

# The Cosmetic, Toiletry and Fragrance Association, Inc.

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## MEMORANDUM

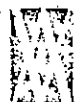
TO: The CTFA Talc Subcommittee  
FROM: Norman F. Estrin, Ph.D.  
DATE: November 2nd, 1976  
SUBJECT: CTFA Talc Methodology

McCrone has performed a very useful service by comparing and evaluating CTFA methodology.

Their suggestions with regard to methodology and their other suggestions should be discussed at the November 10th Talc Subcommittee meeting.

NFE:jj  
Attachment  
cc: Walter C. McCrone

PLAINTIFF'S  
EXHIBIT  
WCD-46



Walter C. McCrone Associates, Inc.

CONSULTING ULTRAMICROANALYSIS • MICROSCOPY • SMALL PARTICLE PROBLEMS • SOLID STATE CHEMISTRY

3 September 1976

Dr. Norman F. Estrin  
CTFA  
1133 15th St., N.W.  
Washington, DC 20005

Dear Dr. Estrin:

As you know, we, at McCrone Associates, have done considerable work on talc and especially on various mineral inclusions in talc. As a result we have accumulated data, procedures (and prejudices) concerning these analyses.

I have recently had occasion to look at the proposed CTFA procedures for asbestiform minerals in talc and can't help feeling that our routine procedures are, I regret to say, considerably more sophisticated. Since I was about to commit our methods to a paper for another publication (unfortunately, for the FDA) I felt that, as an intellectual exercise, I would recast the same material as a CTFA method. I am enclosing this horrendous document for your perusal and sympathize if you choose to quickly burn it at the stake. Note first, however, that I have retained some of the features of your method that I liked.

Still, in our hands, the methods we propose work very well. In addition, they are rapid and reasonably inexpensive. We are interested in improving the competence of microanalysts generally and, as you may know, teach about 40 courses a year in these procedures both here and abroad. As a matter of fact, I leave this weekend where I will be teaching 3 back-to-back courses in the identification of asbestiform minerals by the methods covered in the infamous enclosure.

Seriously, I don't propose you adopt these methods in the detail I've suggested but I do suggest that you urge each CTFA member to take steps now that will lead to their ability to make such analyses. The more each company knows about the products it makes and the raw materials it uses the better able will that company be to stay out of trouble and represent its best interests if trouble arises. We can help here through our teaching arm. I suggest we offer a course either directly through the CTFA or simply to the member companies. This course would train one or more qualified microanalysts in each company in the use of the proposed x-ray diffraction and dispersion staining methods for the study of cosmetic talc and possible contaminating substances.

We would further aid each company in setting up (purchasing, if necessary) the equipment, supplies and mineral standards required for such studies. The entire package would include a one-week intensive course in Chicago, evaluation of the company laboratory and equipment, furnishing sets of

Dr. Norman F. Estrin  
Page two

standard samples and test material and a follow-up over a several-month period of progress in each company by means of a series of round-robin sample analyses. We will sign off each company when we are satisfied their personnel and equipment can do a professional job of analyzing talc samples. The cost of this package would be \$1500 per company.

I look forward to your response and hope I haven't scared you away.

Yours Sincerely,

Walter C. McCrone

WCM:cdb  
Enclosure

COSMETIC TALC

**DEFINITION:** Cosmetic Talc is a white, essentially odorless, fine powder, ground from naturally occurring rock ore, consisting mainly of hydrated magnesium silicate having the ideal formula  $3\text{Mg}(\text{Si}_2\text{O}_7) \cdot (\text{OH})_2$ , with lesser amounts of naturally associated minerals such as calcite, chlorite, dolomite, kaolin and magnesite, and containing no asbestos minerals detectable by x-ray diffraction.

TEST	SPECIFICATION	METHOD
Color.....	As specified by the buyer and showing no change after heating	Heat 1 to 2 g at 200°C for 5 minutes
Odor.....	As specified by the buyer	CTFA C 3-1
Identification.....	Positive: 1. Close match to CTFA Spectrum with no indication of foreign materials  <u>OR</u> 2. (Alternate) Close match Powder Diffraction File No. 19-770, published by ASTM, showing the most intense reflections at d values about 9.35, 1.53 and 4.59 Å	CTFA C 3-1  ASTM D 934-74
Slip.....	As specified by the buyer	
Lustre.....	Do.	
Water-Soluble Iron.....	Passes test	USP XIX, page 487
Screen Test.....	100% through 100 mesh 90% minimum through 200 mesh Finer grades: as specified by the buyer	CTFA C 6-1
Water Soluble Substances...	0.1% maximum	USP XIX, page 487 See test for "Reaction and Soluble Substances"

Acid Soluble Substances....	As specified by the buyer 6.0% maximum	CTFA E 31-1
Loss of Ignition.....	5.0% maximum	USP XIX, page 487
Arsenic (as As).....	3 ppm maximum	CTFA F 1-1, Parts 1-A and 11
Lead (as Pb).....	20 ppm maximum	CTFA F 2-1, Parts 1-A and 11
Amphiboles.....	None detected by XRD (Asbestiform Tremolite et al)	CTFA J 4-1
Free Crystalline Silica....	As specified by the buyer (Quartz)	CTFA J 5-1 (DTA) Alternate: CTFA J 6-1 (X-ray)

ACID SOLUBLE SUBSTANCES IN TALC

Principle

A sample of talc is mixed with diluted hydrochloric acid and the insoluble portion is removed by centrifugation and filtration. The filtrate is sulfated, evaporated to dryness and ignited. The acid soluble matter is determined gravimetrically as the sulfate.

