At lower temperatures the refractive index tends to a constant value, as further thermal contraction begins to be frozen out. On going between the extreme temperatures the refractive index changes from 1.5139 at 293 K to 1.5554 at 6 K. In a lens application involving LDPE this would correspond to a focal length reduction of 7.5% in going to the lower temperature. This is considerably greater than the 0.1% chromatic variation expected in the focal length of polyethylene lenses in this spectral region⁽¹⁸⁾, and could be significant in some applications. It points out the need for quantitative optical constant data at appropriate temperatures. In many applications it may be incorrect to assume, for example, that the room temperature focal length of a polymeric lens would apply at a reduced temperature.

4 CONCLUSIONS

The results of a determination of the temperature dependence of the spectral variation of the optical constants of low density polyethylene between 6 and 293 K, and $30\text{ to }120\text{ cm}^{-1}$ have been presented and discussed. These have been presented both in graphical and tabular form, to provide a body of quantitative information that can be used for optical design purposes in the terahertz spectral region. As the optical constants of polymers are sensitive to the particular details of their manufacturing process and previous history, the present spectra are intended as a guide to typical values that can be expected.

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Table 1 LDPE

(cm	(THz)		(cm ⁻¹)		
19.53	586	556165		421651	00052
20 51	0.615	555964	0.06	2.421025	0.00078
	0.645	555991	0.12	2.421108	0.00139
	0.674	1.555932	11	420923	0.00117
23.44	703	555811	0.07	.420547	0.00075
	0.732	.555748		2.420351	0.00106
25	762	555723	0.15	420274	0.00142
	0.791	555646	15	2.420034	0.00143
27 34	0.820	1.555541	13	2.419708	0.00118
28.32	0.850	555458	0.13	2 419449	0.00111
	0.879	555422	0.14	.419339	0.00114
.27	0.908	555435	13	2.419377	0.00107
31 25	0.938	555417	0.14	419323	0.00111
32 23	0 967	.555411	15	2.419302	0.00113
33.20	0.996	555403		2.419278	0.00104
	.025	555391	0.13	419242	0.00093
16	055	.555376	0.13	.419193	0.00090
36.13	084	555333	15	2.419061	0.00106
	113	.555343	0.15	2 419092	0.00101
38.09	143	1.555417		419322	0.00070
39.06	.172	555455	.10	2.419440	0.00064
40.04	201	.555408	0.14	419294	0.00085
41.02	230	555392		.419243	0.00095
	1.260	555468		2.419479	0.00107
42.97	289	.555506	0.20	2 419599	0.00118
43	318	555496	0.22	2 419568	0.00126
44.92	348	1.555525	0.24	2.419659	0.00133
45	.377	555564	0.26	419779	0.00140
46.88	406	555540	0.27	419706	0.00143
47 85	436	1.555440	0.28	2.419394	0.00144
48.83	465	.555363		.419153	0.00153
49.80	.494	555380	0.32	2.419207	0.00158
78	523	.555416	31	2 419320	0.00153
51 76	1.553	555386	0.31	2.419227	0.00148
52.73	582	555348	0.30	2 419106	0.00143
71	611	1.555340	0.30	419081	0.00139
54.69	641	555330	0.30	2.419052	0.00135
55.66	670	1.555328		419044	0.00132
56.64	699	555343	0.30	2.419090	0.00131
	729	555372		2.419183	0.00129
58.59	1.758	555417		419322	0.00129
59.57	787	1.555448	32	2.419418	0.00132
60.55	816	555452	32	2.419431	0.00132
52	846	555462	0.34	2 419461	0.00135
	.875	1.555480	36	2.419517	0.00144
63.48	904	555482	0.40	419523	0.00156
64.45	934	1.555505	0.43	2.419597	0.00166
65.43	1.963	555568	0.47	2 419792	0.00176
66.41	992	.555606	0.51	419909	0.00190

Table 1 (contd). LDPE 6 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
67.38	2.021	1.555585	0.56	2.419843	0.00205
68.36	2.051	1.555555	0.60	2.419750	0.00216
69.34	2.080	1.555538	0.61	2.419697	0.00219
70.31	2.109	1.555514	0.62	2.419624	0.00219
71.29	2.139	1.555511	0.63	2.419615	0.00217
72.27	2.168	1.555570	0.62	2.419798	0.00211
73.24	2.197	1.555665	0.60	2.420095	0.00204
74.22	2.227	1.555778	0.63	2.420444	0.00212
75.20	2.256	1.555902	0.78	2.420831	0.00257
76.17	2.285	1.556008	1.05	2.421160	0.00342
77.15	2.314	1.556092	1.40	2.421420	0.00451
78.13	2.344	1.556086	1.84	2.421401	0.00583
79.10	2.373	1.555833	2.58	2.420611	0.00808
80.08	2.402	1.553969	2.99	2.414812	0.00924
81.05	2.432	1.553669	1.67	2.413886	0.00511
82.03	2.461	1.553885	1.11	2.414557	0.00333
83.01	2.490	1.554119	0.87	2.415286	0.00259
83.98	2.520	1.554265	0.77	2.415741	0.00227
84.96	2.549	1.554373	0.74	2.416074	0.00215
85.94	2.578	1.554482	0.72	2.416413	0.00206
86.91	2.607	1.554552	0.67	2.416632	0.00190
87.89	2.637	1.554579	0.63	2.416715	0.00178
88.87	2.666	1.554599	0.61	2.416778	0.00170
89.84	2.695	1.554630	0.57	2.416875	0.00158
90.82	2.725	1.554709	0.55	2.417120	0.00149
91.80	2.754	1.554809	0.54	2.417430	0.00146
92.77	2.783	1.554854	0.57	2.417570	0.00152
93.75	2.813	1.554867	0.64	2.417612	0.00168
94.73	2.842	1.554887	0.74	2.417674	0.00192
95.70	2.871	1.554905	0.81	2.417730	0.00210
96.68	2.900	1.554905	0.81	2.417730	0.00207
97.66	2.930	1.554897	0.80	2.417705	0.00204
98.63	2.959	1.554878	0.88	2.417645	0.00221
99.61	2.988	1.554873	0.93	2.417630	0.00231
100.59	3.018	1.554868	0.91	2.417614	0.00225
101.56	3.047	1.554821	0.93	2.417468	0.00226
102.54	3.076	1.554756	0.93	2.417267	0.00224
103.52	3.105	1.554715	0.87	2.417139	0.00208
104.49	3.135	1.554704	0.84	2.417104	0.00198
105.47	3.164	1.554695	0.83	2.417077	0.00195
106.45	3.193	1.554682	0.84	2.417034	0.00195
107.42	3.223	1.554680	0.83	2.417029	0.00191
108.40	3.252	1.554706	0.81	2.417111	0.00185
109.38	3.281	1.554755	0.79	2.417262	0.00179
110.35	3.311	1.554787	0.75	2.417363	0.00169
111.33	3.340	1.554794	0.74	2.417384	0.00164
112.30	3.369	1.554776	0.77	2.417327	0.00169
113.28	3.398	1.554772	0.79	2.417315	0.00173
114.26	3.428	1.554817	0.83	2.417455	0.00179

