

**RAPIDLY AND ACCURATELY DETERMINING
REFRACTIVE INDICES OF ASBESTOS FIBERS
BY USING
DISPERSION STAINING METHOD**

***A STANDARD OPERATION PROCEDURE FOR
BULK ASBESTOS ANALYSIS BY
POLARIZED LIGHT MICROSCOPY***

Shu-Chun Su, Ph.D.

Rev. 2010-07-11

For those laboratories that have received earlier versions of this paper, please replace them with this updated version. A much condensed version of this paper was published in 2003: *A rapid and accurate procedure for the determination of refractive indices of asbestos minerals*. American Mineralogist, 88, 1979-1982.

If anyone has any questions or suggestions concerning this procedure or need the electronic files (Word or PDF format), please contact me at shuchunsu@gmail.com.

This version has corrected an error with the two crocidolite tables (Tables 7 and 8): α and γ tables were transposed in older versions although the resultant differences between the RIs obtained from the previous tables and current tables are in most cases <0.002 , which is well within the expected experimental errors resulted from the inherited errors in estimating the matching wavelengths. In fact, because the dispersion coefficients of between α (1.161) and γ (1.174) are so negligible that they were combined into a single table in the above American Mineralogist paper. The same is true for chrysotile and amosite.

Shu-Chun Su, Ph.D.
NVLAP Technical Expert
Bulk and Airborne Asbestos Analysis Programs

Introduction

Refractive index (RI) is the most important optical properties of non-opaque minerals. It is also the leading diagnostic optical property used to identify asbestos components in bulk insulation or building materials by polarized light microscopy (PLM) using oil immersion method (Perkins and Harvey, 1993). Most environmental laboratories in the United States participate in the National Voluntary Laboratory Accreditation Program (NVLAP) administered by the National Institute of Standards and Technology (NIST), U.S. Department of Commerce. NVLAP requires the refractive indices α and γ of asbestos fibers to be determined and recorded during routine bulk asbestos sample analysis. Generally, an attainable and reasonable accuracy is ± 0.005 for chrysotile, amosite, tremolite, actinolite, and anthophyllite, or ± 0.010 for crocidolite.

In many environmental laboratories, the high volume of samples demands analysts to minimize the amount of time spent on the determination of required optical properties, particularly the refractive indices. It is most desirable to determine both α and γ from a single slide or a preparation (Su, 1993). Among the three methods for assessing the direction and magnitude of the mismatch between a solid and a surrounding liquid, Becke line (Bloss, 1961), dispersion staining (McCrone, 1987), and oblique illumination (Stoiber and Morse, 1994), only the later two, i.e., dispersion staining (DS) and oblique illumination (OI), can meet the specific needs for the routine PLM analysis of bulk asbestos samples in commercial environmental laboratories. The advantage of OI method is that it is as simple and accurate as DS and does not require special objective lens. In the meantime, it can be applied using high power objective lens (20X, 40X, etc.)

This paper provides a rapid and accurate procedure to enable bulk asbestos analysts to convert an observed DS color associated with α or γ for a specific asbestos mineral in a specific immersion liquid through its corresponding matching wavelength (λ_0) into corresponding numerical RI value.

Procedure

1. Select a proper immersion liquid to mount the sample

Mount the suspected asbestos fibers in an appropriate liquid according to Table 1. For asbestos types other than chrysotile, there are two choices of immersion liquids. The first choice, which is the liquid outside the parentheses, gives higher accuracy than the second choice, which is the liquid inside the parentheses. For example, when measuring crocidolite, 1.700 liquid is a much better choice than 1.680. For routine analysis, 1.550 (for chrysotile), 1.620 (for tremolite, actinolite, and anthophyllite), and 1.700 (for amosite and crocidolite) are quite adequate to obtain good accuracy for both α and γ . When higher accuracy is desirable (for example, when performing NVLAP Proficiency Testing), other liquids may be more appropriate and different liquids may be used for α and γ . For example, use 1.615 for the α and 1.635 for the γ of anthophyllite. Therefore, additional tables are included for higher accuracy work.

It is imperative to have fresh surface of asbestos fibers in direct contact with the surrounding liquid. Sometimes, the surface of an asbestos bundle may be coated by matrix or binder materials. In this case, true DS colors intrinsic to the asbestos/liquid combination might not be displayed.

Table 1. The Selection of Immersion Liquids for Asbestos Analysis

Suspected Asbestos		Immersion Liquids (Conversion Table Number)	
Type	RI	Proficiency Testing Samples (Different liquids for α and γ)	Routine Samples (Same liquid for both α and γ)
Chrysotile	α	1.550 (4A/B)	
	γ		
Grunerite (Amosite)	α	1.680 (5A)	1.700 (6A/B) [2 nd choice 1.680 (5A/B)]
	γ	1.700 (6B)	
Riebeckite (Crocidolite)	α	1.700 (8A)	1.700 (8A/B) [or 1.680 (7A/B)]
	γ		
Tremolite	α	1.605 (9A)	1.620 (11A/B) [2 nd choice 1.625 (12A/B)]
	γ	1.635 ¹ (14B)	
Actinolite	α	1.610 ¹ (16A)	1.625 (19A/B) [2 nd choice 1.620 (18A/B)]
	γ	1.640 ¹ (22B)	
Anthophyllite	α	1.615 ¹ (25A)	1.625 (27A/B) [2 nd choice 1.620 (26A/B)]
	γ	1.635 ¹ (29B)	

1. Cargille makes two series of immersion liquids in the range of 1.500 to 1.640: Series A (normal dispersion), which is in increment of 0.002, and Series E (high dispersion), which is in increment of 0.005. All oils between 1.605 and 1.640 used to generate the conversion tables in this paper are Series E liquids. For tremolite, actinolite, and anthophyllite, the central-stop DS colors produced by these Series E high dispersion liquids are more intense and vivid than those produced by Series A liquids. Tables 9 to 27 are not applicable if Series A liquids are used instead.
2. For qualitative analysis, 1.605 liquid is somehow okay for tremolite, actinolite, and anthophyllite. When accurate RI measurement is required, 1.605 liquid should be avoided because their γ are significantly higher than 1.605 and exhibit yellow to pale yellow central-stop DS colors. The inherent error in converting DS colors to λ_0 is always higher in the range of yellow than in the range of blue to orange.

A simple and effective way to bring out the true DS colors is to grind or rub the fiber bundle with a needle or probe to break the fiber bundle into finer bundles so that fresh surface is revealed and made in direct contact with the surrounding liquid.

2. Measure the temperature of the immersion liquid

Measure and record t (in °C), the temperature of the immersion liquid on the microscope slide. If the temperature of the liquid, slide, cover glass and sample can be reasonably assumed to be in equilibrium with the room temperature, t can be assumed to be equal to the room

temperature. The temperature data is needed for making temperature correction. Certain microscope tends to heat up the slide, resulting in an increase 2° or more in the liquid temperature.

3. Check the alignment of the polarized light microscope

Make sure that the polarized light microscope is properly aligned:

- DS objective and its central stop is centered;
- substage condenser is centered (if possible, set the microscope to Köhler illumination);
- the vibration (or privileged) directions of polarizer and analyzer are parallel to the E-W and N-S cross hairs in the eyepiece, respectively.

4. Observe the central-stop DS color associated with α of the asbestos fibers

Assuming that the polarizer is parallel to the E-W cross hair, rotate the microscope stage until a fiber bundle is parallel to the E-W cross hair if the asbestos is suspected to be crocidolite or perpendicular to the E-W cross hair if the asbestos is suspected to be other five asbestos types (chrysotile, tremolite, actinolite, anthophyllite, and amosite). Although the α of monoclinic amphiboles (tremolite and actinolite) is not exactly perpendicular to the fiber elongation, the RI at this orientation can be assumed to be reasonably close to α . Adjust the aperture diaphragm and field diaphragm to optimize the DS color displayed by the asbestos fibers.

Usually, a range of DS color is displayed. Make sure that the DS color that gives the **lowest** RI is observed, i.e. the DS color corresponding to the **longest** λ_0 . For example, if the DS color ranges from blue to light blue, choose light blue.

5. Covert the observed DS color into corresponding matching wavelength, λ_0 , between the asbestos fiber and the immersion liquid used by referring to Figure 1 or Table 2

6. Find out the numerical value of α corresponding to the observed λ_0 and t

Refer to one of the conversion tables to convert λ_0 and t into the corresponding refractive index. Notice that each table is for a specific direction (α or γ) of a specific asbestos mineral mounted in a specific RI liquid. If an RI liquid with a different n_D and/or a different dispersion coefficient [$n_F - n_C$] is used, the current tables are no longer applicable. In this case, a new table may be calculated by using an Excel program written by the author, which is available upon request. The algorithm used to compute all conversion tables in this paper can be found in Su (1993 and 2003). The 1993 reference is included in this SOP as an Appendix.

7. Observe the DS color associated with γ of the asbestos fibers

Rotate the microscope stage 90° and then repeat Steps 4 - 6 to determine γ . Again, a range of DS color is usually displayed. Make sure that the DS color that gives the **highest** RI is observed, i.e. the DS color corresponding to the **shortest** λ_0 . For example, if the DS color ranges from purple to red-purple, choose red-purple.

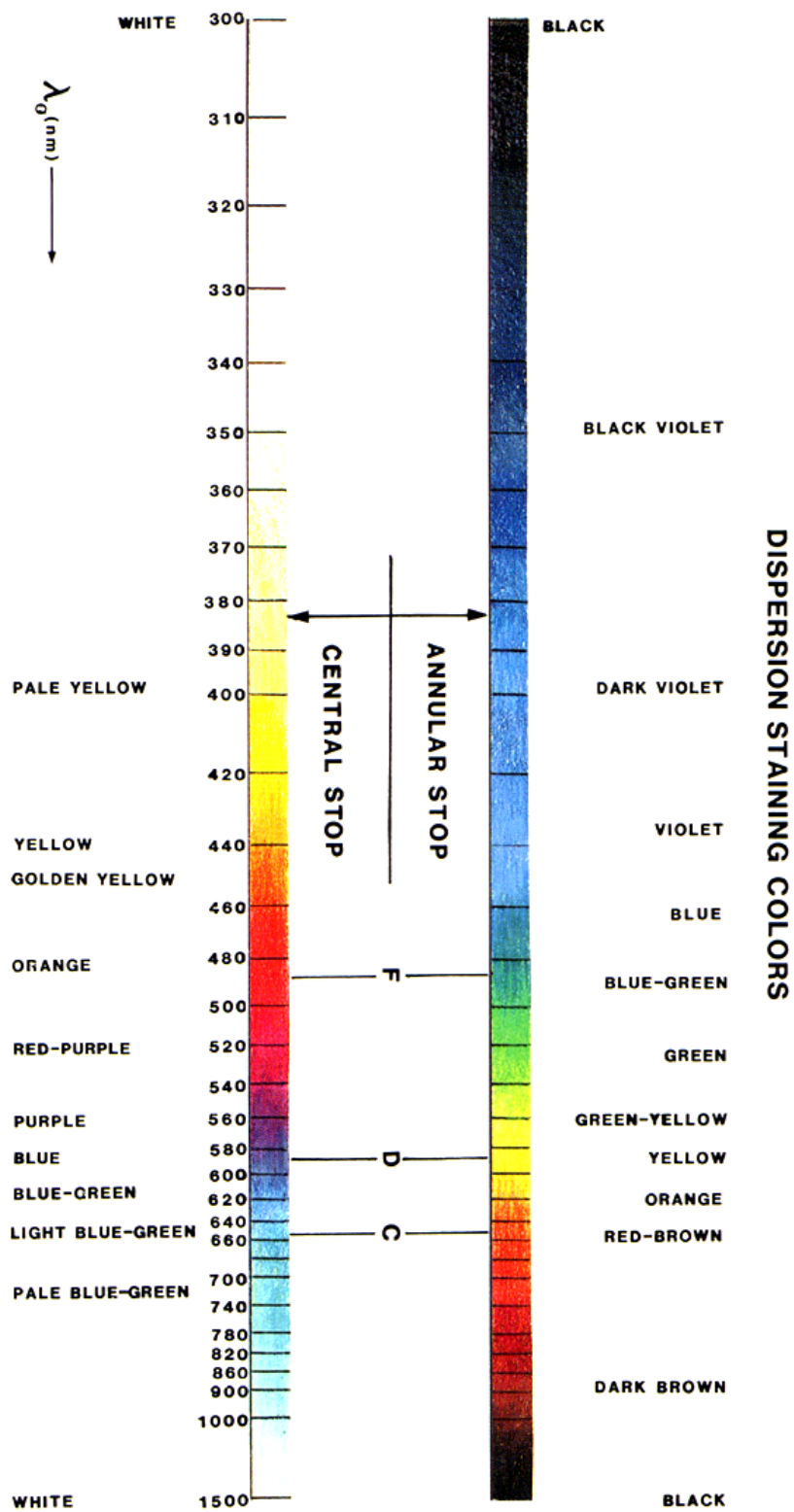


Fig. 1. Converting dispersion staining color to corresponding λ_0 (McCrone, 1987).