APPARATUS

1. Controlled temperature water bath
2. Beaker, Griffin, 100 ml
3. Volumetric flask, 50 ml.
4. Centrifuge
5. Centrifuge tubes (2), 50 ml
6. Graduated Cylinder, 50 ml
7. Sintered glass funnel, ultra fine porosity, 60 ml (0.9 to 1.4 μm) Corning F36060-UF or equivalent
8. Vacuum flask, 125 ml

9. Pipette, 10 ml

10. Platinum or Vycor evaporating dish or equivalent

#### Reagents

1. Hydrochloric Acid, diluted, 10% v/v

2. Sulfuric Acid, diluted, 10% v/v

#### Procedure

Weigh 2 g ( $\pm 0.001$  g) of sample into a 100 ml beaker, add 40 ml diluted hydrochloric acid, and place in water bath at  $55^\circ$  ( $\pm 2.5^\circ\text{C}$ ), with occasional stirring for 30 minutes. Immediately remove beaker from bath and pour contents into a 50 ml centrifuge tube, rinsing beaker and stirring bar with 2 to 3 ml of distilled water. Centrifuge at 5000 RPM for 30 minutes (Note 1).

Filter supernatant through ultrafine porosity sintered glass funnel into vacuum flask, using 2 to 3 ml of distilled water to rinse the centrifuge tube and funnel, and using care to avoid dislodging the packed talc at the bottom of the tube. Filtrate must be clear (Note 1). Pour filtrate into 50 ml volumetric flask, rinsing with 3 to 5 ml distilled water. Adjust to volume with distilled water.

Pipette 25 ml of adjusted filtrate into tared, ignited evaporating dish. Add 2 ml of diluted sulfuric acid and evaporate to dryness.

Ignite at  $600^\circ$  ( $\pm 25^\circ\text{C}$ ) for 1 hour. Cool and weigh.

#### Calculation

$\% \text{ Acid Soluble Substances} = \frac{\text{Weight of Residue in g} \times 200}{\text{Weight of Sample in g}}$

#### Note

1. Examine the centrifuged sample carefully to assure good clarity before proceeding with filtration. If haziness is detected, centrifuge the sample for an additional 15 to 30 minutes as necessary.

#### ASBESTIFORM MINERALS IN COSMETIC TALC

The presence of asbestiform minerals in talc is determined by x-ray diffraction with a sensitivity of about 0.5% by weight. The mineral identification is confirmed and the asbestiform habit is determined by polarized light microscopy with the added help furnished by dispersion staining.

If  $>0.5\%$  of asbestiform mineral is present the sample is rejected. If the non-asbestiform habits are present, e.g., lizardite, antigorite, grunerite, cummingtonite and reibeckite the sample passes. If  $<0.5\%$  of the asbestiform habits are present the sample passes. (Note: The polarizing microscope with dispersion staining will detect 0.01% of any mineral with not more than 30 minutes scanning time and if the particles are, at least,  $0.2 \times 3 \mu\text{m}$ .)

## PART I — ASBESTIFORM MINERALS BY X-RAY DIFFRACTION

### Principle

The x-ray diffraction method is based upon the principle that when a crystalline material is placed in an x-ray beam, a portion of the x-rays are diffracted by each set of atomic planes within the crystal. The diffracted rays strike a scintillation counter as the sample is scanned through a prescribed angle with the resulting development of peaks corresponding to each interplanar distance ( $d$ ). A peak with a  $d$  value in the range of 8.04 to 8.65 Å for a talc sample is strong evidence for the presence of amphibole. The limit of detection of amphibole by careful application of this method is 0.5%.

### Apparatus

1. X-ray diffractometer, employing nickel-filtered copper K-alpha radiation, horizontal or vertical goniometer with variable scan speed capability, suitable talc pellet sample holder, variable speed recorder, electronic panel including ratemeter, variable attenuation and time constant settings
2. Hydraulic press, capable of attaining a pressure of 15,000 to 24,000 lb applied to a 3" ram
3. Mortar and pestle or grinding mill (Note 1)
4. Waring Blendor, or equivalent blender
5. Spex Mixer/Mill, or equivalent mechanical mixer
6. Sieve, 325-mesh
7. Optical microscope (Note 2)
8. 1-1/4" pellet press

### Reagents

1. Standard talc sample, containing no detectable amphibole minerals
2. Standard tremolite sample (at least 95% pure), may be obtained by ordering from The Cosmetic Toiletry and Fragrance Association, Inc., 1133 Fifteenth Street, N.W., Washington, D.C. 20005
3. Denatured ethanol
4. Boric acid

### Procedure

The procedure consists of scanning (1°/min) under otherwise high tivity conditions, a compressed pellet of the sample talc over the 2 range from 4° to 54° (about 20 Å to 2.6 Å) with Cu K $\alpha$  radiation. Check the recorded trace for the peaks tabulated in Table 1.