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Table 1 (contd). LDPE 6 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
115.23	3.457	1.554847	0.90	2.417548	0.00192
116.21	3.486	1.554831	0.94	2.417500	0.00200
117.19	3.516	1.554807	0.95	2.417424	0.00202
118.16	3.545	1.554803	0.97	2.417412	0.00204
119.14	3.574	1.554808	0.97	2.417427	0.00201
120.12	3.604	1.554798	0.97	2.417396	0.00199
121.09	3.633	1.554809	0.98	2.417432	0.00201
122.07	3.662	1.554814	0.99	2.417446	0.00201
123.05	3.691	1.554804	1.01	2.417415	0.00203
124.02	3.721	1.554827	1.06	2.417488	0.00212
125.00	3.750	1.554835	1.03	2.417513	0.00204

Table 2. LDPE 20 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
22.46	0.674	1.555334	0.02	2.419065	0.00026
23.44	0.703	1.555339	0.08	2.419080	0.00086
24.41	0.732	1.555302	0.07	2.418965	0.00075
25.39	0.762	1.555323	0.08	2.419029	0.00080
26.37	0.791	1.555340	0.10	2.419083	0.00094
27.34	0.820	1.555212	0.10	2.418685	0.00091
28.32	0.850	1.555115	0.12	2.418381	0.00108
29.30	0.879	1.555132	0.15	2.418436	0.00127
30.27	0.908	1.555177	0.16	2.418575	0.00127
31.25	0.938	1.555173	0.16	2.418563	0.00130
32.23	0.967	1.555122	0.17	2.418404	0.00129
33.20	0.996	1.555120	0.16	2.418397	0.00119
34.18	1.025	1.555173	0.16	2.418563	0.00112
35.16	1.055	1.555178	0.17	2.418577	0.00118
36.13	1.084	1.555122	0.18	2.418405	0.00123
37.11	1.113	1.555103	0.19	2.418345	0.00123
38.09	1.143	1.555126	0.19	2.418417	0.00121
39.06	1.172	1.555107	0.19	2.418359	0.00119
40.04	1.201	1.555063	0.19	2.418222	0.00116
41.02	1.230	1.555033	0.17	2.418128	0.00106
41.99	1.260	1.555032	0.18	2.418123	0.00107
42.97	1.289	1.555060	0.21	2.418210	0.00119
43.95	1.318	1.555086	0.22	2.418292	0.00123
44.92	1.348	1.555136	0.21	2.418448	0.00118
45.90	1.377	1.555198	0.22	2.418639	0.00116
46.88	1.406	1.555198	0.22	2.418641	0.00117
47.85	1.436	1.555136	0.23	2.418448	0.00119
48.83	1.465	1.555110	0.25	2.418367	0.00129
49.80	1.494	1.555162	0.28	2.418530	0.00140
50.78	1.523	1.555201	0.29	2.418649	0.00143
51.76	1.553	1.555173	0.30	2.418563	0.00145
52.73	1.582	1.555130	0.31	2.418428	0.00146
53.71	1.611	1.555110	0.31	2.418368	0.00141
54.69	1.641	1.555115	0.31	2.418381	0.00140
55.66	1.670	1.555107	0.34	2.418358	0.00150
56.64	1.699	1.555094	0.36	2.418317	0.00158
57.62	1.729	1.555118	0.37	2.418392	0.00159
58.59	1.758	1.555159	0.38	2.418519	0.00161
59.57	1.787	1.555162	0.40	2.418530	0.00166
60.55	1.816	1.555158	0.40	2.418517	0.00162
61.52	1.846	1.555187	0.39	2.418606	0.00156
62.50	1.875	1.555226	0.41	2.418728	0.00161
63.48	1.904	1.555257	0.46	2.418824	0.00177
64.45	1.934	1.555290	0.51	2.418927	0.00197
65.43	1.963	1.555324	0.55	2.419033	0.00207
66.41	1.992	1.555323	0.59	2.419030	0.00219
67.38	2.021	1.555280	0.63	2.418894	0.00231
68.36	2.051	1.555263	0.65	2.418843	0.00234

Table 2 (

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
69.34	2.080	1.555268	0.68	2.418859	0.00243
70.31	2.109	1.555241	0.72	2.418775	0.00253
71.29	2.139	1.555204	0.72	2.418658	0.00250
72.27	2.168	1.555238	0.69	2.418764	0.00238
73.24	2.197	1.555330	0.70	2.419050	0.00238
74.22	2.227	1.555420	0.75	2.419332	0.00252
75.20	2.256	1.555528	0.88	2.419665	0.00288
76.17	2.285	1.555617	1.12	2.419944	0.00365
77.15	2.314	1.555639	1.52	2.420010	0.00488
78.13	2.344	1.555571	1.99	2.419797	0.00630
79.10	2.373	1.555098	2.64	2.418323	0.00825
80.08	2.402	1.553584	2.26	2.413617	0.00696
81.05	2.432	1.553440	1.40	2.413173	0.00427
82.03	2.461	1.553631	1.02	2.413768	0.00309
83.01	2.490	1.553838	0.83	2.414410	0.00248
83.98	2.520	1.553981	0.73	2.414855	0.00216
84.96	2.549	1.554087	0.67	2.415185	0.00196
85.94	2.578	1.554175	0.62	2.415461	0.00177
86.91	2.607	1.554254	0.60	2.415705	0.00172
87.89	2.637	1.554322	0.63	2.415916	0.00177
88.87	2.666	1.554341	0.60	2.415977	0.00167
89.84	2.695	1.554362	0.52	2.416040	0.00142
90.82	2.725	1.554446	0.51	2.416301	0.00138
91.80	2.754	1.554520	0.58	2.416533	0.00156
92.77	2.783	1.554558	0.67	2.416650	0.00178
93.75	2.813	1.554609	0.74	2.416810	0.00195
94.73	2.842	1.554627	0.78	2.416864	0.00203
95.70	2.871	1.554582	0.80	2.416725	0.00206
96.68	2.900	1.554569	0.81	2.416686	0.00207
97.66	2.930	1.554576	0.80	2.416707	0.00202
98.63	2.959	1.554534	0.85	2.416576	0.00212
99.61	2.988	1.554468	0.93	2.416370	0.00230
100.59	3.018	1.554429	0.89	2.416249	0.00218
101.56	3.047	1.554423	0.79	2.416231	0.00191
102.54	3.076	1.554447	0.71	2.416304	0.00173
103.52	3.105	1.554500	0.67	2.416471	0.00160
104.49	3.135	1.554531	0.68	2.416565	0.00161
105.47	3.164	1.554526	0.71	2.416551	0.00167
106.45	3.193	1.554513	0.70	2.416510	0.00162
107.42	3.223	1.554533	0.69	2.416573	0.00158
108.40	3.252	1.554578	0.79	2.416713	0.00180
109.38	3.281	1.554602	0.85	2.416788	0.00191
110.35	3.311	1.554565	0.84	2.416671	0.00187
111.33	3.340	1.554513	0.83	2.416510	0.00184
112.30	3.369	1.554535	0.82	2.416579	0.00180
113.28	3.398	1.554549	0.88	2.416623	0.00191
114.26	3.428	1.554493	0.97	2.416448	0.00210
115.23	3.457	1.554456	1.00	2.416334	0.00214
116.21	3.486	1.554466	0.96	2.416363	0.00205