Table 2. Converting dispersion staining color to corresponding λ_0 (McCrone, 1987)

Matching Wavelength λ_0 , nm	Particle Edge Colors ¹		Becke Line Colors ²	
	Annular Stop ³	Central Stop ⁴	Particle	Liquid
<340	Black violet	white	white	X
<400	dark violet	pale yellow	pale yellow	X
430	violet	yellow	pale yellow	X
455	blue	golden yellow	yellow	violet
485	blue-green	orange	orange	violet
520	green	red purple	orange-red	violet-blue
560	yellow-green	purple	red-orange	blue-violet
595	yellow	deep blue	red	blue
625	orange	blue-green	faint red	blue
660	red-brown	light blue-green	X	blue-green
700	dark red-brown	pale blue-green	X	pale blue-green
1500	black-brown	very pale blue-green	X	very pale blue-green

1. In focus
2. On focusing up
3. Observed on a brightfield
4. Observed on a darkfield

Table 3. Refractive Indices and Dispersion Coefficients [$n_F - n_C$] of Six Asbestos Minerals

Mineral		n_F	n_D	n_C	$[n_F - n_C]$	Reference
Chrysotile	α	1.5563	1.5490	1.5456	0.0107	NIST SRM 1866
	γ	1.5649	1.5560	1.5530	0.0119	
Grunerite (Amosite)	α	1.6931	1.6790	1.6734	0.0197	NIST SRM 1866
	γ	1.7156	1.7010	1.6951	0.0205	
Riebeckite (Crocidolite)	α	1.7132	1.7015	1.6971	0.0161	McCrone (1987) Figs. 104A and 104B
	γ	1.7206	1.7072	1.7032	0.0174	
Tremolite	α	1.6128	1.6063	1.6036	0.0092	NIST SRM 1867
	β	1.6299	1.6230	1.6201	0.0098	
	γ	1.6423	1.6343	1.6310	0.0113	
Actinolite	α	1.6201	1.6126	1.6095	0.0106	NIST SRM 1867
	β	1.6369	1.6288	1.6254	0.0115	
	γ	1.6485	1.6393	1.6355	0.0130	
Anthophyllite	α	1.6227	1.6148	1.6116	0.0111	NIST SRM 1867
	β	1.6350	1.6273	1.6241	0.0109	
	γ	1.6449	1.6362	1.6326	0.0123	

1. $[n_F - n_C]$ is the **only** parameter used in calculating all conversion tables. When changes in elemental composition, thermal history, etc. have caused variations in n_F , n_D , and n_C , the dispersion coefficient $[n_F - n_C]$ remains relatively unaffected or only slightly affected.
2. The dispersion coefficient of NIST SRM 1866 grunerite is much higher than that of the grunerite in McCrone (1987, Figs. 104A and 104B). Therefore, some values in Tables 6A and 6B, which are based on NIST grunerite, are markedly different from the values in McCrone (1989, p.51, Table I), which are based on the grunerite in Figs. 104A and 104B (McCrone, 1987).
3. For tremolite, actinolite and anthophyllite, n_C is close to α and n_2 to γ .

Table 4A. **Chrysotile α** (In Cargille Series E: 1.550)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.583	1.582	1.581	1.580	1.579	1.578	1.577
420	1.577	1.576	1.575	1.574	1.573	1.572	1.571
440	1.573	1.572	1.571	1.570	1.569	1.568	1.567
460	1.569	1.568	1.567	1.566	1.565	1.564	1.563
480	1.565	1.564	1.563	1.562	1.561	1.560	1.559
500	1.562	1.561	1.560	1.559	1.558	1.557	1.556
520	1.560	1.559	1.558	1.557	1.556	1.555	1.554
540	1.558	1.557	1.556	1.555	1.554	1.553	1.552
560	1.556	1.555	1.554	1.553	1.552	1.551	1.550
580	1.554	1.553	1.552	1.551	1.550	1.549	1.548
589	1.553	1.552	1.551	1.550	1.549	1.548	1.547
600	1.552	1.551	1.550	1.549	1.548	1.547	1.546
620	1.551	1.550	1.549	1.548	1.547	1.546	1.545
640	1.549	1.548	1.547	1.546	1.545	1.544	1.543
660	1.548	1.547	1.546	1.545	1.544	1.543	1.542
680	1.547	1.546	1.545	1.544	1.543	1.542	1.541
700	1.546	1.545	1.544	1.543	1.542	1.541	1.540
750	1.544	1.543	1.542	1.541	1.540	1.539	1.538
800	1.542	1.541	1.540	1.539	1.538	1.537	1.536

Table 4B. **Chrysotile γ** (In Cargille Series E: 1.550)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.581	1.580	1.579	1.578	1.577	1.576	1.575
420	1.575	1.574	1.573	1.572	1.571	1.570	1.569
440	1.571	1.570	1.569	1.568	1.567	1.566	1.565
460	1.567	1.566	1.565	1.565	1.564	1.563	1.562
480	1.564	1.563	1.562	1.561	1.560	1.559	1.558
500	1.562	1.561	1.560	1.559	1.558	1.557	1.556
520	1.559	1.558	1.557	1.556	1.555	1.554	1.553
540	1.557	1.556	1.555	1.554	1.553	1.552	1.551
560	1.555	1.554	1.553	1.552	1.551	1.550	1.549
580	1.554	1.553	1.552	1.551	1.550	1.549	1.548
589	1.553	1.552	1.551	1.550	1.549	1.548	1.547
600	1.552	1.551	1.550	1.549	1.548	1.547	1.546
620	1.551	1.550	1.549	1.548	1.547	1.546	1.545
640	1.550	1.549	1.548	1.547	1.546	1.545	1.544
660	1.548	1.547	1.546	1.546	1.545	1.544	1.543
680	1.547	1.546	1.545	1.544	1.544	1.543	1.542
700	1.546	1.546	1.545	1.544	1.543	1.542	1.541
750	1.544	1.543	1.542	1.541	1.540	1.540	1.539
800	1.543	1.542	1.541	1.540	1.539	1.538	1.537

Table 5A. **Amosite α** (In Cargille Series **B: 1.680**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.711	1.710	1.709	1.708	1.707	1.706	1.705
420	1.706	1.705	1.704	1.703	1.702	1.701	1.700
440	1.701	1.700	1.699	1.699	1.698	1.697	1.696
460	1.698	1.697	1.696	1.695	1.694	1.693	1.692
480	1.694	1.694	1.693	1.692	1.691	1.690	1.689
500	1.692	1.691	1.690	1.689	1.688	1.687	1.686
520	1.689	1.688	1.687	1.686	1.685	1.685	1.684
540	1.687	1.686	1.685	1.684	1.683	1.682	1.681
560	1.685	1.684	1.683	1.682	1.681	1.681	1.680
580	1.684	1.683	1.682	1.681	1.680	1.679	1.678
589	1.683	1.682	1.681	1.680	1.679	1.678	1.677
600	1.682	1.681	1.680	1.679	1.678	1.677	1.676
620	1.681	1.680	1.679	1.678	1.677	1.676	1.675
640	1.679	1.678	1.678	1.677	1.676	1.675	1.674
660	1.678	1.677	1.676	1.675	1.674	1.674	1.673
680	1.677	1.676	1.675	1.674	1.673	1.672	1.671
700	1.676	1.675	1.674	1.673	1.672	1.671	1.671
750	1.674	1.673	1.672	1.671	1.670	1.669	1.668
800	1.672	1.671	1.671	1.670	1.669	1.668	1.667

Table 5B. **Amosite γ** (In Cargille Series **B: 1.680**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.710	1.709	1.708	1.707	1.706	1.705	1.704
420	1.705	1.704	1.703	1.702	1.701	1.700	1.699
440	1.700	1.699	1.698	1.698	1.697	1.696	1.695
460	1.697	1.696	1.695	1.694	1.693	1.692	1.691
480	1.694	1.693	1.692	1.691	1.690	1.689	1.688
500	1.691	1.690	1.689	1.688	1.687	1.686	1.686
520	1.689	1.688	1.687	1.686	1.685	1.684	1.683
540	1.687	1.686	1.685	1.684	1.683	1.682	1.681
560	1.685	1.684	1.683	1.682	1.681	1.680	1.679
580	1.684	1.683	1.682	1.681	1.680	1.679	1.678
589	1.683	1.682	1.681	1.680	1.679	1.678	1.677
600	1.682	1.681	1.680	1.679	1.678	1.677	1.676
620	1.681	1.680	1.679	1.678	1.677	1.676	1.675
640	1.680	1.679	1.678	1.677	1.676	1.675	1.674
660	1.679	1.678	1.677	1.676	1.675	1.674	1.673
680	1.678	1.677	1.676	1.675	1.674	1.673	1.672
700	1.677	1.676	1.675	1.674	1.673	1.672	1.671
750	1.675	1.674	1.673	1.672	1.671	1.670	1.669
800	1.673	1.672	1.671	1.670	1.669	1.668	1.667

Table 6A. **Amosite α** (In Cargille Series **B: 1.700**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.735	1.734	1.733	1.732	1.731	1.730	1.729
420	1.729	1.728	1.727	1.726	1.725	1.724	1.723
440	1.724	1.723	1.722	1.721	1.720	1.719	1.718
460	1.720	1.719	1.718	1.717	1.716	1.715	1.714
480	1.716	1.715	1.714	1.713	1.712	1.711	1.710
500	1.713	1.712	1.711	1.710	1.709	1.708	1.707
520	1.710	1.709	1.708	1.707	1.706	1.705	1.705
540	1.708	1.707	1.706	1.705	1.704	1.703	1.702
560	1.706	1.705	1.704	1.703	1.702	1.701	1.700
580	1.704	1.703	1.702	1.701	1.700	1.699	1.698
589	1.703	1.702	1.701	1.700	1.699	1.698	1.697
600	1.702	1.701	1.700	1.699	1.698	1.697	1.696
620	1.700	1.699	1.698	1.698	1.697	1.696	1.695
640	1.699	1.698	1.697	1.696	1.695	1.694	1.693
660	1.698	1.697	1.696	1.695	1.694	1.693	1.692
680	1.696	1.695	1.695	1.694	1.693	1.692	1.691
700	1.695	1.694	1.693	1.692	1.691	1.691	1.690
750	1.693	1.692	1.691	1.690	1.689	1.688	1.687
800	1.691	1.690	1.689	1.688	1.687	1.686	1.685

Table 6B. **Amosite γ** (In Cargille Series **B: 1.700**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.734	1.733	1.732	1.731	1.730	1.729	1.728
420	1.728	1.727	1.726	1.725	1.724	1.723	1.722
440	1.723	1.722	1.721	1.720	1.719	1.718	1.717
460	1.719	1.718	1.717	1.716	1.715	1.714	1.713
480	1.716	1.715	1.714	1.713	1.712	1.711	1.710
500	1.713	1.712	1.711	1.710	1.709	1.708	1.707
520	1.710	1.709	1.708	1.707	1.706	1.705	1.704
540	1.708	1.707	1.706	1.705	1.704	1.703	1.702
560	1.706	1.705	1.704	1.703	1.702	1.701	1.700
580	1.704	1.703	1.702	1.701	1.700	1.699	1.698
589	1.703	1.702	1.701	1.700	1.699	1.698	1.697
600	1.702	1.701	1.700	1.699	1.698	1.697	1.696
620	1.701	1.700	1.699	1.698	1.697	1.696	1.695
640	1.699	1.698	1.697	1.696	1.695	1.694	1.693
660	1.698	1.697	1.696	1.695	1.694	1.693	1.692
680	1.697	1.696	1.695	1.694	1.693	1.692	1.691
700	1.696	1.695	1.694	1.693	1.692	1.691	1.690
750	1.693	1.692	1.691	1.691	1.690	1.689	1.688
800	1.691	1.691	1.690	1.689	1.688	1.687	1.686