TABLE 1

Possible Characteristic Strong Peaks in the X-Ray Spectrum of Talc

<u>2<math>\theta</math>, degrees</u>	<u>d, Å</u>	<u>I</u>	<u>Mineral</u>
6.31	14.0	80	chlorite
9.45	9.35	100	talc
9.66	9.15	20	cummingtonite (amosite)
10.52	8.40	100	crocidolite
10.52	8.40	100	hornblende
10.55	8.38	100	tremolite, actinolite, anthophyllite
10.61	8.33	100	cummingtonite
12.01	7.36	100	chrysotile
12.04	7.34	100	lizardite
12.20	7.25	100	antigorite
12.51	7.07	8	talc
18.99	4.67	8	talc
19.32	4.59	45	talc
19.45	4.56	25	talc
19.48	4.53	12	talc
20.49	4.35	6	talc
20.83	4.26	35	quartz

23.02	3.66	12	calcite	41.98	2.15	60	lizardite
24.30	3.66	100	chrysotile	42.99	2.102	45	magnesite
24.50	3.63	60	lizardite	45.08	2.095	18	calcite
24.57	3.62	60	antigorite	46.81	1.94	12	magnesite
25.25	3.541	80	chlorite	48.05	1.892	50	tremolite
25.83	-	40	apatite	48.65	1.870	4	talc
26.64	3.343	100	quartz	50.16	1.817	17	quartz
27.26	3.268	75	tremolite	50.55	1.804	20	dolomite
27.33	3.26	30	hornblende	51.10	1.786	30	dolomite
27.59	3.23	50	anthophyllite	51.25	1.781		
28.59	3.121	100	tremolite	53.88	1.700	35	magnesite
28.60	3.12	40	talc	59.26	1.558	2	talc
28.60	3.12	55	crocidolite	60.24	1.535	60	chrysotile
28.63	3.11	100	actinolite	60.41	1.531	70	lizardite
28.77	3.10	70	hornblende	60.50	1.529	55	talc
29.16	3.06	100	anthophyllite, amosite	61.80	1.500	60	lizardite
29.55	3.02	100	calcite				
30.96	2.885	100	dolomite				
31.60	2.829	20	chlorite				
31.76	2.814	100	apatite				
31.82	2.81	100	calcite				
32.19	2.778	60	apatite				
32.46	2.756	70	amosite				
32.63	2.742	100	magnesite				
32.83	2.726	40	crocidolite				
32.90	2.720	60	apatite				
33.09	2.705	90	tremolite				
33.15	2.70	50	actinolite				
33.19	2.697	20	hornblende				
35.60	2.52	90	antigorite				
35.85	2.503	18	magnesite				
36.04	2.49	100	lizardite				
36.56	2.456	80	chrysotile				
38.49	2.337	2	talc				
39.40	2.285	18	calcite				
41.40	2.192	30	dolomite				

Some minerals, e.g., carbonates, quartz, hornblende etc. have been listed here not because of any known harmful effects but because they may be observed in talc samples.

Under ideal conditions 0.5-1.0% of all of the above minerals should be indicated by a possible peak in the 4°-34° range. Appropriate peak regions for the indicated mineral should then be scanned at 0.1°/min as indicated below.

Should the presence of a small peak above the background "noise" be in question, it will be necessary to statistically evaluate the scan made at 0.1°/min in the suspected peak region(s). A timer/scaler is required on the electronic panel of the x-ray diffractometer. In order for a peak to be statistically significant, the peak intensity must equal or exceed three standard deviations (3σ) above the average background intensity (N):

$$N + 3\sigma = \text{minimum peak intensity,}$$

$$N = \text{average background count } \sigma = \sqrt{N}$$

Figure 1

"Peak"	"A"	"B"	10.3	10.7
10.0	10.2	10.4	10.6	11.0

Example:

In Figure 1.

Peak	Region ("20")	Time (sec.)
Background	10.40 to 10.60	120
Region A.....	10.30 to 10.40	60
Region B.....	10.60 to 10.70	60

Background					
Peak		Region A		Region B	
10.40 to 10.60*28		10.30 to 10.40*28		10.60 to 10.70*28	
time secs.	count	time secs.	count	time secs.	counts
120	60,332	60	28,784	60	28,506
120	59,870	60	28,943	60	28,368
120	60,105	60	28,634	60	28,204
Average	60,102		28,787		28,359

$$N = 28,787 + 28,359 = 57,146$$

$$s = 57,146 = 239 \quad 3s = 717$$

$$N + 3s = \sqrt{57,146} + 717 = 57,863$$

The actual number of counts obtained for the integrated peak intensity was 60,102; therefore, the "suspect" peak is statistically present in the scan.

#### Standard Preparation

Optimal instrument conditions must first be determined with the use of standards containing 1.0%, 0.75%, 0.5% by weight of the suspected contaminant prepared in a standard talc which is free of interfering peaks.

Weigh out appropriate amounts of the standard talc and the mineral of interest both of which have been ground to pass a 325-mesh sieve. Transfer to a Waring Blender. Add 100 ml of ethanol to the blender and blend at low speed for 5 minutes.