Table 2 (contd). LDPE 20 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
117.19	3.516	1.554483	0.94	2.416416	0.00199
118.16	3.545	1.554557	0.89	2.416647	0.00187
119.14	3.574	1.554611	0.81	2.416815	0.00169
120.12	3.604	1.554588	0.81	2.416743	0.00166
121.09	3.633	1.554562	0.79	2.416662	0.00162
122.07	3.662	1.554573	0.80	2.416698	0.00163
123.05	3.691	1.554591	0.86	2.416752	0.00172
124.02	3.721	1.554583	0.92	2.416727	0.00184
125.00	3.750	1.554625	1.02	2.416860	0.00201

Table 3. LDPE 40 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
19.53	0.586	1.554942	0.01	2.417844	0.00015
20.51	0.615	1.554848	0.10	2.417553	0.00127
21.48	0.645	1.554927	0.12	2.417799	0.00132
22.46	0.674	1.555077	0.11	2.418266	0.00119
23.44	0.703	1.555149	0.10	2.418489	0.00111
24.41	0.732	1.555019	0.10	2.418084	0.00098
25.39	0.762	1.554938	0.12	2.417832	0.00118
26.37	0.791	1.554926	0.16	2.417795	0.00151
27.34	0.820	1.554891	0.17	2.417686	0.00153
28.32	0.850	1.554860	0.18	2.417589	0.00157
29.30	0.879	1.554834	0.19	2.417510	0.00165
30.27	0.908	1.554825	0.18	2.417481	0.00148
31.25	0.938	1.554782	0.17	2.417346	0.00131
32.23	0.967	1.554765	0.16	2.417295	0.00121
33.20	0.996	1.554813	0.16	2.417444	0.00120
34.18	1.025	1.554821	0.19	2.417470	0.00136
35.16	1.055	1.554783	0.20	2.417351	0.00144
36.13	1.084	1.554771	0.22	2.417313	0.00148
37.11	1.113	1.554793	0.22	2.417382	0.00148
38.09	1.143	1.554813	0.22	2.417444	0.00142
39.06	1.172	1.554805	0.22	2.417418	0.00138
40.04	1.201	1.554793	0.21	2.417381	0.00129
41.02	1.230	1.554776	0.21	2.417327	0.00125
41.99	1.260	1.554767	0.22	2.417300	0.00132
42.97	1.289	1.554773	0.24	2.417320	0.00136
43.95	1.318	1.554806	0.22	2.417421	0.00126
44.92	1.348	1.554874	0.20	2.417633	0.00110
45.90	1.377	1.554913	0.20	2.417753	0.00109
46.88	1.406	1.554915	0.23	2.417761	0.00120
47.85	1.436	1.554900	0.25	2.417714	0.00127
48.83	1.465	1.554884	0.27	2.417665	0.00136
49.80	1.494	1.554882	0.31	2.417656	0.00152
50.78	1.523	1.554865	0.33	2.417606	0.00163
51.76	1.553	1.554851	0.34	2.417562	0.00163
52.73	1.582	1.554861	0.32	2.417592	0.00153
53.71	1.611	1.554874	0.32	2.417633	0.00149
54.69	1.641	1.554888	0.34	2.417676	0.00154
55.66	1.670	1.554878	0.35	2.417645	0.00158
56.64	1.699	1.554850	0.37	2.417558	0.00161
57.62	1.729	1.554862	0.37	2.417597	0.00159
58.59	1.758	1.554907	0.37	2.417735	0.00155
59.57	1.787	0.000240	0.39	-0.000000	0.000000
60.55	1.816	1.554928	0.40	2.417800	0.00164
61.52	1.846	1.554942	0.41	2.417845	0.00167
62.50	1.875	1.554971	0.45	2.417936	0.00179
63.48	1.904	1.554984	0.47	2.417975	0.00185
64.45	1.934	1.554994	0.50	2.418005	0.00194
65.43	1.963	1.555023	0.56	2.418097	0.00213