Table 7A. **Crocidolite α** (In Cargille Series **B: 1.680**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.718	1.717	1.716	1.715	1.714	1.713	1.712
420	1.711	1.710	1.709	1.708	1.707	1.706	1.705
440	1.706	1.705	1.704	1.703	1.702	1.701	1.700
460	1.701	1.700	1.699	1.698	1.697	1.696	1.695
480	1.697	1.696	1.695	1.694	1.693	1.692	1.692
500	1.694	1.693	1.692	1.691	1.690	1.689	1.688
520	1.691	1.690	1.689	1.688	1.687	1.686	1.685
540	1.688	1.687	1.686	1.685	1.684	1.683	1.682
560	1.686	1.685	1.684	1.683	1.682	1.681	1.680
580	1.684	1.683	1.682	1.681	1.680	1.679	1.678
589	1.683	1.682	1.681	1.680	1.679	1.678	1.677
600	1.682	1.681	1.680	1.679	1.678	1.677	1.676
620	1.680	1.679	1.678	1.677	1.676	1.675	1.674
640	1.679	1.678	1.677	1.676	1.675	1.674	1.673
660	1.677	1.676	1.675	1.674	1.673	1.672	1.671
680	1.676	1.675	1.674	1.673	1.672	1.671	1.670
700	1.675	1.674	1.673	1.672	1.671	1.670	1.669
750	1.672	1.671	1.670	1.669	1.668	1.667	1.666
800	1.670	1.669	1.668	1.667	1.666	1.665	1.664

Table 7B. **Crocidolite γ** (In Cargille Series **B: 1.680**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.715	1.714	1.713	1.712	1.711	1.711	1.710
420	1.709	1.708	1.707	1.706	1.705	1.704	1.704
440	1.704	1.703	1.702	1.701	1.700	1.699	1.698
460	1.700	1.699	1.698	1.697	1.696	1.695	1.694
480	1.696	1.695	1.694	1.693	1.692	1.691	1.691
500	1.693	1.692	1.691	1.690	1.689	1.688	1.687
520	1.690	1.689	1.688	1.687	1.686	1.686	1.685
540	1.688	1.687	1.686	1.685	1.684	1.683	1.682
560	1.686	1.685	1.684	1.683	1.682	1.681	1.680
580	1.684	1.683	1.682	1.681	1.680	1.679	1.678
589	1.683	1.682	1.681	1.680	1.679	1.678	1.677
600	1.682	1.681	1.680	1.679	1.678	1.677	1.676
620	1.680	1.679	1.678	1.677	1.677	1.676	1.675
640	1.679	1.678	1.677	1.676	1.675	1.674	1.673
660	1.678	1.677	1.676	1.675	1.674	1.673	1.672
680	1.676	1.675	1.674	1.674	1.673	1.672	1.671
700	1.675	1.674	1.673	1.672	1.671	1.670	1.670
750	1.673	1.672	1.671	1.670	1.669	1.668	1.667
800	1.671	1.670	1.669	1.668	1.667	1.666	1.665

Table 8A. Crocidolite α (In Cargille Series B: 1.700)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.742	1.741	1.740	1.739	1.738	1.737	1.736
420	1.735	1.734	1.733	1.732	1.731	1.730	1.729
440	1.728	1.728	1.727	1.726	1.725	1.724	1.723
460	1.723	1.722	1.721	1.720	1.720	1.719	1.718
480	1.719	1.718	1.717	1.716	1.715	1.714	1.713
500	1.715	1.714	1.713	1.712	1.711	1.710	1.709
520	1.712	1.711	1.710	1.709	1.708	1.707	1.706
540	1.709	1.708	1.707	1.706	1.705	1.704	1.703
560	1.706	1.705	1.704	1.703	1.702	1.701	1.700
580	1.704	1.703	1.702	1.701	1.700	1.699	1.698
589	1.703	1.702	1.701	1.700	1.699	1.698	1.697
600	1.702	1.701	1.700	1.699	1.698	1.697	1.696
620	1.700	1.699	1.698	1.697	1.696	1.695	1.694
640	1.698	1.697	1.696	1.695	1.694	1.693	1.692
660	1.697	1.696	1.695	1.694	1.693	1.692	1.691
680	1.695	1.694	1.693	1.692	1.691	1.690	1.689
700	1.694	1.693	1.692	1.691	1.690	1.689	1.688
750	1.691	1.690	1.689	1.688	1.687	1.686	1.685
800	1.688	1.687	1.686	1.686	1.685	1.684	1.683

Table 8B. Crocidolite γ (In Cargille Series B: 1.700)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.739	1.738	1.738	1.737	1.736	1.735	1.734
420	1.733	1.732	1.731	1.730	1.729	1.728	1.727
440	1.727	1.726	1.725	1.724	1.723	1.722	1.721
460	1.722	1.721	1.720	1.719	1.718	1.717	1.716
480	1.718	1.717	1.716	1.715	1.714	1.713	1.712
500	1.714	1.713	1.712	1.711	1.711	1.710	1.709
520	1.711	1.710	1.709	1.708	1.707	1.706	1.705
540	1.708	1.708	1.707	1.706	1.705	1.704	1.703
560	1.706	1.705	1.704	1.703	1.702	1.701	1.700
580	1.704	1.703	1.702	1.701	1.700	1.699	1.698
589	1.703	1.702	1.701	1.700	1.699	1.698	1.697
600	1.702	1.701	1.700	1.699	1.698	1.697	1.696
620	1.700	1.699	1.698	1.697	1.696	1.695	1.694
640	1.698	1.697	1.697	1.696	1.695	1.694	1.693
660	1.697	1.696	1.695	1.694	1.693	1.692	1.691
680	1.696	1.695	1.694	1.693	1.692	1.691	1.690
700	1.694	1.693	1.692	1.691	1.690	1.690	1.689
750	1.692	1.691	1.690	1.689	1.688	1.687	1.686
800	1.689	1.688	1.687	1.686	1.685	1.685	1.684

Table 9A. **Tremolite α** (In Cargille Series E: **1.605**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.636	1.635	1.634	1.633	1.632	1.631	1.631
420	1.631	1.630	1.629	1.628	1.627	1.626	1.625
440	1.626	1.625	1.624	1.624	1.623	1.622	1.621
460	1.622	1.622	1.621	1.620	1.619	1.618	1.617
480	1.619	1.618	1.617	1.617	1.616	1.615	1.614
500	1.616	1.616	1.615	1.614	1.613	1.612	1.611
520	1.614	1.613	1.612	1.611	1.611	1.610	1.609
540	1.612	1.611	1.610	1.609	1.608	1.608	1.607
560	1.610	1.609	1.608	1.607	1.607	1.606	1.605
580	1.608	1.607	1.607	1.606	1.605	1.604	1.603
589	1.608	1.607	1.606	1.605	1.604	1.603	1.602
600	1.607	1.606	1.605	1.604	1.603	1.602	1.602
620	1.605	1.605	1.604	1.603	1.602	1.601	1.600
640	1.604	1.603	1.602	1.602	1.601	1.600	1.599
660	1.603	1.602	1.601	1.600	1.600	1.599	1.598
680	1.602	1.601	1.600	1.599	1.598	1.598	1.597
700	1.601	1.600	1.599	1.598	1.598	1.597	1.596
750	1.599	1.598	1.597	1.596	1.595	1.595	1.594
800	1.597	1.596	1.595	1.595	1.594	1.593	1.592

Table 9B. **Tremolite γ** (In Cargille Series E: **1.605**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.632	1.631	1.630	1.629	1.628	1.627	1.627
420	1.627	1.626	1.626	1.625	1.624	1.623	1.622
440	1.624	1.623	1.622	1.621	1.620	1.619	1.618
460	1.620	1.619	1.619	1.618	1.617	1.616	1.615
480	1.618	1.617	1.616	1.615	1.614	1.613	1.612
500	1.615	1.614	1.614	1.613	1.612	1.611	1.610
520	1.613	1.612	1.611	1.611	1.610	1.609	1.608
540	1.611	1.610	1.610	1.609	1.608	1.607	1.606
560	1.610	1.609	1.608	1.607	1.606	1.605	1.604
580	1.608	1.607	1.607	1.606	1.605	1.604	1.603
589	1.608	1.607	1.606	1.605	1.604	1.603	1.602
600	1.607	1.606	1.605	1.604	1.603	1.603	1.602
620	1.606	1.605	1.604	1.603	1.602	1.601	1.600
640	1.605	1.604	1.603	1.602	1.601	1.600	1.599
660	1.604	1.603	1.602	1.601	1.600	1.599	1.598
680	1.603	1.602	1.601	1.600	1.599	1.598	1.598
700	1.602	1.601	1.600	1.599	1.598	1.598	1.597
750	1.600	1.599	1.598	1.598	1.597	1.596	1.595
800	1.599	1.598	1.597	1.596	1.595	1.594	1.593

Table 10A. **Tremolite α** (In Cargille Series E: **1.610**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.642	1.642	1.641	1.640	1.639	1.638	1.637
420	1.637	1.636	1.635	1.634	1.633	1.632	1.631
440	1.632	1.631	1.630	1.629	1.629	1.628	1.627
460	1.628	1.627	1.627	1.626	1.625	1.624	1.623
480	1.625	1.624	1.623	1.622	1.621	1.620	1.619
500	1.622	1.621	1.620	1.619	1.618	1.617	1.616
520	1.620	1.619	1.618	1.617	1.616	1.615	1.614
540	1.617	1.616	1.615	1.615	1.614	1.613	1.612
560	1.615	1.614	1.613	1.613	1.612	1.611	1.610
580	1.614	1.613	1.612	1.611	1.610	1.609	1.608
589	1.613	1.612	1.611	1.610	1.609	1.608	1.607
600	1.612	1.611	1.610	1.609	1.608	1.607	1.606
620	1.611	1.610	1.609	1.608	1.607	1.606	1.605
640	1.609	1.608	1.607	1.606	1.605	1.604	1.604
660	1.608	1.607	1.606	1.605	1.604	1.603	1.602
680	1.607	1.606	1.605	1.604	1.603	1.602	1.601
700	1.606	1.605	1.604	1.603	1.602	1.601	1.600
750	1.604	1.603	1.602	1.601	1.600	1.599	1.598
800	1.602	1.601	1.600	1.599	1.598	1.597	1.596

Table 10B. **Tremolite γ** (In Cargille Series E: **1.610**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.639	1.638	1.637	1.636	1.635	1.634	1.633
420	1.634	1.633	1.632	1.631	1.630	1.629	1.628
440	1.630	1.629	1.628	1.627	1.626	1.625	1.624
460	1.626	1.625	1.624	1.624	1.623	1.622	1.621
480	1.623	1.623	1.622	1.621	1.620	1.619	1.618
500	1.621	1.620	1.619	1.618	1.617	1.616	1.615
520	1.619	1.618	1.617	1.616	1.615	1.614	1.613
540	1.617	1.616	1.615	1.614	1.613	1.612	1.611
560	1.615	1.614	1.613	1.612	1.611	1.610	1.609
580	1.614	1.613	1.612	1.611	1.610	1.609	1.608
589	1.613	1.612	1.611	1.610	1.609	1.608	1.607
600	1.612	1.611	1.610	1.609	1.608	1.607	1.606
620	1.611	1.610	1.609	1.608	1.607	1.606	1.605
640	1.610	1.609	1.608	1.607	1.606	1.605	1.604
660	1.609	1.608	1.607	1.606	1.605	1.604	1.603
680	1.608	1.607	1.606	1.605	1.604	1.603	1.602
700	1.607	1.606	1.605	1.604	1.603	1.602	1.601
750	1.605	1.604	1.603	1.602	1.601	1.600	1.599
800	1.603	1.602	1.601	1.600	1.599	1.599	1.598

Table 11A. **Tremolite α** (In Cargille Series E: **1.620**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.653	1.652	1.651	1.650	1.649	1.648	1.647
420	1.647	1.646	1.645	1.644	1.644	1.643	1.642
440	1.642	1.642	1.641	1.640	1.639	1.638	1.637
460	1.638	1.638	1.637	1.636	1.635	1.634	1.633
480	1.635	1.634	1.633	1.632	1.631	1.631	1.630
500	1.632	1.631	1.630	1.629	1.629	1.628	1.627
520	1.630	1.629	1.628	1.627	1.626	1.625	1.624
540	1.627	1.626	1.625	1.625	1.624	1.623	1.622
560	1.625	1.624	1.623	1.623	1.622	1.621	1.620
580	1.623	1.623	1.622	1.621	1.620	1.619	1.618
589	1.623	1.622	1.621	1.620	1.619	1.618	1.617
600	1.622	1.621	1.620	1.619	1.618	1.617	1.616
620	1.620	1.619	1.619	1.618	1.617	1.616	1.615
640	1.619	1.618	1.617	1.616	1.615	1.615	1.614
660	1.618	1.617	1.616	1.615	1.614	1.613	1.612
680	1.617	1.616	1.615	1.614	1.613	1.612	1.611
700	1.616	1.615	1.614	1.613	1.612	1.611	1.610
750	1.613	1.613	1.612	1.611	1.610	1.609	1.608
800	1.612	1.611	1.610	1.609	1.608	1.607	1.606