Carefully transfer, with repeated ethanol washings, the contents of the blender into a large beaker. Evaporate the ethanol on a steam bath.

Shake the sample in a plastic vial for 5 minutes on a Spex Mixer/Mill to remove clumps and caked sample resulting from the evaporation of ethanol.

Determine by microscopy the homogeneity of the prepared standard previous to the x-ray diffraction analysis.

Press the homogeneous standard into a 11/4" pellet with a backing of boric acid. Transfer 2 ( $\pm 0.2$ ) gram of standard to the die-holder and evenly distribute on a polished, scratch-free die. Distribute 4 ( $\pm 0.2$ ) grams of boric acid evenly on the talc layer. Press the mixture into a pellet under conditions suitable for obtaining a smooth planar surface (for example, a pressure of 15,000 to 24,000 lb calculated on a 3" ram has been found to produce suitable pellets). The resulting pellet must have a talc face which is free of flaws; if not, the pellet must be discarded (Note 3).

#### Sample Preparation

Prepare two pellets from each sample in the manner described for the standard pellets. Make a qualitative scan from 4 to 34 $^{\circ}$ 2 $\theta$  on one of these pellets to ascertain the presence of non-talc minerals having interfering peaks.

### Instrumentation

Instrumental variables are optimized on the 1% standard. Lower standards are then analyzed under the optimum conditions to determine the lower level of detection. Of major importance in obtaining maximum instrument sensitivity are a slow diffractometer speed combined with compatible recorder speed, and high attenuation combined with a statistically acceptable time constant on the ratemeter. Under appropriate instrumental conditions the peak obtained for the 0.5% standard should be detectable above background noise as shown in Figure 2 for tremolite.

Typical instrumental conditions employed for the Siemens Diffractometer (Model No. M386-X-A4), and Counter and Recorder Unit (Type T) are:

Radiation: Cu with K $\alpha$  filter at 40KV and 24 ma  
Divergence slit: 1° Receiving slit: 0.2 mm (.007")  
Goniometer speed: 1/16°/28/minute  
Recorder speed: 300 mm/hour  
Attenuation:  $1 \times 10^3$  impulses/second  
Time constant: T (s) = 4

Statistical error of 1.1% under these conditions

Rise Time = 0.18  
Attenuator = 20

### PART II: ASBESTIFORM AMPHIBOLE MINERALS BY POLARIZED LIGHT MICROSCOPY AND DISPERSION STAINING

#### Apparatus

1. Polarizing microscope. Best results will be obtained if the instrument includes the following:
  - a. Individually centering objectives or centerable stage
  - b. Bertrand lens
  - c. High-intensity light source
  - d. Centering condenser/substage
2. Dispersion staining device (Note 4)
3. Vacuum filtration equipment, including either a porcelain cone with glass fiber filter mat or a porous glass bottom cup

#### Reagents

2. Cargille immersion liquids:  $n_D^{25} = 1.550$  (HD series); (Note 5)  
 $n_D^{25} = 1.605$  (HD " )  
 $n_D^{25} = 1.660$  (RF " )  
 $n_D^{25} = 1.710$  (H " )

#### Optical Microscopy and Dispersion Staining

Carefully adjust the dispersion staining objective for optimum viewing of central stop colors. The microscope is first arranged for Köhler illumination: lamp iris (field diaphragm) in focus in the field of view; lamp filament in focus in objective back focal plane. The lamp, if movable, should be placed close to the mirror so that the image of the lamp filament is as small as possible in the objective back focal plane. This along with overvolting the lamp by 15-20% and removing the daylight blue filter will ensure bright central stop colors and detection of submicrometer particles.



The stage should next be centered and the central stop should be precisely centered with respect to the image of the substage iris (aperture diaphragm) in the objective back focal plane. The substage iris is then closed just behind the central stop and the Bertrand lens (or equivalent viewing system) is removed. The preparation is scanned for  $\lambda_0$  colors in the visible; critical study of an area or of a given particle is carried out with the field diaphragm nearly closed around the center portion of the field of view.

Identification of non-talc minerals by dispersion staining.

Mount a representative sample (about 0.1 mg) in the following Cargille refractive index liquids and examine carefully for non-talc substances. The particles are mounted in the drop of Cargille liquid between slide and coverslip. The particles are best dispersed by sliding the coverslip with a rotary motion of a pencil eraser "gripping" the coverslip. The final prep should be thin and the coverslip should be parallel to the slide (this avoids a "prism" shaped prep that will decenter the image of the substage iris relative to the central stop). The slide and coverslip must be carefully cleaned before use and the pencil eraser must be dipped in diluted rubber cement and dried before use to avoid transfer of particles to the top of the coverslip. The minerals to be checked for include:

	Refractive Indices			
	$n_{or e}$	$\delta$	$\gamma_{or c}$	
Chrysotile	1.545	-	1.556	
Lizardite	1.545	-	1.556	
Antigorite	1.564	$\approx 1.566$	1.570	
Chlorite	1.600	1.603	1.610	
Quartz	1.544		1.553	
Calcite	1.658		1.486	
Dolomite	1.679		1.560	
Magnésite	1.700		1.509	
Hornblende	1.655	1.665	1.672	
Forsterite	1.640	1.656	1.674	
Talc	1.540	1.589	1.595	
Anthophyllite	1.525	1.635	1.650	
Tremolite	1.599	1.612	1.622	
Actinolite	1.628	1.640	1.650	
Amosite	Cummingtonite	1.648	1.658	1.674
		Grunerite	1.680	1.700
Crocidolite	Glaucophane	1.630	1.640	1.645
		Riebeckite	1.695	1.704