Table 3 (contd). LDPE 40 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
66.41	1.992	1.555038	0.61	2.418144	0.00225
67.38	2.021	1.555026	0.61	2.418104	0.00226
68.36	2.051	1.555008	0.64	2.418048	0.00232
69.34	2.080	1.554991	0.69	2.417998	0.00247
70.31	2.109	1.554996	0.70	2.418011	0.00247
71.29	2.139	1.555007	0.68	2.418046	0.00235
72.27	2.168	1.555044	0.70	2.418161	0.00238
73.24	2.197	1.555111	0.76	2.418369	0.00259
74.22	2.227	1.555165	0.84	2.418539	0.00280
75.20	2.256	1.555279	0.96	2.418891	0.00318
76.17	2.285	1.555437	1.23	2.419382	0.00400
77.15	2.314	1.555447	1.67	2.419413	0.00537
78.13	2.344	1.555162	2.24	2.418525	0.00709
79.10	2.373	1.554270	2.78	2.415746	0.00870
80.08	2.402	1.553212	2.15	2.412462	0.00664
81.05	2.432	1.553209	1.39	2.412458	0.00425
82.03	2.461	1.553438	0.96	2.413168	0.00289
83.01	2.490	1.553611	0.76	2.413708	0.00225
83.98	2.520	1.553745	0.68	2.414124	0.00200
84.96	2.549	1.553859	0.62	2.414479	0.00180
85.94	2.578	1.553936	0.56	2.414716	0.00163
86.91	2.607	1.553997	0.55	2.414907	0.00156
87.89	2.637	1.554067	0.55	2.415125	0.00156
88.87	2.666	1.554153	0.53	2.415390	0.00148
89.84	2.695	1.554198	0.50	2.415532	0.00136
90.82	2.725	1.554238	0.50	2.415656	0.00136
91.80	2.754	1.554320	0.54	2.415909	0.00145
92.77	2.783	1.554355	0.59	2.416020	0.00157
93.75	2.813	1.554345	0.68	2.415987	0.00179
94.73	2.842	1.554356	0.77	2.416023	0.00200
95.70	2.871	1.554362	0.77	2.416040	0.00200
96.68	2.900	1.554300	0.79	2.415847	0.00201
97.66	2.930	1.554224	0.81	2.415613	0.00205
98.63	2.959	1.554178	0.84	2.415470	0.00211
99.61	2.988	1.554158	0.86	2.415406	0.00214
100.59	3.018	1.554186	0.79	2.415493	0.00195
101.56	3.047	1.554211	0.72	2.415572	0.00176
102.54	3.076	1.554235	0.73	2.415645	0.00176
103.52	3.105	1.554267	0.75	2.415745	0.00180
104.49	3.135	1.554249	0.74	2.415690	0.00174
105.47	3.164	1.554223	0.69	2.415608	0.00162
106.45	3.193	1.554273	0.64	2.415766	0.00148
107.42	3.223	1.554319	0.64	2.415907	0.00146
108.40	3.252	1.554261	0.67	2.415727	0.00152
109.38	3.281	1.554213	0.68	2.415579	0.00153
110.35	3.311	1.554233	0.78	2.415639	0.00174
111.33	3.340	1.554249	0.89	2.415690	0.00198
112.30	3.369	1.554226	0.95	2.415617	0.00209
113.28	3.398	1.554232	0.86	2.415637	0.00188

Table 3 (contd). LDPE 40 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
114.26	3.428	1.554269	0.77	2.415753	0.00167
115.23	3.457	1.554194	0.83	2.415520	0.00178
116.21	3.486	1.554100	0.81	2.415227	0.00172
117.19	3.516	1.554124	0.84	2.415300	0.00177
118.16	3.545	1.554153	1.04	2.415390	0.00217
119.14	3.574	1.554211	1.08	2.415570	0.00224
120.12	3.604	1.554257	0.95	2.415715	0.00196
121.09	3.633	1.554242	0.86	2.415666	0.00175
122.07	3.662	1.554295	0.87	2.415833	0.00176
123.05	3.691	1.554350	0.95	2.416005	0.00191
124.02	3.721	1.554324	0.95	2.415924	0.00190
125.00	3.750	1.554406	0.97	2.416178	0.00192

Table 4. LDPE 60 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
19.53	0.586	1.554263	0.06	2.415734	0.00073
20.51	0.615	1.554053	0.12	2.415080	0.00148
21.48	0.645	1.554011	0.17	2.414949	0.00199
22.46	0.674	1.553928	0.18	2.414693	0.00199
23.44	0.703	1.553819	0.14	2.414353	0.00148
24.41	0.732	1.553786	0.15	2.414250	0.00149
25.39	0.762	1.553843	0.18	2.414428	0.00172
26.37	0.791	1.553895	0.17	2.414590	0.00161
27.34	0.820	1.553827	0.17	2.414377	0.00154
28.32	0.850	1.553729	0.18	2.414074	0.00155
29.30	0.879	1.553710	0.18	2.414013	0.00154
30.27	0.908	1.553737	0.17	2.414098	0.00143
31.25	0.938	1.553752	0.17	2.414145	0.00133
32.23	0.967	1.553745	0.18	2.414124	0.00140
33.20	0.996	1.553748	0.19	2.414132	0.00139
34.18	1.025	1.553793	0.19	2.414274	0.00135
35.16	1.055	1.553799	0.21	2.414292	0.00146
36.13	1.084	1.553767	0.23	2.414191	0.00157
37.11	1.113	1.553782	0.24	2.414239	0.00163
38.09	1.143	1.553793	0.23	2.414274	0.00153
39.06	1.172	1.553774	0.23	2.414213	0.00146
40.04	1.201	1.553765	0.26	2.414185	0.00162
41.02	1.230	1.553751	0.29	2.414143	0.00173
41.99	1.260	1.553734	0.28	2.414088	0.00165
42.97	1.289	1.553720	0.27	2.414045	0.00155
43.95	1.318	1.553718	0.28	2.414038	0.00155
44.92	1.348	1.553746	0.29	2.414126	0.00160
45.90	1.377	1.553772	0.29	2.414207	0.00155
46.88	1.406	1.553766	0.27	2.414190	0.00144
47.85	1.436	1.553759	0.29	2.414167	0.00149
48.83	1.465	1.553758	0.31	2.414162	0.00154
49.80	1.494	1.553755	0.31	2.414155	0.00151
50.78	1.523	1.553760	0.33	2.414171	0.00162
51.76	1.553	1.553760	0.36	2.414170	0.00172
52.73	1.582	1.553759	0.35	2.414165	0.00164
53.71	1.611	1.553786	0.34	2.414251	0.00158
54.69	1.641	1.553806	0.37	2.414313	0.00169
55.66	1.670	1.553784	0.39	2.414245	0.00173
56.64	1.699	1.553754	0.39	2.414152	0.00170
57.62	1.729	1.553754	0.41	2.414151	0.00178
58.59	1.758	1.553790	0.43	2.414264	0.00181
59.57	1.787	1.553805	0.42	2.414309	0.00176
60.55	1.816	1.553791	0.42	2.414266	0.00172
61.52	1.846	1.553801	0.42	2.414297	0.00168
62.50	1.875	1.553830	0.43	2.414387	0.00169
63.48	1.904	1.553839	0.45	2.414415	0.00175
64.45	1.934	1.553838	0.49	2.414411	0.00186
65.43	1.963	1.553865	0.54	2.414495	0.00204