Table 11B. **Tremolite γ** (In Cargille Series E: **1.620**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.648	1.647	1.646	1.646	1.645	1.644	1.643
420	1.643	1.643	1.642	1.641	1.640	1.639	1.638
440	1.639	1.639	1.638	1.637	1.636	1.635	1.634
460	1.636	1.635	1.634	1.633	1.633	1.632	1.631
480	1.633	1.632	1.631	1.631	1.630	1.629	1.628
500	1.631	1.630	1.629	1.628	1.627	1.626	1.625
520	1.629	1.628	1.627	1.626	1.625	1.624	1.623
540	1.627	1.626	1.625	1.624	1.623	1.622	1.621
560	1.625	1.624	1.623	1.622	1.621	1.620	1.619
580	1.623	1.622	1.622	1.621	1.620	1.619	1.618
589	1.623	1.622	1.621	1.620	1.619	1.618	1.617
600	1.622	1.621	1.620	1.619	1.618	1.617	1.617
620	1.621	1.620	1.619	1.618	1.617	1.616	1.615
640	1.620	1.619	1.618	1.617	1.616	1.615	1.614
660	1.619	1.618	1.617	1.616	1.615	1.614	1.613
680	1.618	1.617	1.616	1.615	1.614	1.613	1.612
700	1.617	1.616	1.615	1.614	1.613	1.612	1.611
750	1.615	1.614	1.613	1.612	1.611	1.610	1.609
800	1.613	1.612	1.611	1.611	1.610	1.609	1.608

Table 12A. **Tremolite α** (In Cargille Series E: **1.625**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.662	1.661	1.660	1.659	1.658	1.657	1.656
420	1.655	1.655	1.654	1.653	1.652	1.651	1.650
440	1.650	1.649	1.648	1.647	1.647	1.646	1.645
460	1.646	1.645	1.644	1.643	1.642	1.641	1.640
480	1.642	1.641	1.640	1.639	1.638	1.637	1.636
500	1.638	1.638	1.637	1.636	1.635	1.634	1.633
520	1.636	1.635	1.634	1.633	1.632	1.631	1.630
540	1.633	1.632	1.631	1.630	1.629	1.628	1.628
560	1.631	1.630	1.629	1.628	1.627	1.626	1.625
580	1.629	1.628	1.627	1.626	1.625	1.624	1.623
589	1.628	1.627	1.626	1.625	1.624	1.623	1.622
600	1.627	1.626	1.625	1.624	1.623	1.622	1.621
620	1.625	1.624	1.623	1.622	1.621	1.621	1.620
640	1.624	1.623	1.622	1.621	1.620	1.619	1.618
660	1.622	1.621	1.620	1.619	1.619	1.618	1.617
680	1.621	1.620	1.619	1.618	1.617	1.616	1.615
700	1.620	1.619	1.618	1.617	1.616	1.615	1.614
750	1.617	1.616	1.615	1.614	1.614	1.613	1.612
800	1.615	1.614	1.613	1.612	1.611	1.611	1.610

Table 12B. **Tremolite γ** (In Cargille Series E: **1.625**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.658	1.657	1.656	1.655	1.654	1.653	1.653
420	1.652	1.651	1.650	1.650	1.649	1.648	1.647
440	1.648	1.647	1.646	1.645	1.644	1.643	1.642
460	1.644	1.643	1.642	1.641	1.640	1.639	1.638
480	1.640	1.639	1.638	1.637	1.637	1.636	1.635
500	1.637	1.636	1.635	1.635	1.634	1.633	1.632
520	1.635	1.634	1.633	1.632	1.631	1.630	1.629
540	1.632	1.631	1.631	1.630	1.629	1.628	1.627
560	1.630	1.629	1.628	1.628	1.627	1.626	1.625
580	1.628	1.628	1.627	1.626	1.625	1.624	1.623
589	1.628	1.627	1.626	1.625	1.624	1.623	1.622
600	1.627	1.626	1.625	1.624	1.623	1.622	1.621
620	1.625	1.624	1.624	1.623	1.622	1.621	1.620
640	1.624	1.623	1.622	1.621	1.620	1.620	1.619
660	1.623	1.622	1.621	1.620	1.619	1.618	1.617
680	1.622	1.621	1.620	1.619	1.618	1.617	1.616
700	1.621	1.620	1.619	1.618	1.617	1.616	1.615
750	1.618	1.617	1.617	1.616	1.615	1.614	1.613
800	1.616	1.616	1.615	1.614	1.613	1.612	1.611

Table 13A. **Tremolite α** (In Cargille Series E: **1.630**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.668	1.667	1.667	1.666	1.665	1.664	1.663
420	1.662	1.661	1.660	1.659	1.658	1.657	1.656
440	1.656	1.655	1.654	1.653	1.652	1.652	1.651
460	1.651	1.650	1.650	1.649	1.648	1.647	1.646
480	1.647	1.646	1.646	1.645	1.644	1.643	1.642
500	1.644	1.643	1.642	1.641	1.640	1.639	1.638
520	1.641	1.640	1.639	1.638	1.637	1.636	1.635
540	1.638	1.637	1.636	1.635	1.635	1.634	1.633
560	1.636	1.635	1.634	1.633	1.632	1.631	1.630
580	1.634	1.633	1.632	1.631	1.630	1.629	1.628
589	1.633	1.632	1.631	1.630	1.629	1.628	1.627
600	1.632	1.631	1.630	1.629	1.628	1.627	1.626
620	1.630	1.629	1.628	1.627	1.626	1.625	1.625
640	1.628	1.627	1.627	1.626	1.625	1.624	1.623
660	1.627	1.626	1.625	1.624	1.623	1.622	1.622
680	1.626	1.625	1.624	1.623	1.622	1.621	1.620
700	1.624	1.623	1.623	1.622	1.621	1.620	1.619
750	1.622	1.621	1.620	1.619	1.618	1.617	1.616
800	1.619	1.619	1.618	1.617	1.616	1.615	1.614

Table 13B. **Tremolite γ** (In Cargille Series E: **1.630**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.664	1.663	1.663	1.662	1.661	1.660	1.659
420	1.658	1.658	1.657	1.656	1.655	1.654	1.653
440	1.654	1.653	1.652	1.651	1.650	1.649	1.648
460	1.649	1.648	1.648	1.647	1.646	1.645	1.644
480	1.646	1.645	1.644	1.643	1.642	1.641	1.640
500	1.643	1.642	1.641	1.640	1.639	1.638	1.637
520	1.640	1.639	1.638	1.637	1.636	1.635	1.635
540	1.638	1.637	1.636	1.635	1.634	1.633	1.632
560	1.635	1.635	1.634	1.633	1.632	1.631	1.630
580	1.634	1.633	1.632	1.631	1.630	1.629	1.628
589	1.633	1.632	1.631	1.630	1.629	1.628	1.627
600	1.632	1.631	1.630	1.629	1.628	1.627	1.626
620	1.630	1.629	1.628	1.628	1.627	1.626	1.625
640	1.629	1.628	1.627	1.626	1.625	1.624	1.623
660	1.628	1.627	1.626	1.625	1.624	1.623	1.622
680	1.626	1.625	1.625	1.624	1.623	1.622	1.621
700	1.625	1.624	1.623	1.623	1.622	1.621	1.620
750	1.623	1.622	1.621	1.620	1.619	1.618	1.618
800	1.621	1.620	1.619	1.618	1.617	1.616	1.616

Table 14A. **Tremolite α** (In Cargille Series E: **1.635**)

λ_0	119°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.675	1.674	1.673	1.672	1.671	1.670	1.669
420	1.668	1.667	1.666	1.665	1.664	1.663	1.662
440	1.662	1.661	1.660	1.659	1.658	1.658	1.657
460	1.657	1.656	1.655	1.654	1.654	1.653	1.652
480	1.653	1.652	1.651	1.650	1.649	1.648	1.648
500	1.649	1.649	1.648	1.647	1.646	1.645	1.644
520	1.646	1.645	1.644	1.643	1.643	1.642	1.641
540	1.643	1.643	1.642	1.641	1.640	1.639	1.638
560	1.641	1.640	1.639	1.638	1.637	1.636	1.635
580	1.639	1.638	1.637	1.636	1.635	1.634	1.633
589	1.638	1.637	1.636	1.635	1.634	1.633	1.632
600	1.637	1.636	1.635	1.634	1.633	1.632	1.631
620	1.635	1.634	1.633	1.632	1.631	1.630	1.629
640	1.633	1.632	1.631	1.630	1.630	1.629	1.628
660	1.632	1.631	1.630	1.629	1.628	1.627	1.626
680	1.630	1.629	1.629	1.628	1.627	1.626	1.625
700	1.629	1.628	1.627	1.626	1.625	1.624	1.624
750	1.626	1.625	1.624	1.624	1.623	1.622	1.621
800	1.624	1.623	1.622	1.621	1.620	1.619	1.618

Table 14B. **Tremolite γ** (In Cargille Series E: **1.635**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.671	1.670	1.669	1.668	1.667	1.666	1.665
420	1.665	1.664	1.663	1.662	1.661	1.660	1.659
440	1.660	1.659	1.658	1.657	1.656	1.655	1.654
460	1.655	1.654	1.653	1.652	1.652	1.651	1.650
480	1.651	1.651	1.650	1.649	1.648	1.647	1.646
500	1.648	1.647	1.646	1.645	1.645	1.644	1.643
520	1.645	1.644	1.644	1.643	1.642	1.641	1.640
540	1.643	1.642	1.641	1.640	1.639	1.638	1.637
560	1.641	1.640	1.639	1.638	1.637	1.636	1.635
580	1.639	1.638	1.637	1.636	1.635	1.634	1.633
589	1.638	1.637	1.636	1.635	1.634	1.633	1.632
600	1.637	1.636	1.635	1.634	1.633	1.632	1.631
620	1.635	1.634	1.633	1.632	1.632	1.631	1.630
640	1.634	1.633	1.632	1.631	1.630	1.629	1.628
660	1.632	1.631	1.631	1.630	1.629	1.628	1.627
680	1.631	1.630	1.629	1.628	1.627	1.627	1.626
700	1.630	1.629	1.628	1.627	1.626	1.625	1.624
750	1.628	1.627	1.626	1.625	1.624	1.623	1.622
800	1.625	1.625	1.624	1.623	1.622	1.621	1.620

Table 15A. **Actinolite α** (In Cargille Series E: **1.605**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.633	1.632	1.631	1.631	1.630	1.629	1.628
420	1.628	1.628	1.627	1.626	1.625	1.624	1.623
440	1.624	1.624	1.623	1.622	1.621	1.620	1.619
460	1.621	1.620	1.619	1.618	1.618	1.617	1.616
480	1.618	1.617	1.616	1.616	1.615	1.614	1.613
500	1.616	1.615	1.614	1.613	1.612	1.611	1.610
520	1.613	1.613	1.612	1.611	1.610	1.609	1.608
540	1.612	1.611	1.610	1.609	1.608	1.607	1.606
560	1.610	1.609	1.608	1.607	1.606	1.605	1.605
580	1.608	1.607	1.607	1.606	1.605	1.604	1.603
589	1.608	1.607	1.606	1.605	1.604	1.603	1.602
600	1.607	1.606	1.605	1.604	1.603	1.603	1.602
620	1.606	1.605	1.604	1.603	1.602	1.601	1.600
640	1.605	1.604	1.603	1.602	1.601	1.600	1.599
660	1.603	1.603	1.602	1.601	1.600	1.599	1.598
680	1.603	1.602	1.601	1.600	1.599	1.598	1.597
700	1.602	1.601	1.600	1.599	1.598	1.597	1.596
750	1.600	1.599	1.598	1.597	1.596	1.595	1.594
800	1.598	1.597	1.596	1.596	1.595	1.594	1.593

Table 15B. **Actinolite γ** (In Cargille Series E: **1.605**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.629	1.628	1.627	1.626	1.625	1.624	1.623
420	1.625	1.624	1.623	1.622	1.621	1.620	1.619
440	1.621	1.621	1.620	1.619	1.618	1.617	1.616
460	1.619	1.618	1.617	1.616	1.615	1.614	1.613
480	1.616	1.615	1.615	1.614	1.613	1.612	1.611
500	1.614	1.613	1.613	1.612	1.611	1.610	1.609
520	1.612	1.612	1.611	1.610	1.609	1.608	1.607
540	1.611	1.610	1.609	1.608	1.607	1.606	1.606
560	1.609	1.609	1.608	1.607	1.606	1.605	1.604
580	1.608	1.607	1.606	1.605	1.605	1.604	1.603
589	1.608	1.607	1.606	1.605	1.604	1.603	1.602
600	1.607	1.606	1.605	1.604	1.604	1.603	1.602
620	1.606	1.605	1.604	1.603	1.602	1.602	1.601
640	1.605	1.604	1.603	1.602	1.602	1.601	1.600
660	1.604	1.603	1.602	1.602	1.601	1.600	1.599
680	1.603	1.603	1.602	1.601	1.600	1.599	1.598
700	1.603	1.602	1.601	1.600	1.599	1.598	1.597
750	1.601	1.600	1.599	1.598	1.598	1.597	1.596
800	1.600	1.599	1.598	1.597	1.596	1.595	1.595