Minerals, especially silicates but also the isomorphous series of carbonates (calcite, dolomite, magnesite etc.) vary in refractive index. Figure 2 a. and b. show average indices for the minerals which might be found in talc. Generally, the dispersion staining curves for these minerals move parallel to themselves as the composition changes. The birefringence values ( $\gamma - E$ ,  $\beta - \alpha$  and  $\epsilon - \omega$ ) will generally remain nearly constant for a given mineral although the indices themselves may vary considerably.

The combination of crystal morphology and optics is also a great help in making sure of the identity of a given mineral. One should look for different views of a given mineral and/or vary the view on a single crystal by tapping gently on the top of the coverslip with a needle. In this way fiberlike talc plates on edge can be tipped into the plate view and quartz can be made to show  $\epsilon$  as well as  $\omega$ .

Both morphology and optics are noted in order to identify the asbestiform minerals. To be asbestiform requires that they be fibers, not slivers, measuring  $< 3 \mu\text{m}$  in diameter,  $< 30 \mu\text{m}$  in length and have a length to width ratio of at least 5:1.

#### Examine the sample for asbestiform or fibrous amphibole minerals

In order for an amphibole mineral to be considered asbestiform or fibrous it must meet the following OSHA definition (Reference 4).

1. Particles must appear to be fibrous rather than as crystals or slivers.
2. The maximum diameter of a fiber to be counted is 3 micrometers.
3. The maximum length of a fiber to be counted 30 micrometers.
4. The length to width ratio must be 5 or more to 1, that is, 5 times or more longer than wide.

5. The separate or individual fibers must contain fibrils or the "bundle of sticks" effect, unless they are at a non-divisible stage. A fibril cannot be subdivided and would be counted, if it meets the other criteria. The length to width ratio of 5 or more to 1 is not meant to imply that other particles are not hazardous.

The analysis proceeds by mounting the sample in successive Cargille liquids with identification of each mineral showing visible  $\lambda_0$  colors in each liquid. The first liquid is  $n_D = 1.550$

#### Cargille high dispersion liquid $n_D^{25} = 1.550$

A representative sample, about 0.1 mg, mounted in this liquid will show characteristic  $\lambda_0$  colors for any of the following: talc, quartz, chrysotile, lizardite, antigorite and many fibers (paper, silk, viscose rayon and human hair etc.). The crystallographic data in Figure 2 should ensure identification of most of these substances or allow the conclusion that any other substance showing colors in this liquid is not one of those listed (Figure 3). Characterization of this extraneous substance will often be possible by referring to the Particle Atlas.

#### Cargille high dispersion liquid $n_D^{25} = 1.605$

Chrysotile and all other substances giving dispersion staining colors in liquid 1.550 will be white or pale blue in 1.605 (Figure 4). Talc is the only substance in this group that shows a  $\lambda_0$  close to the visible (ca 700 nm). All talc plates show both  $n$ 's ( $\beta$  &  $\gamma$ ) close to 1.605 in the red hence the central stop shows a pale blue in all directions lying in the talc plate and white corresponding to the  $\epsilon$  direction. Other minerals showing colors in  $n_D = 1.605$  include tremolite, chlorite and actinolite (Figure 5).

#### Cargille Liquid $n_D = 1.660$ (RF series)

Non-talc minerals showing dispersion staining colors in  $n_D = 1.660$  include actinolite, forsterite, hornblende, calcite, cummingtonite and dolomite (Figure 6).