Table 4 (contd). LDPE 60 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
66.41	1.992	1.553906	0.57	2.414623	0.00214
67.38	2.021	1.553908	0.57	2.414629	0.00208
68.36	2.051	1.553884	0.57	2.414555	0.00207
69.34	2.080	1.553883	0.62	2.414552	0.00221
70.31	2.109	1.553926	0.68	2.414685	0.00240
71.29	2.139	1.553986	0.72	2.414872	0.00251
72.27	2.168	1.554033	0.75	2.415017	0.00257
73.24	2.197	1.554073	0.81	2.415142	0.00274
74.22	2.227	1.554145	0.91	2.415364	0.00303
75.20	2.256	1.554226	1.01	2.415618	0.00334
76.17	2.285	1.554292	1.16	2.415823	0.00377
77.15	2.314	1.554370	1.48	2.416065	0.00473
78.13	2.344	1.554298	2.08	2.415838	0.00658
79.10	2.373	1.553190	2.96	2.412390	0.00925
80.08	2.402	1.552170	2.03	2.409228	0.00626
81.05	2.432	1.552212	1.33	2.409362	0.00407
82.03	2.461	1.552393	0.97	2.409922	0.00292
83.01	2.490	1.552557	0.79	2.410434	0.00236
83.98	2.520	1.552672	0.71	2.410791	0.00209
84.96	2.549	1.552768	0.67	2.411087	0.00194
85.94	2.578	1.552820	0.62	2.411251	0.00177
86.91	2.607	1.552855	0.58	2.411357	0.00165
87.89	2.637	1.552909	0.56	2.411528	0.00159
88.87	2.666	1.552949	0.54	2.411651	0.00151
89.84	2.695	1.553002	0.54	2.411815	0.00147
90.82	2.725	1.553086	0.59	2.412076	0.00161
91.80	2.754	1.553152	0.63	2.412282	0.00170
92.77	2.783	1.553185	0.59	2.412385	0.00157
93.75	2.813	1.553197	0.60	2.412420	0.00159
94.73	2.842	1.553164	0.69	2.412319	0.00181
95.70	2.871	1.553150	0.74	2.412275	0.00192
96.68	2.900	1.553171	0.79	2.412340	0.00201
97.66	2.930	1.553164	0.81	2.412317	0.00206
98.63	2.959	1.553110	0.80	2.412152	0.00200
99.61	2.988	1.553055	0.80	2.411980	0.00199
100.59	3.018	1.553091	0.80	2.412090	0.00197
101.56	3.047	1.553133	0.74	2.412223	0.00181
102.54	3.076	1.553118	0.62	2.412176	0.00150
103.52	3.105	1.553151	0.57	2.412277	0.00135
104.49	3.135	1.553188	0.62	2.412393	0.00146
105.47	3.164	1.553194	0.66	2.412410	0.00154
106.45	3.193	1.553216	0.66	2.412478	0.00154
107.42	3.223	1.553224	0.67	2.412506	0.00155
108.40	3.252	1.553204	0.68	2.412444	0.00156
109.38	3.281	1.553175	0.70	2.412353	0.00157
110.35	3.311	1.553143	0.74	2.412252	0.00165
111.33	3.340	1.553163	0.75	2.412315	0.00167
112.30	3.369	1.553167	0.78	2.412328	0.00172
113.28	3.398	1.553211	0.73	2.412463	0.00158

Table (contd). LDPE 60

(cm ⁻¹)	(THz)		(cm ⁻¹)	ε'	ε''
114.26	3.428	553268			
115.23	3.457	.553275	.67	2.412642	0.00144
116.21	3.486	1.553234	0.67	2.412663	0.00143
117	3.516	553187	0.67	2.412534	0.00142
118.16	3.545	553186	0.81	412389	0.00171
119	3.574	.553172	.02	2.412387	0.00213
120.	3.604	553222	1.12	2.412342	0.00232
121.09	3.633	.553335		2.412499	0.00225
122	3.662	1.553308	0.82	2.412848	0.00168
123.05	3.691	553202	0.72	2.412766	0.00146
124.02	3.721	.553192	0.83	2.412436	0.00167
125.00	3.750	1.553236	0.94	2.412405	0.00188
			0.93	2.412542	0.00183

Table 5. LDPE 80 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
20.51	0.615	1.552417	0.05	2.409997	0.00065
21.48	0.645	1.552384	0.09	2.409897	0.00105
22.46	0.674	1.552512	0.06	2.410294	0.00072
23.44	0.703	1.552494	0.06	2.410239	0.00063
24.41	0.732	1.552370	0.10	2.409852	0.00097
25.39	0.762	1.552279	0.12	2.409570	0.00117
26.37	0.791	1.552289	0.14	2.409602	0.00134
27.34	0.820	1.552336	0.14	2.409747	0.00126
28.32	0.850	1.552370	0.14	2.409853	0.00125
29.30	0.879	1.552391	0.15	2.409918	0.00127
30.27	0.908	1.552391	0.14	2.409916	0.00118
31.25	0.938	1.552376	0.14	2.409870	0.00108
32.23	0.967	1.552310	0.15	2.409666	0.00113
33.20	0.996	1.552289	0.18	2.409601	0.00131
34.18	1.025	1.552356	0.20	2.409809	0.00147
35.16	1.055	1.552406	0.20	2.409964	0.00143
36.13	1.084	1.552376	0.20	2.409872	0.00139
37.11	1.113	1.552340	0.20	2.409759	0.00133
38.09	1.143	1.552296	0.18	2.409622	0.00115
39.06	1.172	1.552224	0.18	2.409400	0.00116
40.04	1.201	1.552224	0.23	2.409400	0.00144
41.02	1.230	1.552270	0.26	2.409543	0.00160
41.99	1.260	1.552301	0.26	2.409638	0.00152
42.97	1.289	1.552294	0.25	2.409616	0.00141
43.95	1.318	1.552273	0.25	2.409550	0.00138
44.92	1.348	1.552270	0.24	2.409543	0.00133
45.90	1.377	1.552307	0.22	2.409656	0.00121
46.88	1.406	1.552350	0.22	2.409791	0.00119
47.85	1.436	1.552337	0.25	2.409750	0.00129
48.83	1.465	1.552342	0.28	2.409765	0.00140
49.80	1.494	1.552382	0.29	2.409891	0.00142
50.78	1.523	1.552387	0.30	2.409905	0.00144
51.76	1.553	1.552377	0.31	2.409874	0.00150
52.73	1.582	1.552368	0.32	2.409846	0.00151
53.71	1.611	1.552362	0.34	2.409827	0.00158
54.69	1.641	1.552349	0.38	2.409788	0.00174
55.66	1.670	1.552330	0.41	2.409727	0.00182
56.64	1.699	1.552321	0.41	2.409701	0.00177
57.62	1.729	1.552328	0.41	2.409721	0.00177
58.59	1.758	1.552350	0.44	2.409789	0.00185
59.57	1.787	1.552356	0.44	2.409809	0.00185
60.55	1.816	1.552342	0.43	2.409765	0.00175
61.52	1.846	1.552341	0.42	2.409764	0.00167
62.50	1.875	1.552362	0.43	2.409827	0.00171
63.48	1.904	1.552397	0.46	2.409935	0.00180
64.45	1.934	1.552432	0.48	2.410046	0.00185
65.43	1.963	1.552459	0.51	2.410127	0.00194
66.41	1.992	1.552480	0.57	2.410194	0.00211