Table 16A. **Actinolite α** (In Cargille Series E: **1.610**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.642	1.642	1.641	1.640	1.639	1.638	1.637
420	1.637	1.636	1.635	1.634	1.633	1.632	1.631
440	1.632	1.631	1.630	1.629	1.629	1.628	1.627
460	1.628	1.627	1.627	1.626	1.625	1.624	1.623
480	1.625	1.624	1.623	1.622	1.621	1.620	1.619
500	1.622	1.621	1.620	1.619	1.618	1.617	1.616
520	1.620	1.619	1.618	1.617	1.616	1.615	1.614
540	1.617	1.616	1.615	1.615	1.614	1.613	1.612
560	1.615	1.614	1.613	1.613	1.612	1.611	1.610
580	1.614	1.613	1.612	1.611	1.610	1.609	1.608
589	1.613	1.612	1.611	1.610	1.609	1.608	1.607
600	1.612	1.611	1.610	1.609	1.608	1.607	1.606
620	1.611	1.610	1.609	1.608	1.607	1.606	1.605
640	1.609	1.608	1.607	1.606	1.605	1.604	1.604
660	1.608	1.607	1.606	1.605	1.604	1.603	1.602
680	1.607	1.606	1.605	1.604	1.603	1.602	1.601
700	1.606	1.605	1.604	1.603	1.602	1.601	1.600
750	1.604	1.603	1.602	1.601	1.600	1.599	1.598
800	1.602	1.601	1.600	1.599	1.598	1.597	1.596

Table 16B. **Actinolite γ** (In Cargille Series E: **1.610**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.639	1.638	1.637	1.636	1.635	1.634	1.633
420	1.634	1.633	1.632	1.631	1.630	1.629	1.628
440	1.630	1.629	1.628	1.627	1.626	1.625	1.624
460	1.626	1.625	1.624	1.624	1.623	1.622	1.621
480	1.623	1.623	1.622	1.621	1.620	1.619	1.618
500	1.621	1.620	1.619	1.618	1.617	1.616	1.615
520	1.619	1.618	1.617	1.616	1.615	1.614	1.613
540	1.617	1.616	1.615	1.614	1.613	1.612	1.611
560	1.615	1.614	1.613	1.612	1.611	1.610	1.609
580	1.614	1.613	1.612	1.611	1.610	1.609	1.608
589	1.613	1.612	1.611	1.610	1.609	1.608	1.607
600	1.612	1.611	1.610	1.609	1.608	1.607	1.606
620	1.611	1.610	1.609	1.608	1.607	1.606	1.605
640	1.610	1.609	1.608	1.607	1.606	1.605	1.604
660	1.609	1.608	1.607	1.606	1.605	1.604	1.603
680	1.608	1.607	1.606	1.605	1.604	1.603	1.602
700	1.607	1.606	1.605	1.604	1.603	1.602	1.601
750	1.605	1.604	1.603	1.602	1.601	1.600	1.599
800	1.603	1.602	1.601	1.600	1.599	1.599	1.598

Table 17A. **Actinolite α** (In Cargille Series E: **1.615**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.646	1.645	1.644	1.644	1.643	1.642	1.641
420	1.641	1.640	1.639	1.638	1.637	1.636	1.635
440	1.636	1.636	1.635	1.634	1.633	1.632	1.631
460	1.633	1.632	1.631	1.630	1.629	1.628	1.627
480	1.629	1.629	1.628	1.627	1.626	1.625	1.624
500	1.627	1.626	1.625	1.624	1.623	1.622	1.621
520	1.624	1.623	1.622	1.622	1.621	1.620	1.619
540	1.622	1.621	1.620	1.619	1.618	1.618	1.617
560	1.620	1.619	1.618	1.617	1.617	1.616	1.615
580	1.618	1.618	1.617	1.616	1.615	1.614	1.613
589	1.618	1.617	1.616	1.615	1.614	1.613	1.612
600	1.617	1.616	1.615	1.614	1.613	1.612	1.611
620	1.615	1.615	1.614	1.613	1.612	1.611	1.610
640	1.614	1.613	1.612	1.612	1.611	1.610	1.609
660	1.613	1.612	1.611	1.610	1.609	1.609	1.608
680	1.612	1.611	1.610	1.609	1.608	1.608	1.607
700	1.611	1.610	1.609	1.608	1.607	1.607	1.606
750	1.609	1.608	1.607	1.606	1.605	1.604	1.603
800	1.607	1.606	1.605	1.604	1.604	1.603	1.602

Table 17B. **Actinolite γ** (In Cargille Series E: **1.615**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.642	1.641	1.640	1.639	1.638	1.637	1.636
420	1.637	1.636	1.635	1.635	1.634	1.633	1.632
440	1.634	1.633	1.632	1.631	1.630	1.629	1.628
460	1.630	1.629	1.629	1.628	1.627	1.626	1.625
480	1.628	1.627	1.626	1.625	1.624	1.623	1.622
500	1.625	1.624	1.623	1.623	1.622	1.621	1.620
520	1.623	1.622	1.621	1.621	1.620	1.619	1.618
540	1.621	1.620	1.620	1.619	1.618	1.617	1.616
560	1.620	1.619	1.618	1.617	1.616	1.615	1.614
580	1.618	1.617	1.617	1.616	1.615	1.614	1.613
589	1.618	1.617	1.616	1.615	1.614	1.613	1.612
600	1.617	1.616	1.615	1.614	1.613	1.613	1.612
620	1.616	1.615	1.614	1.613	1.612	1.611	1.610
640	1.615	1.614	1.613	1.612	1.611	1.610	1.609
660	1.614	1.613	1.612	1.611	1.610	1.609	1.608
680	1.613	1.612	1.611	1.610	1.609	1.608	1.607
700	1.612	1.611	1.610	1.609	1.608	1.608	1.607
750	1.610	1.609	1.608	1.608	1.607	1.606	1.605
800	1.609	1.608	1.607	1.606	1.605	1.604	1.603

Table 18A. **Actinolite α** (In Cargille Series E: **1.620**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.653	1.652	1.651	1.650	1.649	1.648	1.647
420	1.647	1.646	1.645	1.644	1.644	1.643	1.642
440	1.642	1.642	1.641	1.640	1.639	1.638	1.637
460	1.638	1.638	1.637	1.636	1.635	1.634	1.633
480	1.635	1.634	1.633	1.632	1.631	1.631	1.630
500	1.632	1.631	1.630	1.629	1.629	1.628	1.627
520	1.630	1.629	1.628	1.627	1.626	1.625	1.624
540	1.627	1.626	1.625	1.625	1.624	1.623	1.622
560	1.625	1.624	1.623	1.623	1.622	1.621	1.620
580	1.623	1.623	1.622	1.621	1.620	1.619	1.618
589	1.623	1.622	1.621	1.620	1.619	1.618	1.617
600	1.622	1.621	1.620	1.619	1.618	1.617	1.616
620	1.620	1.619	1.619	1.618	1.617	1.616	1.615
640	1.619	1.618	1.617	1.616	1.615	1.615	1.614
660	1.618	1.617	1.616	1.615	1.614	1.613	1.612
680	1.617	1.616	1.615	1.614	1.613	1.612	1.611
700	1.616	1.615	1.614	1.613	1.612	1.611	1.610
750	1.613	1.613	1.612	1.611	1.610	1.609	1.608
800	1.612	1.611	1.610	1.609	1.608	1.607	1.606

Table 18B. **Actinolite γ** (In Cargille Series E: **1.620**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.648	1.647	1.646	1.646	1.645	1.644	1.643
420	1.643	1.643	1.642	1.641	1.640	1.639	1.638
440	1.639	1.639	1.638	1.637	1.636	1.635	1.634
460	1.636	1.635	1.634	1.633	1.633	1.632	1.631
480	1.633	1.632	1.631	1.631	1.630	1.629	1.628
500	1.631	1.630	1.629	1.628	1.627	1.626	1.625
520	1.629	1.628	1.627	1.626	1.625	1.624	1.623
540	1.627	1.626	1.625	1.624	1.623	1.622	1.621
560	1.625	1.624	1.623	1.622	1.621	1.620	1.619
580	1.623	1.622	1.622	1.621	1.620	1.619	1.618
589	1.623	1.622	1.621	1.620	1.619	1.618	1.617
600	1.622	1.621	1.620	1.619	1.618	1.617	1.617
620	1.621	1.620	1.619	1.618	1.617	1.616	1.615
640	1.620	1.619	1.618	1.617	1.616	1.615	1.614
660	1.619	1.618	1.617	1.616	1.615	1.614	1.613
680	1.618	1.617	1.616	1.615	1.614	1.613	1.612
700	1.617	1.616	1.615	1.614	1.613	1.612	1.611
750	1.615	1.614	1.613	1.612	1.611	1.610	1.609
800	1.613	1.612	1.611	1.611	1.610	1.609	1.608

Table 19A. **Actinolite α** (In Cargille Series E: **1.625**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.659	1.658	1.657	1.657	1.656	1.655	1.654
420	1.653	1.652	1.652	1.651	1.650	1.649	1.648
440	1.648	1.648	1.647	1.646	1.645	1.644	1.643
460	1.644	1.643	1.642	1.642	1.641	1.640	1.639
480	1.641	1.640	1.639	1.638	1.637	1.636	1.635
500	1.638	1.637	1.636	1.635	1.634	1.633	1.632
520	1.635	1.634	1.633	1.632	1.631	1.630	1.630
540	1.633	1.632	1.631	1.630	1.629	1.628	1.627
560	1.630	1.630	1.629	1.628	1.627	1.626	1.625
580	1.629	1.628	1.627	1.626	1.625	1.624	1.623
589	1.628	1.627	1.626	1.625	1.624	1.623	1.622
600	1.627	1.626	1.625	1.624	1.623	1.622	1.621
620	1.625	1.624	1.623	1.623	1.622	1.621	1.620
640	1.624	1.623	1.622	1.621	1.620	1.619	1.618
660	1.623	1.622	1.621	1.620	1.619	1.618	1.617
680	1.621	1.621	1.620	1.619	1.618	1.617	1.616
700	1.620	1.619	1.619	1.618	1.617	1.616	1.615
750	1.618	1.617	1.616	1.615	1.614	1.613	1.613
800	1.616	1.615	1.614	1.613	1.612	1.612	1.611

Table 19B. **Actinolite γ** (In Cargille Series E: **1.625**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.655	1.654	1.653	1.652	1.651	1.650	1.649
420	1.650	1.649	1.648	1.647	1.646	1.645	1.644
440	1.645	1.645	1.644	1.643	1.642	1.641	1.640
460	1.642	1.641	1.640	1.639	1.638	1.637	1.637
480	1.639	1.638	1.637	1.636	1.635	1.634	1.633
500	1.636	1.635	1.634	1.634	1.633	1.632	1.631
520	1.634	1.633	1.632	1.631	1.630	1.629	1.628
540	1.632	1.631	1.630	1.629	1.628	1.627	1.626
560	1.630	1.629	1.628	1.627	1.626	1.626	1.625
580	1.628	1.627	1.627	1.626	1.625	1.624	1.623
589	1.628	1.627	1.626	1.625	1.624	1.623	1.622
600	1.627	1.626	1.625	1.624	1.623	1.622	1.622
620	1.626	1.625	1.624	1.623	1.622	1.621	1.620
640	1.624	1.624	1.623	1.622	1.621	1.620	1.619
660	1.623	1.622	1.622	1.621	1.620	1.619	1.618
680	1.622	1.621	1.621	1.620	1.619	1.618	1.617
700	1.621	1.620	1.620	1.619	1.618	1.617	1.616
750	1.619	1.618	1.618	1.617	1.616	1.615	1.614
800	1.618	1.617	1.616	1.615	1.614	1.613	1.612

Table 20A. **Actinolite α** (In Cargille Series E: **1.630**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.666	1.665	1.664	1.663	1.662	1.661	1.660
420	1.660	1.659	1.658	1.657	1.656	1.655	1.654
440	1.654	1.653	1.653	1.652	1.651	1.650	1.649
460	1.650	1.649	1.648	1.647	1.646	1.646	1.645
480	1.646	1.645	1.645	1.644	1.643	1.642	1.641
500	1.643	1.642	1.641	1.640	1.639	1.639	1.638
520	1.640	1.639	1.638	1.638	1.637	1.636	1.635
540	1.638	1.637	1.636	1.635	1.634	1.633	1.632
560	1.636	1.635	1.634	1.633	1.632	1.631	1.630
580	1.634	1.633	1.632	1.631	1.630	1.629	1.628
589	1.633	1.632	1.631	1.630	1.629	1.628	1.627
600	1.632	1.631	1.630	1.629	1.628	1.627	1.626
620	1.630	1.629	1.628	1.627	1.627	1.626	1.625
640	1.629	1.628	1.627	1.626	1.625	1.624	1.623
660	1.627	1.626	1.626	1.625	1.624	1.623	1.622
680	1.626	1.625	1.624	1.623	1.623	1.622	1.621
700	1.625	1.624	1.623	1.622	1.621	1.620	1.620
750	1.623	1.622	1.621	1.620	1.619	1.618	1.617
800	1.620	1.620	1.619	1.618	1.617	1.616	1.615