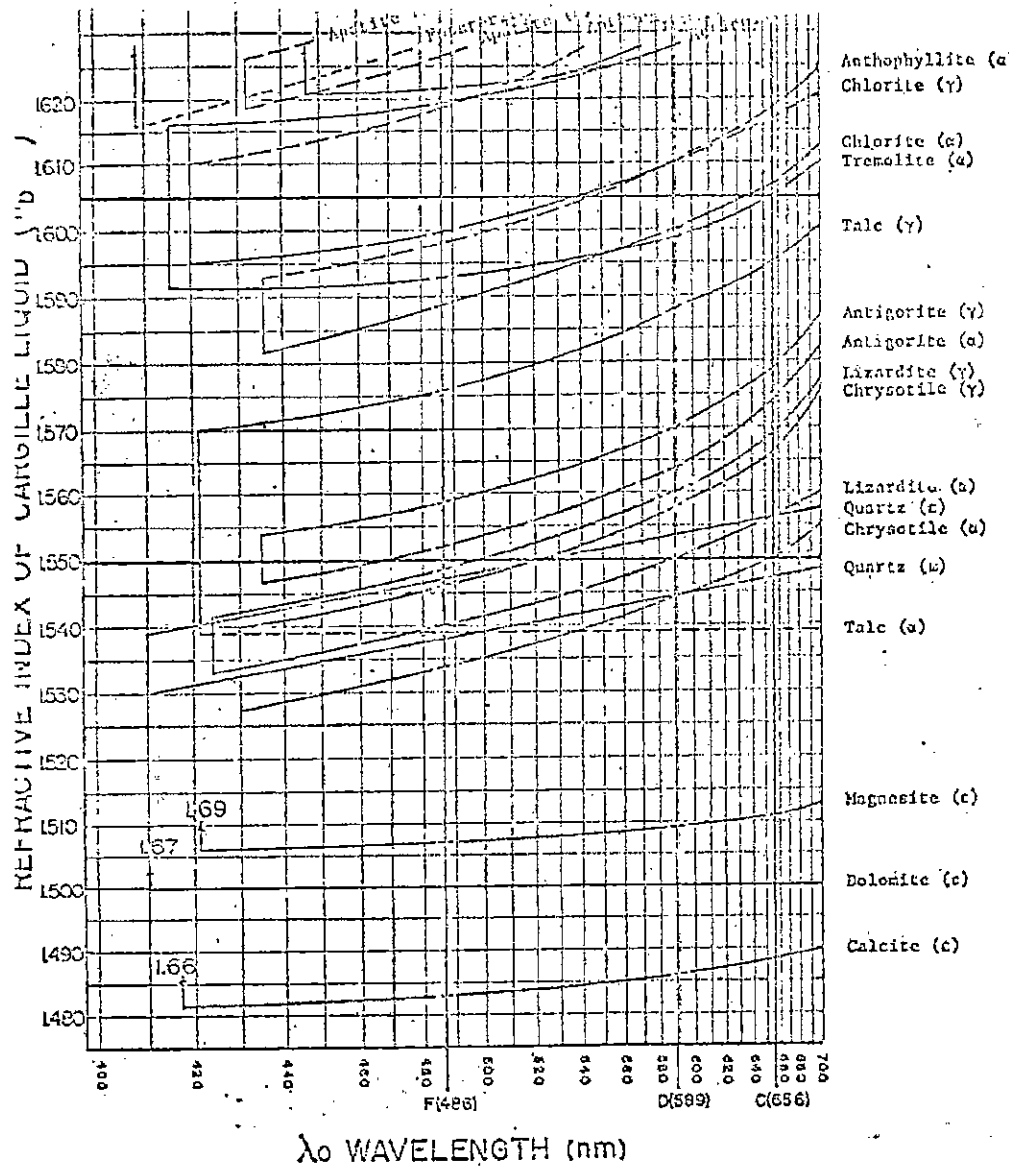


Figure 2a. Dispersion staining curves.

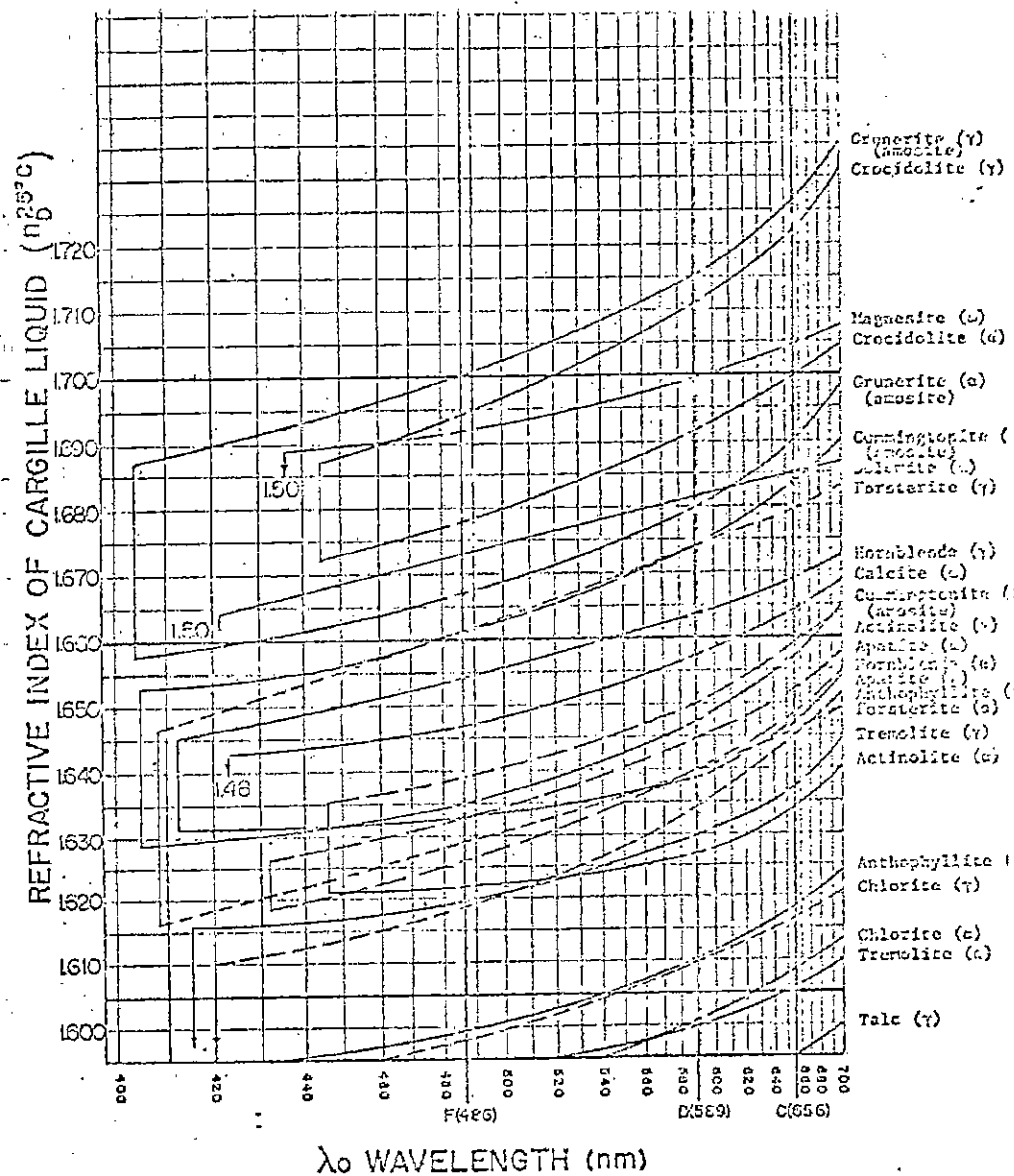
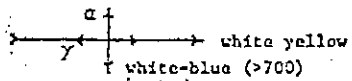
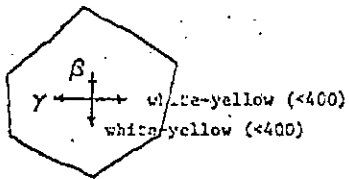
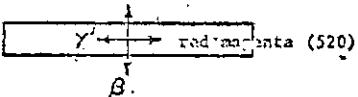
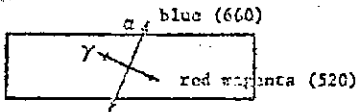