Table 5 (contd). LDPE 80 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
67.38	2.021	1.552476	0.59	2.410182	0.00215
68.36	2.051	1.552472	0.60	2.410168	0.00217
69.34	2.080	1.552505	0.67	2.410270	0.00239
70.31	2.109	1.552534	0.77	2.410362	0.00272
71.29	2.139	1.552507	0.84	2.410277	0.00290
72.27	2.168	1.552539	0.87	2.410375	0.00297
73.24	2.197	1.552626	0.92	2.410648	0.00309
74.22	2.227	1.552641	1.02	2.410693	0.00340
75.20	2.256	1.552684	1.19	2.410825	0.00391
76.17	2.285	1.552708	1.44	2.410900	0.00467
77.15	2.314	1.552496	1.90	2.410239	0.00607
78.13	2.344	1.551968	2.35	2.408598	0.00743
79.10	2.373	1.551130	2.30	2.405999	0.00718
80.08	2.402	1.550681	1.68	2.404608	0.00519
81.05	2.432	1.550789	1.17	2.404945	0.00356
82.03	2.461	1.550963	0.87	2.405486	0.00262
83.01	2.490	1.551092	0.75	2.405887	0.00224
83.98	2.520	1.551216	0.68	2.406269	0.00200
84.96	2.549	1.551300	0.64	2.406531	0.00185
85.94	2.578	1.551350	0.64	2.406687	0.00183
86.91	2.607	1.551427	0.65	2.406927	0.00185
87.89	2.637	1.551517	0.59	2.407204	0.00166
88.87	2.666	1.551578	0.54	2.407393	0.00149
89.84	2.695	1.551614	0.52	2.407507	0.00144
90.82	2.725	1.551642	0.50	2.407593	0.00135
91.80	2.754	1.551695	0.52	2.407758	0.00140
92.77	2.783	1.551765	0.58	2.407974	0.00155
93.75	2.813	1.551800	0.65	2.408082	0.00170
94.73	2.842	1.551788	0.75	2.408046	0.00195
95.70	2.871	1.551756	0.80	2.407946	0.00206
96.68	2.900	1.551688	0.72	2.407737	0.00184
97.66	2.930	1.551658	0.64	2.407642	0.00163
98.63	2.959	1.551667	0.64	2.407671	0.00161
99.61	2.988	1.551636	0.66	2.407574	0.00163
100.59	3.018	1.551618	0.63	2.407517	0.00156
101.56	3.047	1.551653	0.60	2.407627	0.00145
102.54	3.076	1.551726	0.57	2.407855	0.00138
103.52	3.105	1.551766	0.61	2.407976	0.00146
104.49	3.135	1.551734	0.68	2.407880	0.00161
105.47	3.164	1.551665	0.70	2.407663	0.00165
106.45	3.193	1.551639	0.64	2.407584	0.00148
107.42	3.223	1.551693	0.56	2.407752	0.00129
108.40	3.252	1.551775	0.60	2.408005	0.00137
109.38	3.281	1.551831	0.72	2.408178	0.00162
110.35	3.311	1.551811	0.71	2.408116	0.00158
111.33	3.340	1.551767	0.60	2.407980	0.00133
112.30	3.369	1.551758	0.56	2.407954	0.00122
113.28	3.398	1.551785	0.70	2.408035	0.00152
114.26	3.428	1.551844	0.81	2.408220	0.00175

Table 5 (contd). LDPE 80

		(THz		()		
	3	3 457	55177			
	1	3 486	551699	86	407992	00183
7	9	3 516	551833	0.92	407769	0.00195
18	6	3 545	551891	90	408186	00189
19		3 574	551872	0.86	408366	0.00179
20		3 604	551755	0.84	408306	0.00175
12	09	3 633	551702	85	407943	0.00174
22	07	3 662	551713	0.8	407779	00159
123	05	3 691	551837	0.74	4078 1	00151
24	02	3 72	551876	87	408196	0.00175
	00	3 750	551834	02	408319	00203
					408187	00222