Table 20B. **Actinolite γ** (In Cargille Series E: **1.630**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.661	1.660	1.659	1.659	1.658	1.657	1.656
420	1.656	1.655	1.654	1.653	1.652	1.651	1.650
440	1.651	1.651	1.650	1.649	1.648	1.647	1.646
460	1.648	1.647	1.646	1.645	1.644	1.643	1.642
480	1.644	1.644	1.643	1.642	1.641	1.640	1.639
500	1.642	1.641	1.640	1.639	1.638	1.637	1.636
520	1.639	1.638	1.637	1.637	1.636	1.635	1.634
540	1.637	1.636	1.635	1.634	1.633	1.633	1.632
560	1.635	1.634	1.633	1.632	1.632	1.631	1.630
580	1.633	1.633	1.632	1.631	1.630	1.629	1.628
589	1.633	1.632	1.631	1.630	1.629	1.628	1.627
600	1.632	1.631	1.630	1.629	1.628	1.627	1.626
620	1.630	1.630	1.629	1.628	1.627	1.626	1.625
640	1.629	1.628	1.627	1.627	1.626	1.625	1.624
660	1.628	1.627	1.626	1.625	1.624	1.624	1.623
680	1.627	1.626	1.625	1.624	1.623	1.623	1.622
700	1.626	1.625	1.624	1.623	1.622	1.622	1.621
750	1.624	1.623	1.622	1.621	1.620	1.619	1.618
800	1.622	1.621	1.620	1.619	1.619	1.618	1.617

Table 21A. **Actinolite α** (In Cargille Series E: **1.635**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.672	1.671	1.670	1.669	1.669	1.668	1.667
420	1.666	1.665	1.664	1.663	1.662	1.661	1.660
440	1.661	1.660	1.659	1.658	1.657	1.656	1.655
460	1.656	1.655	1.654	1.653	1.652	1.651	1.650
480	1.652	1.651	1.650	1.649	1.648	1.647	1.646
500	1.649	1.648	1.647	1.646	1.645	1.644	1.643
520	1.646	1.645	1.644	1.643	1.642	1.641	1.640
540	1.643	1.642	1.641	1.640	1.639	1.638	1.637
560	1.641	1.640	1.639	1.638	1.637	1.636	1.635
580	1.639	1.638	1.637	1.636	1.635	1.634	1.633
589	1.638	1.637	1.636	1.635	1.634	1.633	1.632
600	1.637	1.636	1.635	1.634	1.633	1.632	1.631
620	1.635	1.634	1.633	1.632	1.631	1.630	1.629
640	1.634	1.633	1.632	1.631	1.630	1.629	1.628
660	1.632	1.631	1.630	1.629	1.628	1.627	1.626
680	1.631	1.630	1.629	1.628	1.627	1.626	1.625
700	1.630	1.629	1.628	1.627	1.626	1.625	1.624
750	1.627	1.626	1.625	1.624	1.623	1.622	1.621
800	1.625	1.624	1.623	1.622	1.621	1.620	1.619

Table 21B. **Actinolite γ** (In Cargille Series E: **1.635**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.668	1.667	1.666	1.665	1.664	1.663	1.662
420	1.662	1.661	1.660	1.659	1.658	1.657	1.656
440	1.658	1.657	1.656	1.655	1.654	1.653	1.652
460	1.654	1.653	1.652	1.651	1.650	1.649	1.648
480	1.650	1.649	1.648	1.647	1.646	1.645	1.644
500	1.647	1.646	1.645	1.644	1.643	1.642	1.641
520	1.645	1.644	1.643	1.642	1.641	1.640	1.639
540	1.643	1.642	1.641	1.640	1.639	1.638	1.637
560	1.641	1.640	1.639	1.638	1.637	1.636	1.635
580	1.639	1.638	1.637	1.636	1.635	1.634	1.633
589	1.638	1.637	1.636	1.635	1.634	1.633	1.632
600	1.637	1.636	1.635	1.634	1.633	1.632	1.631
620	1.636	1.635	1.634	1.633	1.632	1.631	1.630
640	1.634	1.633	1.632	1.631	1.630	1.629	1.628
660	1.633	1.632	1.631	1.630	1.629	1.628	1.627
680	1.632	1.631	1.630	1.629	1.628	1.627	1.626
700	1.631	1.630	1.629	1.628	1.627	1.626	1.625
750	1.629	1.628	1.627	1.626	1.625	1.624	1.623
800	1.627	1.626	1.625	1.624	1.623	1.622	1.621

Table 22A. **Actinolite α** (In Cargille Series E: **1.640**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.679	1.678	1.677	1.676	1.675	1.674	1.673
420	1.672	1.671	1.670	1.669	1.668	1.667	1.667
440	1.666	1.665	1.665	1.664	1.663	1.662	1.661
460	1.662	1.661	1.660	1.659	1.658	1.657	1.656
480	1.658	1.657	1.656	1.655	1.654	1.653	1.652
500	1.654	1.653	1.652	1.651	1.650	1.649	1.649
520	1.651	1.650	1.649	1.648	1.647	1.646	1.645
540	1.648	1.647	1.646	1.645	1.645	1.644	1.643
560	1.646	1.645	1.644	1.643	1.642	1.641	1.640
580	1.644	1.643	1.642	1.641	1.640	1.639	1.638
589	1.643	1.642	1.641	1.640	1.639	1.638	1.637
600	1.642	1.641	1.640	1.639	1.638	1.637	1.636
620	1.640	1.639	1.638	1.637	1.636	1.635	1.634
640	1.638	1.637	1.637	1.636	1.635	1.634	1.633
660	1.637	1.636	1.635	1.634	1.633	1.632	1.631
680	1.636	1.635	1.634	1.633	1.632	1.631	1.630
700	1.634	1.633	1.633	1.632	1.631	1.630	1.629
750	1.632	1.631	1.630	1.629	1.628	1.627	1.626
800	1.629	1.628	1.628	1.627	1.626	1.625	1.624

Table 22B. **Actinolite γ** (In Cargille Series E: **1.640**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.674	1.673	1.672	1.672	1.671	1.670	1.669
420	1.668	1.667	1.667	1.666	1.665	1.664	1.663
440	1.663	1.663	1.662	1.661	1.660	1.659	1.658
460	1.659	1.658	1.657	1.657	1.656	1.655	1.654
480	1.656	1.655	1.654	1.653	1.652	1.651	1.650
500	1.653	1.652	1.651	1.650	1.649	1.648	1.647
520	1.650	1.649	1.648	1.647	1.646	1.645	1.644
540	1.648	1.647	1.646	1.645	1.644	1.643	1.642
560	1.645	1.645	1.644	1.643	1.642	1.641	1.640
580	1.644	1.643	1.642	1.641	1.640	1.639	1.638
589	1.643	1.642	1.641	1.640	1.639	1.638	1.637
600	1.642	1.641	1.640	1.639	1.638	1.637	1.636
620	1.640	1.639	1.638	1.638	1.637	1.636	1.635
640	1.639	1.638	1.637	1.636	1.635	1.634	1.633
660	1.638	1.637	1.636	1.635	1.634	1.633	1.632
680	1.636	1.636	1.635	1.634	1.633	1.632	1.631
700	1.635	1.634	1.634	1.633	1.632	1.631	1.630
750	1.633	1.632	1.631	1.630	1.629	1.628	1.628
800	1.631	1.630	1.629	1.628	1.627	1.626	1.626

Table 23A. **Anthophyllite α** (In Cargille Series E: **1.605**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.632	1.631	1.630	1.630	1.629	1.628	1.627
420	1.628	1.627	1.626	1.625	1.624	1.623	1.622
440	1.624	1.623	1.622	1.621	1.620	1.619	1.619
460	1.621	1.620	1.619	1.618	1.617	1.616	1.615
480	1.618	1.617	1.616	1.615	1.614	1.613	1.613
500	1.615	1.615	1.614	1.613	1.612	1.611	1.610
520	1.613	1.612	1.612	1.611	1.610	1.609	1.608
540	1.611	1.611	1.610	1.609	1.608	1.607	1.606
560	1.610	1.609	1.608	1.607	1.606	1.605	1.604
580	1.608	1.607	1.607	1.606	1.605	1.604	1.603
589	1.608	1.607	1.606	1.605	1.604	1.603	1.602
600	1.607	1.606	1.605	1.604	1.603	1.603	1.602
620	1.606	1.605	1.604	1.603	1.602	1.601	1.600
640	1.605	1.604	1.603	1.602	1.601	1.600	1.599
660	1.604	1.603	1.602	1.601	1.600	1.599	1.598
680	1.603	1.602	1.601	1.600	1.599	1.598	1.597
700	1.602	1.601	1.600	1.599	1.598	1.597	1.597
750	1.600	1.599	1.598	1.597	1.597	1.596	1.595
800	1.599	1.598	1.597	1.596	1.595	1.594	1.593

Table 23B. **Anthophyllite γ** (In Cargille Series E: **1.605**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.631	1.630	1.629	1.628	1.627	1.626	1.625
420	1.626	1.625	1.625	1.624	1.623	1.622	1.621
440	1.623	1.622	1.621	1.620	1.619	1.618	1.617
460	1.620	1.619	1.618	1.617	1.616	1.615	1.614
480	1.617	1.616	1.615	1.614	1.614	1.613	1.612
500	1.615	1.614	1.613	1.612	1.611	1.610	1.610
520	1.613	1.612	1.611	1.610	1.609	1.608	1.608
540	1.611	1.610	1.609	1.609	1.608	1.607	1.606
560	1.610	1.609	1.608	1.607	1.606	1.605	1.604
580	1.608	1.607	1.606	1.606	1.605	1.604	1.603
589	1.608	1.607	1.606	1.605	1.604	1.603	1.602
600	1.607	1.606	1.605	1.604	1.603	1.603	1.602
620	1.606	1.605	1.604	1.603	1.602	1.601	1.601
640	1.605	1.604	1.603	1.602	1.601	1.600	1.600
660	1.604	1.603	1.602	1.601	1.600	1.600	1.599
680	1.603	1.602	1.601	1.600	1.600	1.599	1.598
700	1.602	1.601	1.601	1.600	1.599	1.598	1.597
750	1.601	1.600	1.599	1.598	1.597	1.596	1.595
800	1.599	1.598	1.597	1.596	1.596	1.595	1.594

Table 24A. **Anthophyllite α** (In Cargille Series E: **1.610**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.639	1.638	1.637	1.636	1.635	1.634	1.633
420	1.634	1.633	1.632	1.631	1.630	1.629	1.628
440	1.630	1.629	1.628	1.627	1.626	1.625	1.624
460	1.627	1.626	1.625	1.624	1.623	1.622	1.621
480	1.624	1.623	1.622	1.621	1.620	1.619	1.618
500	1.621	1.620	1.619	1.618	1.617	1.616	1.615
520	1.619	1.618	1.617	1.616	1.615	1.614	1.613
540	1.617	1.616	1.615	1.614	1.613	1.612	1.611
560	1.615	1.614	1.613	1.612	1.611	1.610	1.609
580	1.614	1.613	1.612	1.611	1.610	1.609	1.608
589	1.613	1.612	1.611	1.610	1.609	1.608	1.607
600	1.612	1.611	1.610	1.609	1.608	1.607	1.606
620	1.611	1.610	1.609	1.608	1.607	1.606	1.605
640	1.610	1.609	1.608	1.607	1.606	1.605	1.604
660	1.609	1.608	1.607	1.606	1.605	1.604	1.603
680	1.608	1.607	1.606	1.605	1.604	1.603	1.602
700	1.607	1.606	1.605	1.604	1.603	1.602	1.601
750	1.605	1.604	1.603	1.602	1.601	1.600	1.599
800	1.603	1.602	1.601	1.600	1.599	1.598	1.597