Figure 2b. Dispersion staining curves.

Talc:

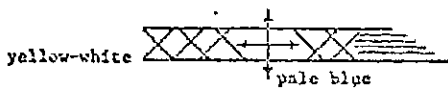


Chrysotile:



Paper fibers:

irregular rounded fibers



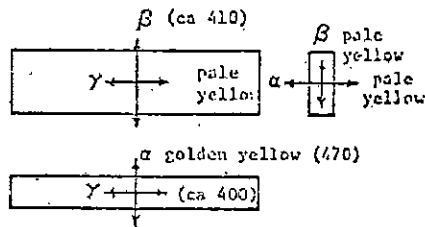
Quartz:

conchoidal flakes, all show  $\lambda_0$  ca 680 nm corresponding to  $w$  on rotation of the stage;  $90^\circ$  from the  $w$  orientation either  $c$  ( $\lambda_0 = 590$  nm) or any  $c'$  ( $590 < \lambda_0 < 680$ ).

Lizardite:

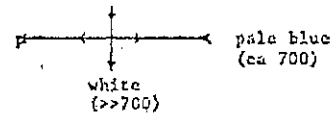
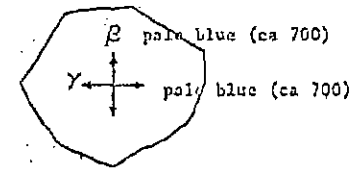
Aggregates of very fine plates,  $n$ 's slight  $>$  chrysotile,  $\beta$  &  $\gamma$  in plane of plates  $\lambda_0 \sim 600$  nm (blue magenta).

Antigorite:

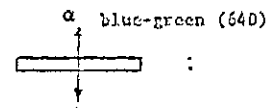
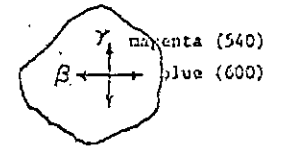


Cargille Liquid  $n_D = 1.605$ :

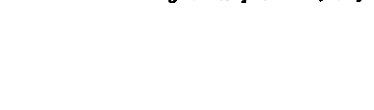
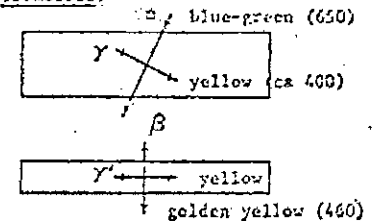
Talc:



Chlorite:



Tremolite:



Actinolite:

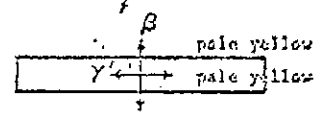
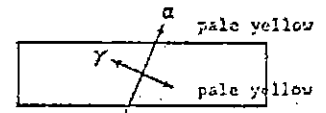
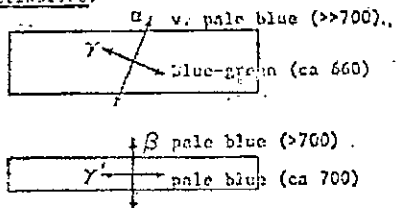


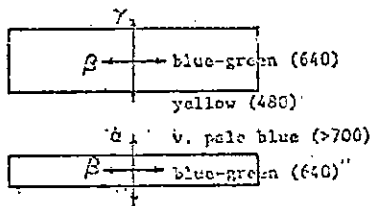
Figure 4. Central stop dispersion staining colors in Cargille liquid  $n_D = 1.605$  (HD series).