Table 6. LDPE 100 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
21.48	0.645	1.550798	0.04	2.404975	0.00048
22.46	0.674	1.550763	0.06	2.404864	0.00064
23.44	0.703	1.550789	0.09	2.404948	0.00090
24.41	0.732	1.550790	0.09	2.404951	0.00096
25.39	0.762	1.550723	0.09	2.404741	0.00087
26.37	0.791	1.550651	0.09	2.404519	0.00085
27.34	0.820	1.550634	0.10	2.404464	0.00092
28.32	0.850	1.550688	0.12	2.404632	0.00107
29.30	0.879	1.550726	0.13	2.404752	0.00112
30.27	0.908	1.550740	0.11	2.404796	0.00090
31.25	0.938	1.550726	0.12	2.404751	0.00095
32.23	0.967	1.550684	0.13	2.404620	0.00101
33.20	0.996	1.550699	0.17	2.404667	0.00129
34.18	1.025	1.550736	0.21	2.404781	0.00152
35.16	1.055	1.550707	0.22	2.404693	0.00157
36.13	1.084	1.550686	0.23	2.404628	0.00156
37.11	1.113	1.550728	0.24	2.404756	0.00158
38.09	1.143	1.550781	0.24	2.404920	0.00156
39.06	1.172	1.550787	0.24	2.404939	0.00150
40.04	1.201	1.550755	0.25	2.404841	0.00152
41.02	1.230	1.550724	0.25	2.404743	0.00152
41.99	1.260	1.550681	0.25	2.404611	0.00145
42.97	1.289	1.550653	0.25	2.404523	0.00146
43.95	1.318	1.550656	0.27	2.404533	0.00151
44.92	1.348	1.550676	0.25	2.404595	0.00135
45.90	1.377	1.550697	0.23	2.404660	0.00122
46.88	1.406	1.550699	0.24	2.404668	0.00128
47.85	1.436	1.550707	0.26	2.404692	0.00135
48.83	1.465	1.550729	0.28	2.404761	0.00144
49.80	1.494	1.550745	0.32	2.404810	0.00157
50.78	1.523	1.550765	0.32	2.404872	0.00155
51.76	1.553	1.550774	0.31	2.404898	0.00148
52.73	1.582	1.550761	0.32	2.404861	0.00150
53.71	1.611	1.550756	0.36	2.404845	0.00164
54.69	1.641	1.550732	0.39	2.404768	0.00175
55.66	1.670	1.550707	0.40	2.404692	0.00176
56.64	1.699	1.550697	0.40	2.404660	0.00173
57.62	1.729	1.550690	0.40	2.404639	0.00170
58.59	1.758	1.550704	0.41	2.404683	0.00172
59.57	1.787	1.550718	0.43	2.404725	0.00176
60.55	1.816	1.550722	0.42	2.404740	0.00171
61.52	1.846	1.550735	0.40	2.404778	0.00162
62.50	1.875	1.550742	0.42	2.404799	0.00166
63.48	1.904	1.550735	0.45	2.404779	0.00175
64.45	1.934	1.550752	0.47	2.404833	0.00182
65.43	1.963	1.550792	0.51	2.404957	0.00191
66.41	1.992	1.550837	0.54	2.405096	0.00201
67.38	2.021	1.550862	0.57	2.405173	0.00210

Table 6 (contd). LDPE 100 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
68.36	2.051	1.550863	0.63	2.405177	0.00229
69.34	2.080	1.550876	0.74	2.405215	0.00263
70.31	2.109	1.550870	0.83	2.405198	0.00290
71.29	2.139	1.550878	0.83	2.405221	0.00289
72.27	2.168	1.550913	0.79	2.405331	0.00270
73.24	2.197	1.550953	0.83	2.405453	0.00278
74.22	2.227	1.550980	0.97	2.405537	0.00323
75.20	2.256	1.550972	1.17	2.405511	0.00384
76.17	2.285	1.551018	1.46	2.405653	0.00473
77.15	2.314	1.551011	1.83	2.405632	0.00586
78.13	2.344	1.550597	2.26	2.404347	0.00715
79.10	2.373	1.549629	2.04	2.401346	0.00637
80.08	2.402	1.549308	1.44	2.400352	0.00442
81.05	2.432	1.549294	1.08	2.400310	0.00328
82.03	2.461	1.549399	0.86	2.400637	0.00259
83.01	2.490	1.549540	0.72	2.401074	0.00213
83.98	2.520	1.549627	0.63	2.401344	0.00184
84.96	2.549	1.549711	0.59	2.401605	0.00171
85.94	2.578	1.549790	0.55	2.401848	0.00158
86.91	2.607	1.549820	0.51	2.401942	0.00146
87.89	2.637	1.549830	0.50	2.401973	0.00139
88.87	2.666	1.549885	0.46	2.402143	0.00127
89.84	2.695	1.549987	0.44	2.402460	0.00120
90.82	2.725	1.550064	0.49	2.402698	0.00134
91.80	2.754	1.550102	0.55	2.402816	0.00146
92.77	2.783	1.550118	0.55	2.402865	0.00147
93.75	2.813	1.550124	0.58	2.402884	0.00154
94.73	2.842	1.550110	0.64	2.402841	0.00166
95.70	2.871	1.550080	0.66	2.402749	0.00170
96.68	2.900	1.550064	0.68	2.402699	0.00172
97.66	2.930	1.550057	0.68	2.402675	0.00171
98.63	2.959	1.550040	0.66	2.402625	0.00166
99.61	2.988	1.550023	0.68	2.402572	0.00168
100.59	3.018	1.550012	0.67	2.402537	0.00165
101.56	3.047	1.550014	0.64	2.402542	0.00155
102.54	3.076	1.550046	0.61	2.402642	0.00146
103.52	3.105	1.550066	0.61	2.402704	0.00146
104.49	3.135	1.550052	0.64	2.402660	0.00152
105.47	3.164	1.550054	0.64	2.402667	0.00149
106.45	3.193	1.550056	0.54	2.402675	0.00125
107.42	3.223	1.550091	0.50	2.402781	0.00115
108.40	3.252	1.550206	0.60	2.403139	0.00137
109.38	3.281	1.550291	0.62	2.403401	0.00140
110.35	3.311	1.550239	0.60	2.403240	0.00134
111.33	3.340	1.550158	0.68	2.402988	0.00150
112.30	3.369	1.550149	0.82	2.402963	0.00180
113.28	3.398	1.550196	0.85	2.403108	0.00184
114.26	3.428	1.550229	0.74	2.403209	0.00159
115.23	3.457	1.550209	0.71	2.403147	0.00153

Table 6 (contd). LDPE 100 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
116.21	3.486	1.550179	0.89	2.403054	0.00189
117.19	3.516	1.550084	0.93	2.402760	0.00195
118.16	3.545	1.550017	0.79	2.402553	0.00164
119.14	3.574	1.549996	0.75	2.402489	0.00154
120.12	3.604	1.549954	0.84	2.402357	0.00173
121.09	3.633	1.550097	0.88	2.402802	0.00179
122.07	3.662	1.550262	0.78	2.403312	0.00157
123.05	3.691	1.550261	0.77	2.403310	0.00155
124.02	3.721	1.550197	0.74	2.403109	0.00146
125.00	3.750	1.550139	0.64	2.402930	0.00127