Table 24B. **Anthophyllite γ** (In Cargille Series E: **1.610**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.637	1.636	1.635	1.634	1.633	1.632	1.631
420	1.632	1.631	1.630	1.629	1.628	1.627	1.627
440	1.629	1.628	1.627	1.626	1.625	1.624	1.623
460	1.625	1.624	1.623	1.623	1.622	1.621	1.620
480	1.623	1.622	1.621	1.620	1.619	1.618	1.617
500	1.620	1.619	1.618	1.618	1.617	1.616	1.615
520	1.618	1.617	1.616	1.615	1.614	1.614	1.613
540	1.617	1.616	1.615	1.614	1.613	1.612	1.611
560	1.615	1.614	1.613	1.612	1.611	1.610	1.609
580	1.613	1.613	1.612	1.611	1.610	1.609	1.608
589	1.613	1.612	1.611	1.610	1.609	1.608	1.607
600	1.612	1.611	1.610	1.609	1.608	1.607	1.606
620	1.611	1.610	1.609	1.608	1.607	1.606	1.605
640	1.610	1.609	1.608	1.607	1.606	1.605	1.604
660	1.609	1.608	1.607	1.606	1.605	1.604	1.603
680	1.608	1.607	1.606	1.605	1.604	1.603	1.602
700	1.607	1.606	1.605	1.604	1.603	1.603	1.602
750	1.605	1.605	1.604	1.603	1.602	1.601	1.600
800	1.604	1.603	1.602	1.601	1.600	1.599	1.598

Table 25A. **Anthophyllite α** (In Cargille Series E: **1.615**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.645	1.644	1.643	1.643	1.642	1.641	1.640
420	1.640	1.639	1.638	1.637	1.637	1.636	1.635
440	1.636	1.635	1.634	1.633	1.632	1.631	1.630
460	1.632	1.631	1.630	1.630	1.629	1.628	1.627
480	1.629	1.628	1.627	1.626	1.625	1.625	1.624
500	1.626	1.625	1.625	1.624	1.623	1.622	1.621
520	1.624	1.623	1.622	1.621	1.620	1.620	1.619
540	1.622	1.621	1.620	1.619	1.618	1.617	1.617
560	1.620	1.619	1.618	1.617	1.616	1.616	1.615
580	1.618	1.618	1.617	1.616	1.615	1.614	1.613
589	1.618	1.617	1.616	1.615	1.614	1.613	1.612
600	1.617	1.616	1.615	1.614	1.613	1.612	1.612
620	1.616	1.615	1.614	1.613	1.612	1.611	1.610
640	1.614	1.613	1.613	1.612	1.611	1.610	1.609
660	1.613	1.612	1.611	1.611	1.610	1.609	1.608
680	1.612	1.611	1.610	1.609	1.609	1.608	1.607
700	1.611	1.610	1.609	1.609	1.608	1.607	1.606
750	1.609	1.608	1.607	1.606	1.606	1.605	1.604
800	1.607	1.607	1.606	1.605	1.604	1.603	1.602

Table 25B. **Anthophyllite γ** (In Cargille Series E: **1.615**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.644	1.643	1.642	1.641	1.640	1.639	1.638
420	1.639	1.638	1.637	1.636	1.635	1.634	1.633
440	1.635	1.634	1.633	1.632	1.631	1.630	1.629
460	1.631	1.630	1.630	1.629	1.628	1.627	1.626
480	1.628	1.627	1.627	1.626	1.625	1.624	1.623
500	1.626	1.625	1.624	1.623	1.622	1.621	1.620
520	1.624	1.623	1.622	1.621	1.620	1.619	1.618
540	1.622	1.621	1.620	1.619	1.618	1.617	1.616
560	1.620	1.619	1.618	1.617	1.616	1.615	1.615
580	1.618	1.617	1.616	1.616	1.615	1.614	1.613
589	1.618	1.617	1.616	1.615	1.614	1.613	1.612
600	1.617	1.616	1.615	1.614	1.613	1.612	1.612
620	1.616	1.615	1.614	1.613	1.612	1.611	1.610
640	1.615	1.614	1.613	1.612	1.611	1.610	1.609
660	1.613	1.613	1.612	1.611	1.610	1.609	1.608
680	1.613	1.612	1.611	1.610	1.609	1.608	1.607
700	1.612	1.611	1.610	1.609	1.608	1.607	1.606
750	1.610	1.609	1.608	1.607	1.606	1.605	1.604
800	1.608	1.607	1.606	1.605	1.604	1.604	1.603

Table 26A. **Anthophyllite α** (In Cargille Series E: **1.620**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.652	1.651	1.650	1.649	1.648	1.647	1.646
420	1.646	1.645	1.645	1.644	1.643	1.642	1.641
440	1.642	1.641	1.640	1.639	1.638	1.637	1.636
460	1.638	1.637	1.636	1.635	1.634	1.633	1.633
480	1.635	1.634	1.633	1.632	1.631	1.630	1.629
500	1.632	1.631	1.630	1.629	1.628	1.627	1.626
520	1.629	1.628	1.628	1.627	1.626	1.625	1.624
540	1.627	1.626	1.625	1.624	1.624	1.623	1.622
560	1.625	1.624	1.623	1.623	1.622	1.621	1.620
580	1.623	1.623	1.622	1.621	1.620	1.619	1.618
589	1.623	1.622	1.621	1.620	1.619	1.618	1.617
600	1.622	1.621	1.620	1.619	1.618	1.617	1.616
620	1.620	1.620	1.619	1.618	1.617	1.616	1.615
640	1.619	1.618	1.617	1.616	1.616	1.615	1.614
660	1.618	1.617	1.616	1.615	1.614	1.613	1.613
680	1.617	1.616	1.615	1.614	1.613	1.612	1.611
700	1.616	1.615	1.614	1.613	1.612	1.611	1.610
750	1.614	1.613	1.612	1.611	1.610	1.609	1.608
800	1.612	1.611	1.610	1.609	1.608	1.607	1.607

Table 26B. **Anthophyllite γ** (In Cargille Series E: **1.620**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.650	1.649	1.648	1.647	1.646	1.645	1.644
420	1.645	1.644	1.643	1.642	1.641	1.640	1.639
440	1.640	1.639	1.639	1.638	1.637	1.636	1.635
460	1.637	1.636	1.635	1.634	1.633	1.632	1.631
480	1.634	1.633	1.632	1.631	1.630	1.629	1.628
500	1.631	1.630	1.629	1.628	1.628	1.627	1.626
520	1.629	1.628	1.627	1.626	1.625	1.624	1.623
540	1.627	1.626	1.625	1.624	1.623	1.622	1.621
560	1.625	1.624	1.623	1.622	1.621	1.621	1.620
580	1.623	1.622	1.622	1.621	1.620	1.619	1.618
589	1.623	1.622	1.621	1.620	1.619	1.618	1.617
600	1.622	1.621	1.620	1.619	1.618	1.617	1.617
620	1.621	1.620	1.619	1.618	1.617	1.616	1.615
640	1.619	1.619	1.618	1.617	1.616	1.615	1.614
660	1.618	1.617	1.617	1.616	1.615	1.614	1.613
680	1.617	1.616	1.616	1.615	1.614	1.613	1.612
700	1.616	1.616	1.615	1.614	1.613	1.612	1.611
750	1.614	1.614	1.613	1.612	1.611	1.610	1.609
800	1.613	1.612	1.611	1.610	1.609	1.608	1.607

Table 27A. **Anthophyllite α** (In Cargille Series E: **1.625**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.658	1.657	1.656	1.656	1.655	1.654	1.653
420	1.653	1.652	1.651	1.650	1.649	1.648	1.647
440	1.648	1.647	1.646	1.645	1.644	1.643	1.642
460	1.644	1.643	1.642	1.641	1.640	1.639	1.638
480	1.640	1.639	1.639	1.638	1.637	1.636	1.635
500	1.637	1.636	1.636	1.635	1.634	1.633	1.632
520	1.635	1.634	1.633	1.632	1.631	1.630	1.629
540	1.632	1.631	1.631	1.630	1.629	1.628	1.627
560	1.630	1.629	1.629	1.628	1.627	1.626	1.625
580	1.628	1.628	1.627	1.626	1.625	1.624	1.623
589	1.628	1.627	1.626	1.625	1.624	1.623	1.622
600	1.627	1.626	1.625	1.624	1.623	1.622	1.621
620	1.625	1.624	1.624	1.623	1.622	1.621	1.620
640	1.624	1.623	1.622	1.621	1.620	1.619	1.619
660	1.623	1.622	1.621	1.620	1.619	1.618	1.617
680	1.622	1.621	1.620	1.619	1.618	1.617	1.616
700	1.621	1.620	1.619	1.618	1.617	1.616	1.615
750	1.618	1.617	1.616	1.616	1.615	1.614	1.613
800	1.616	1.615	1.615	1.614	1.613	1.612	1.611

Table 27B. **Anthophyllite γ** (In Cargille Series E: **1.625**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.656	1.655	1.654	1.653	1.652	1.652	1.651
420	1.651	1.650	1.649	1.648	1.647	1.646	1.645
440	1.646	1.645	1.645	1.644	1.643	1.642	1.641
460	1.643	1.642	1.641	1.640	1.639	1.638	1.637
480	1.639	1.638	1.638	1.637	1.636	1.635	1.634
500	1.637	1.636	1.635	1.634	1.633	1.632	1.631
520	1.634	1.633	1.632	1.631	1.631	1.630	1.629
540	1.632	1.631	1.630	1.629	1.628	1.628	1.627
560	1.630	1.629	1.628	1.627	1.627	1.626	1.625
580	1.628	1.628	1.627	1.626	1.625	1.624	1.623
589	1.628	1.627	1.626	1.625	1.624	1.623	1.622
600	1.627	1.626	1.625	1.624	1.623	1.622	1.621
620	1.626	1.625	1.624	1.623	1.622	1.621	1.620
640	1.624	1.623	1.622	1.622	1.621	1.620	1.619
660	1.623	1.622	1.621	1.620	1.619	1.619	1.618
680	1.622	1.621	1.620	1.619	1.618	1.618	1.617
700	1.621	1.620	1.619	1.618	1.617	1.617	1.616
750	1.619	1.618	1.617	1.616	1.615	1.614	1.614
800	1.617	1.616	1.615	1.614	1.614	1.613	1.612

Table 28A. **Anthophyllite α** (In Cargille Series E: **1.630**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.665	1.664	1.663	1.662	1.661	1.660	1.659
420	1.659	1.658	1.657	1.656	1.655	1.654	1.653
440	1.654	1.653	1.652	1.651	1.650	1.649	1.648
460	1.650	1.649	1.648	1.647	1.646	1.645	1.644
480	1.646	1.645	1.644	1.643	1.642	1.641	1.641
500	1.643	1.642	1.641	1.640	1.639	1.638	1.637
520	1.640	1.639	1.638	1.637	1.636	1.636	1.635
540	1.638	1.637	1.636	1.635	1.634	1.633	1.632
560	1.635	1.635	1.634	1.633	1.632	1.631	1.630
580	1.634	1.633	1.632	1.631	1.630	1.629	1.628
589	1.633	1.632	1.631	1.630	1.629	1.628	1.627
600	1.632	1.631	1.630	1.629	1.628	1.627	1.626
620	1.630	1.629	1.628	1.628	1.627	1.626	1.625
640	1.629	1.628	1.627	1.626	1.625	1.624	1.623
660	1.627	1.627	1.626	1.625	1.624	1.623	1.622
680	1.626	1.625	1.625	1.624	1.623	1.622	1.621
700	1.625	1.624	1.623	1.623	1.622	1.621	1.620
750	1.623	1.622	1.621	1.620	1.619	1.618	1.617
800	1.621	1.620	1.619	1.618	1.617	1.616	1.615

Table 28B. **Anthophyllite γ** (In Cargille Series E: **1.630**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.663	1.662	1.661	1.660	1.659	1.658	1.657
420	1.657	1.656	1.655	1.654	1.653	1.652	1.652
440	1.652	1.651	1.651	1.650	1.649	1.648	1.647
460	1.648	1.647	1.647	1.646	1.645	1.644	1.643
480	1.645	1.644	1.643	1.642	1.641	1.641	1.640
500	1.642	1.641	1.640	1.639	1.638	1.638	1.637
520	1.640	1.639	1.638	1.637	1.636	1.635	1.634
540	1.637	1.636	1.635	1.635	1.634	1.633	1.632
560	1.635	1.634	1.633	1.633	1.632	1.631	1.630
580	1.633	1.633	1.632	1.631	1.630	1.629	1.628
589	1.633	1.632	1.631	1.630	1.629	1.628	1.627
600	1.632	1.631	1.630	1.629	1.628	1.627	1.626
620	1.630	1.629	1.629	1.628	1.627	1.626	1.625
640	1.629	1.628	1.627	1.626	1.625	1.625	1.624
660	1.628	1.627	1.626	1.625	1.624	1.623	1.622
680	1.627	1.626	1.625	1.624	1.623	1.622	1.621
700	1.626	1.625	1.624	1.623	1.622	1.621	1.620
750	1.623	1.623	1.622	1.621	1.620	1.619	1.618
800	1.622	1.621	1.620	1.619	1.618	1.617	1.616