Figure 3. Central stop dispersion staining colors in  $n_D = 1.550$  (HD).

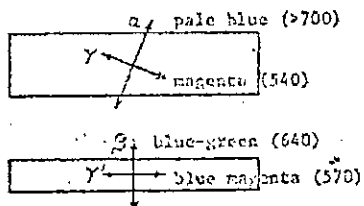
Actinolite:



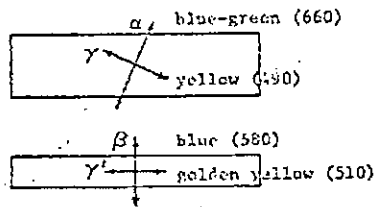
Forsterite:



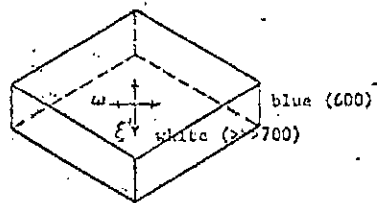
Hornblende:



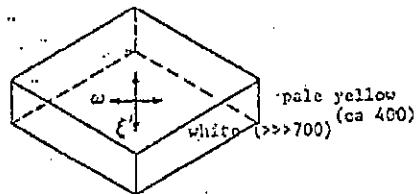
Cumingtonite:



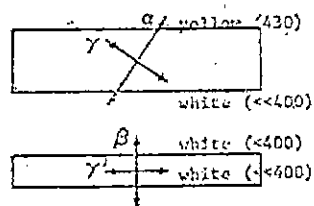
Calcite:



Dolomite:



Grunerite:



Apatite:

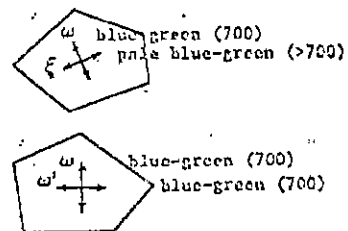
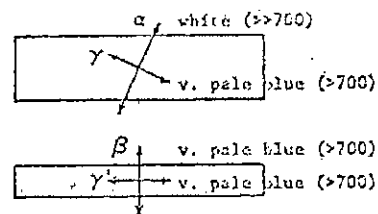
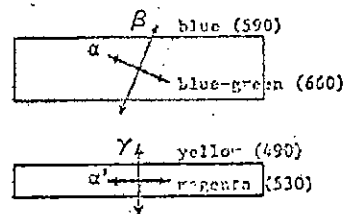


Figure 5. Central stop dispersion staining colors in Cargille liquid  $n_D$  1.660 (RF series).

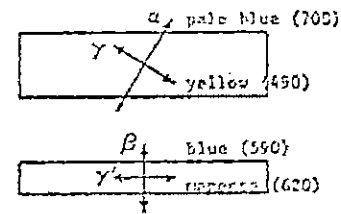
Cumingtonite:



Crocidolite:



Grunerite:



Magnesite:

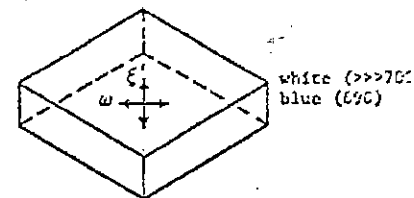


Figure 6. Central stop dispersion staining colors in Cargille liquid  $n_D$  = 1.700 (H-series).

Caselle Liquid  $n_D = 1.700$  (N series)

Minerals to look for in  $n_D = 1.700$  include cummingtonite, grunerite, crocidolite and magnesite.

Report results as "Asbestiform Amphibole Present" or as "Asbestiform Amphibole Absent."

It is imperative that both dispersion-staining color and fibrous morphology criteria be satisfied before identifying a particle as asbestiform amphibole, since other substances may show colors similar to those described.

#### Notes

1. Talcs to be analyzed and the standard minerals used to prepare standard samples must be -325 mesh (maximum particle size of 44 micrometers). Tekmar Analytical Mill (Model A-10) is recommended. It is available from:

Tekmar Company  
P. O. Box 37202  
Cincinnati, OH 45222

2. It is important that the homogeneity of the prepared talc-tremolite standard samples be verified by optical microscopy.
3. This requirement is critical since excessive surface scatter will cause abnormally high background counts.
4. The only commercially available dispersion staining device is sold by:

Walter C. McCrone Associates, Inc.  
2820 South Michigan Avenue  
Chicago, IL 60616

5. Available from:

R. P. Cargille Laboratories, Inc.  
Cedar Grove, NJ 07009

or from laboratory suppliers

#### References

1. Rohl, A. N., A. M. Langer, Environmental Health Perspectives 9, 95 (1974).
2. Rubin, I. B., X. J. Maggiore, Environmental Health Perspectives 9, 81 (1974).
3. L. S. Birks, X-Ray Spectrochemical Analysis, pages 5455, Interscience Publishers (1959).
4. "Tremolite and Talc." U.S. Department of Labor, Occupational Safety and Health Administration, Field Information Memorandum #74-92, November 21, 1974.
5. McCrone, W. C. and J. D. Dally, Particle Atlas, 2nd Edition, Ann Arbor Science Publishers, Inc. (1973).