Table 7. LDPE 293 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
24.41	0.732	1.514291	0.19	2.293076	0.00190
25.39	0.762	1.514252	0.20	2.292960	0.00192
26.37	0.791	1.514205	0.24	2.292817	0.00218
27.34	0.820	1.514210	0.25	2.292833	0.00224
28.32	0.850	1.514225	0.24	2.292877	0.00207
29.30	0.879	1.514230	0.24	2.292892	0.00195
30.27	0.908	1.514250	0.27	2.292952	0.00213
31.25	0.938	1.514291	0.31	2.293075	0.00239
32.23	0.967	1.514303	0.31	2.293113	0.00235
33.20	0.996	1.514238	0.31	2.292915	0.00224
34.18	1.025	1.514163	0.33	2.292689	0.00230
35.16	1.055	1.514132	0.34	2.292596	0.00232
36.13	1.084	1.514076	0.34	2.292426	0.00226
37.11	1.113	1.514080	0.36	2.292438	0.00234
38.09	1.143	1.514111	0.41	2.292531	0.00256
39.06	1.172	1.514012	0.42	2.292231	0.00260
40.04	1.201	1.513947	0.39	2.292034	0.00237
41.02	1.230	1.513985	0.37	2.292150	0.00216
41.99	1.260	1.513975	0.37	2.292119	0.00212
42.97	1.289	1.513920	0.37	2.291954	0.00210
43.95	1.318	1.513914	0.35	2.291936	0.00193
44.92	1.348	1.513957	0.35	2.292064	0.00187
45.90	1.377	1.513987	0.36	2.292155	0.00191
46.88	1.406	1.514002	0.34	2.292202	0.00172
47.85	1.436	1.514008	0.31	2.292220	0.00158
48.83	1.465	1.513982	0.33	2.292141	0.00164
49.80	1.494	1.513990	0.34	2.292165	0.00165
50.78	1.523	1.514019	0.35	2.292255	0.00166
51.76	1.553	1.514024	0.36	2.292269	0.00169
52.73	1.582	1.514027	0.36	2.292278	0.00165
53.71	1.611	1.514031	0.35	2.292291	0.00158
54.69	1.641	1.514025	0.34	2.292273	0.00149
55.66	1.670	1.514040	0.32	2.292316	0.00140
56.64	1.699	1.514080	0.34	2.292437	0.00145
57.62	1.729	1.514117	0.38	2.292552	0.00157
58.59	1.758	1.514136	0.41	2.292607	0.00171
59.57	1.787	1.514131	0.44	2.292594	0.00178
60.55	1.816	1.514109	0.46	2.292527	0.00182
61.52	1.846	1.514096	0.47	2.292487	0.00186
62.50	1.875	1.514124	0.47	2.292571	0.00183
63.48	1.904	1.514163	0.49	2.292688	0.00185
64.45	1.934	1.514188	0.53	2.292763	0.00197
65.43	1.963	1.514201	0.58	2.292805	0.00215
66.41	1.992	1.514200	0.65	2.292802	0.00237
67.38	2.021	1.514181	0.70	2.292743	0.00251
68.36	2.051	1.514140	0.74	2.292618	0.00261
69.34	2.080	1.514112	0.83	2.292535	0.00287
70.31	2.109	1.514054	0.93	2.292358	0.00319

Table 7 (contd). LDPE 293 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
71.29	2.139	1.513938	0.98	2.292007	0.00333
72.27	2.168	1.513813	0.99	2.291630	0.00329
73.24	2.197	1.513746	0.94	2.291427	0.00309
74.22	2.227	1.513710	0.88	2.291317	0.00285
75.20	2.256	1.513624	0.78	2.291058	0.00251
76.17	2.285	1.513601	0.67	2.290988	0.00211
77.15	2.314	1.513640	0.64	2.291106	0.00200
78.13	2.344	1.513665	0.66	2.291180	0.00203
79.10	2.373	1.513676	0.66	2.291214	0.00202
80.08	2.402	1.513682	0.65	2.291233	0.00195
81.05	2.432	1.513710	0.60	2.291319	0.00180
82.03	2.461	1.513757	0.59	2.291460	0.00173
83.01	2.490	1.513754	0.65	2.291451	0.00187
83.98	2.520	1.513697	0.68	2.291279	0.00195
84.96	2.549	1.513681	0.68	2.291229	0.00191
85.94	2.578	1.513673	0.65	2.291205	0.00181
86.91	2.607	1.513610	0.61	2.291015	0.00168
87.89	2.637	1.513601	0.54	2.290989	0.00147
88.87	2.666	1.513735	0.59	2.291394	0.00159
89.84	2.695	1.513738	0.66	2.291401	0.00176
90.82	2.725	1.513694	0.68	2.291268	0.00180
91.80	2.754	1.513656	0.64	2.291156	0.00168
92.77	2.783	1.513675	0.59	2.291211	0.00154
93.75	2.813	1.513686	0.65	2.291244	0.00167
94.73	2.842	1.513675	0.67	2.291212	0.00170
95.70	2.871	1.513653	0.65	2.291145	0.00164
96.68	2.900	1.513646	0.64	2.291125	0.00159
97.66	2.930	1.513667	0.69	2.291187	0.00169
98.63	2.959	1.513664	0.72	2.291180	0.00176
99.61	2.988	1.513592	0.65	2.290959	0.00158
100.59	3.018	1.513539	0.55	2.290801	0.00131
101.56	3.047	1.513586	0.57	2.290942	0.00134
102.54	3.076	1.513605	0.63	2.290999	0.00148
103.52	3.105	1.513572	0.61	2.290901	0.00143
104.49	3.135	1.513585	0.50	2.290939	0.00116
105.47	3.164	1.513676	0.37	2.291215	0.00085
106.45	3.193	1.513724	0.38	2.291361	0.00086
107.42	3.223	1.513701	0.46	2.291291	0.00103
108.40	3.252	1.513679	0.50	2.291224	0.00110
109.38	3.281	1.513677	0.50	2.291219	0.00109
110.35	3.311	1.513664	0.49	2.291178	0.00106
111.33	3.340	1.513643	0.52	2.291115	0.00112
112.30	3.369	1.513602	0.59	2.290992	0.00127
113.28	3.398	1.513611	0.61	2.291017	0.00130
114.26	3.428	1.513636	0.56	2.291093	0.00119
115.23	3.457	1.513632	0.54	2.291081	0.00113
116.21	3.486	1.513663	0.55	2.291176	0.00114
117.19	3.516	1.513668	0.56	2.291190	0.00116
118.16	3.545	1.513613	0.58	2.291024	0.00118

Table 7 (contd). LDPE 293 K.

ν (cm^{-1})	f (THz)	n	α (cm^{-1})	ϵ'	ϵ''
119.14	3.574	1.513595	0.54	2.290970	0.00109
120.12	3.604	1.513575	0.50	2.290910	0.00099
121.09	3.633	1.513532	0.54	2.290780	0.00107
122.07	3.662	1.513545	0.47	2.290818	0.00093
123.05	3.691	1.513578	0.42	2.290917	0.00083
124.02	3.721	1.513587	0.44	2.290946	0.00084
125.00	3.750	1.513584	0.41	2.290936	0.00080