Table 29A. **Anthophyllite α** (In Cargille Series E: 1.635)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.671	1.670	1.669	1.669	1.668	1.667	1.666
420	1.665	1.664	1.663	1.662	1.661	1.660	1.660
440	1.660	1.659	1.658	1.657	1.656	1.655	1.654
460	1.655	1.654	1.654	1.653	1.652	1.651	1.650
480	1.652	1.651	1.650	1.649	1.648	1.647	1.646
500	1.648	1.647	1.646	1.645	1.645	1.644	1.643
520	1.645	1.645	1.644	1.643	1.642	1.641	1.640
540	1.643	1.642	1.641	1.640	1.639	1.638	1.637
560	1.641	1.640	1.639	1.638	1.637	1.636	1.635
580	1.639	1.638	1.637	1.636	1.635	1.634	1.633
589	1.638	1.637	1.636	1.635	1.634	1.633	1.632
600	1.637	1.636	1.635	1.634	1.633	1.632	1.631
620	1.635	1.634	1.633	1.632	1.631	1.631	1.630
640	1.634	1.633	1.632	1.631	1.630	1.629	1.628
660	1.632	1.631	1.630	1.630	1.629	1.628	1.627
680	1.631	1.630	1.629	1.628	1.627	1.626	1.626
700	1.630	1.629	1.628	1.627	1.626	1.625	1.624
750	1.627	1.626	1.626	1.625	1.624	1.623	1.622
800	1.625	1.624	1.623	1.623	1.622	1.621	1.620

Table 29B. **Anthophyllite γ** (In Cargille Series E: 1.635)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.670	1.669	1.668	1.667	1.666	1.665	1.664
420	1.664	1.663	1.662	1.661	1.660	1.659	1.658
440	1.659	1.658	1.657	1.656	1.655	1.654	1.653
460	1.655	1.654	1.653	1.652	1.651	1.650	1.649
480	1.651	1.650	1.649	1.648	1.647	1.646	1.645
500	1.648	1.647	1.646	1.645	1.644	1.643	1.642
520	1.645	1.644	1.643	1.642	1.641	1.640	1.640
540	1.643	1.642	1.641	1.640	1.639	1.638	1.637
560	1.641	1.640	1.639	1.638	1.637	1.636	1.635
580	1.639	1.638	1.637	1.636	1.635	1.634	1.633
589	1.638	1.637	1.636	1.635	1.634	1.633	1.632
600	1.637	1.636	1.635	1.634	1.633	1.632	1.631
620	1.635	1.634	1.633	1.633	1.632	1.631	1.630
640	1.634	1.633	1.632	1.631	1.630	1.629	1.628
660	1.633	1.632	1.631	1.630	1.629	1.628	1.627
680	1.631	1.630	1.630	1.629	1.628	1.627	1.626
700	1.630	1.629	1.628	1.628	1.627	1.626	1.625
750	1.628	1.627	1.626	1.625	1.624	1.623	1.622
800	1.626	1.625	1.624	1.623	1.622	1.621	1.620

Table 30A. **Anthophyllite α** (In Cargille Series E: **1.640**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.678	1.677	1.676	1.675	1.674	1.673	1.672
420	1.671	1.670	1.669	1.669	1.668	1.667	1.666
440	1.666	1.665	1.664	1.663	1.662	1.661	1.660
460	1.661	1.660	1.659	1.658	1.657	1.656	1.655
480	1.657	1.656	1.655	1.654	1.653	1.652	1.651
500	1.654	1.653	1.652	1.651	1.650	1.649	1.648
520	1.651	1.650	1.649	1.648	1.647	1.646	1.645
540	1.648	1.647	1.646	1.645	1.644	1.643	1.642
560	1.646	1.645	1.644	1.643	1.642	1.641	1.640
580	1.644	1.643	1.642	1.641	1.640	1.639	1.638
589	1.643	1.642	1.641	1.640	1.639	1.638	1.637
600	1.642	1.641	1.640	1.639	1.638	1.637	1.636
620	1.640	1.639	1.638	1.637	1.636	1.635	1.634
640	1.639	1.638	1.637	1.636	1.635	1.634	1.633
660	1.637	1.636	1.635	1.634	1.633	1.632	1.631
680	1.636	1.635	1.634	1.633	1.632	1.631	1.630
700	1.635	1.634	1.633	1.632	1.631	1.630	1.629
750	1.632	1.631	1.630	1.629	1.628	1.627	1.626
800	1.630	1.629	1.628	1.627	1.626	1.625	1.624

Table 30B. **Anthophyllite γ** (In Cargille Series E: **1.640**)

λ_0	19°C	21°C	23°C	25°C	27°C	29°C	31°C
400	1.676	1.675	1.674	1.673	1.672	1.671	1.670
420	1.670	1.669	1.668	1.667	1.666	1.665	1.664
440	1.665	1.664	1.663	1.662	1.661	1.660	1.659
460	1.660	1.659	1.658	1.657	1.656	1.655	1.654
480	1.656	1.656	1.655	1.654	1.653	1.652	1.651
500	1.653	1.652	1.651	1.650	1.649	1.648	1.647
520	1.650	1.649	1.648	1.647	1.647	1.646	1.645
540	1.648	1.647	1.646	1.645	1.644	1.643	1.642
560	1.646	1.645	1.644	1.643	1.642	1.641	1.640
580	1.644	1.643	1.642	1.641	1.640	1.639	1.638
589	1.643	1.642	1.641	1.640	1.639	1.638	1.637
600	1.642	1.641	1.640	1.639	1.638	1.637	1.636
620	1.640	1.639	1.638	1.637	1.636	1.635	1.635
640	1.639	1.638	1.637	1.636	1.635	1.634	1.633
660	1.638	1.637	1.636	1.635	1.634	1.633	1.632
680	1.636	1.635	1.634	1.633	1.632	1.631	1.630
700	1.635	1.634	1.633	1.632	1.631	1.630	1.629
750	1.633	1.632	1.631	1.630	1.629	1.628	1.627
800	1.631	1.630	1.629	1.628	1.627	1.626	1.625

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APPENDIX

G. W. Bailey and C. L. Rieder, Eds., Proc. 51st Annual Meeting of the Microscopy Society of America
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DETERMINATION OF REFRACTIVE INDEX OF SOLIDS BY DISPERSION STAINING METHOD: AN ANALYTICAL APPROACH

Shu-Chun Su

Hercules Incorporated, Research Center, 500 Hercules Road, Wilmington, DE 19808-1599, USA

When immersion liquids are used to determine the refractive index (RI) of non-opaque solids, the dispersion staining method is a simple, effective and precise way to determine the matching wavelength, λ_0 , at which the RI of an immersion liquid equals that of the solid. A series of equations has been derived to calculate the RI at any given visible wavelength such as n_F , n_D and n_C , i.e. the RI's at Fraunhofer spectral lines F (486 nm), D (589 nm), and C (656 nm), from λ_0 data obtained by the dispersion staining method. Two methods have been established: the *Single Liquid Method* and the *Double Liquid Method*.

The *Single Liquid Method* is applicable for solids with known dispersion coefficients, which is defined as $(n_F - n_C)$. This method uses only one immersion liquid whose RI is close to the RI of the solid to be measured so that a match between the liquid and the solid occurs in the visible range. If the matching wavelength is determined to be λ_0 (nm), the RI of the solid at wavelength i (nm) can be readily calculated using the following equation:

$$n_i^s = n_i^l + (\Delta^L - \Delta^s) \cdot k_i,$$

where n_i^s is the RI of the solid at wavelength i (nm); n_i^l the RI of the liquid at wavelength i , Δ^L the dispersion coefficient of the liquid, $(n_F^L - n_C^L)$; Δ^s the dispersion coefficient of the solid, $(n_F^s - n_C^s)$; and k_i equals $(X_0 - X_i)/(X_F - X_C)$. X_0 , X_i , X_F , and X_C are defined by replacing the λ in the expression $(\lambda - 200)^{-1}$ with λ_0 , i , 486 and 656, respectively. Therefore, $k_i = [(\lambda_0 - 200)^{-1} - (i - 200)^{-1}] / [(486 - 200)^{-1} - (656 - 200)^{-1}]$, or $[(\lambda_0 - 200)^{-1} - (i - 200)^{-1}] / 0.001304$. In most cases, n_D^s , the RI of the solid at 589 nm, is to be determined. The above equation then becomes

$$n_D^s = n_D^l + (\Delta^L - \Delta^s) \cdot k_D,$$

where n_D^l is the RI of the liquid at 589 nm and k_D equals $[(\lambda_0 - 200)^{-1} - (589 - 200)^{-1}] / [(486 - 200)^{-1} - (656 - 200)^{-1}]$ or $[(\lambda_0 - 200)^{-1} - 0.002571] / 0.001304$. Because n_D^l , Δ^L , and Δ^s are known, the only parameter that needs to be measured is λ_0 . A table for quick conversion of λ_0 to k_D is provided to minimize the calculations involved.

The *Single Liquid Method* is extremely useful for rapid identification of synthetic and natural fibers, such as polypropylene, polyethylene, nylon, cellulose, etc., as well as fibrous components in bulk insulation samples, such as the six fibrous asbestos minerals regulated by the Environmental Protection Agency: chrysotile, grunerite (or amosite), riebeckite (or crocidolite), tremolite, actinolite, anthophyllite. A single RI liquid mount (1.550 for chrysotile, 1.680 or 1.700 for grunerite and riebeckite and 1.605 for tremolite, actinolite and anthophyllite) is sufficient for

rapidly determining both $n_{\perp}$ and $n_{\parallel}$, the RI's perpendicular and parallel to the fiber elongation, respectively, with reasonable accuracy. A series of conversion tables for the six asbestos minerals are presented in this paper to aid the conversion of an observed λ_0 to its corresponding n_D^S value. Other applications of this method include the estimation of the composition of common rock-forming minerals such as plagioclase, olivine, orthopyroxene and augite.

The **Double Liquid Method** is applicable to any solid and requires *no* knowledge about its dispersion coefficient, $(n_F^S - n_C^S)$, or other optical properties. This method uses two immersion liquids whose RI's at 589 nm bracket the RI at 589 nm of the solid to be measured. If the matching wavelengths for Liquid #1 and Liquid #2 are measured to be λ_0^1 (nm) and λ_0^2 (nm), respectively, the RI of the solid at wavelength i (nm), n_i^S , can be readily calculated using the following equation:

$$n_i^S = n_i^1 + (n_i^2 - n_i^1) \cdot k_i,$$

where n_i^1 is the RI of Liquid #1 at i ; n_i^2 the RI of Liquid #2 at i ; and k_i equals $(X_0^1 - X_i)/(X_0^1 - X_0^2)$. X_i , X_0^1 and X_0^2 are defined by replacing the λ in the expression $(\lambda - 200)^{-1}$ with i , λ_0^1 and λ_0^2 , respectively. Therefore, $k_i = [(\lambda_0^1 - 200)^{-1} - (i - 200)^{-1}] / [(\lambda_0^1 - 200)^{-1} - (\lambda_0^2 - 200)^{-1}]$. In most cases, n_D^S , the RI of the solid at 589 nm, is to be determined. The above equation then becomes

$$n_D^S = n_D^1 + (n_D^2 - n_D^1) \cdot k_D,$$

where n_D^1 is the RI of Liquid #1 at 589 nm; n_D^2 the RI of Liquid #2 at 589 nm; and k_D equals $[(\lambda_0^1 - 200)^{-1} - 0.00257] / [(\lambda_0^1 - 200)^{-1} - (\lambda_0^2 - 200)^{-1}]$. Because n_D^1 and n_D^2 are known, the parameters that need to be measured are λ_0^1 and λ_0^2 . A table for quick conversion of λ_0^1 and λ_0^2 to k_D is provided to minimize the calculations involved. Apparently, the **Double Liquid Method** is more accurate than the **Single Liquid Method**.

If t , the temperature of the liquid at the time of determination, is not 25°C, temperature correction must be applied to all RI's of the liquids used in the above calculations. The equation used for this purpose is

$$n_i^t = n_i^{25^\circ\text{C}} + (t - 25) \cdot dn/dt,$$

where n_i^t is the RI of a liquid at temperature t (°C) and wavelength i (nm); $n_i^{25^\circ\text{C}}$ the RI of the liquid at 25°C and wavelength i (nm); and dn/dt the temperature coefficient of the liquid. It should be noted that dn/dt is a negative value. Therefore, if the t is higher than 25°C, n_i^t is lower than $n_i^{25^\circ\text{C}}$.

Besides dispersion staining, there are other techniques for determining the matching wavelength λ_0 between the RI of a solid and that of its surrounding liquid medium, e.g., the traditional wavelength-variation method, double-variation method, oblique illumination method, etc. The above equations are equally applicable to the λ_0 data obtained by these and *any* other techniques.