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Cargille

IMMERSION OIL and the MICROSCOPE

by John J. Cargille, president
R. P. Cargille Laboratories, Inc.

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- For Technical Data on Cargille Immersion Oils please see page 8.
- Additional copies of this technical reprint are available for technicians' review or training, and for use by schools. Send request to:

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Introduction

Since the microscopist's major field of interest is the application of microscopes and related equipment, the fields in which the instruments are used are, in a sense, secondary. However, many scientists, having selected a field, find the use of the microscope a necessity but secondary to their major field of interest, therefore, the microscope is thrust upon them as an essential tool. Often, basic background necessary for proper use of the "tool" is lacking or inadequate, having been picked up on the job so they can "get by."

Considering the number of microscopes being used in all types of laboratories and the number of scientists and technicians using these instruments, from reports and requests we gather that they have learned to use them in what might be referred to as "on the job" training to the "get by" level of proficiency.

This paper will attempt to broaden the understanding of the "business area" of the microscope, between the condenser and the objective, as it is affected by the use of oil immersion objectives, and also expand on properties of immersion oils and how they can be more fully utilized.

The Function of Immersion Oil

Immersion Oil contributes to two characteristics of the image viewed through the microscope: finer resolution and brightness. These characteristics are most critical under high magnifications; so it is only the higher power, short focus, objectives that are designed for oil immersion.

Oil immersion objectives are generally available from 40 to 120x. These must not be confused with "high dry" objectives or water immersion objectives that are also made in this range. Just as an "oil" immersion objective must be used with oil to get a usable image, a "water" immersion objective must be used with water and a "dry" must be used dry. The use of oil on a high dry will destroy the image by negating corrections for spherical and chromatic aberration.

For any given lens there is a fixed focal length. With the objective in focus there is a cone of light extending from a point on the specimen to the full diameter of the objective lens. The angle formed by this cone is the *angular aperture* (A.A.), shown diagrammatically in Figure 1. It may vary from 10° for low power dry (long focus), to 140° for high power oil (short focus). The greatest theoretical angular aperture is, of course, 180° with zero focal length.

Below the specimen is a second, matching, cone of light, the base of the cone being the top surface of the condenser and the apex at a point on the specimen. Theoretical illumination, then, provides a straight line path for each ray from condenser to objective lens.

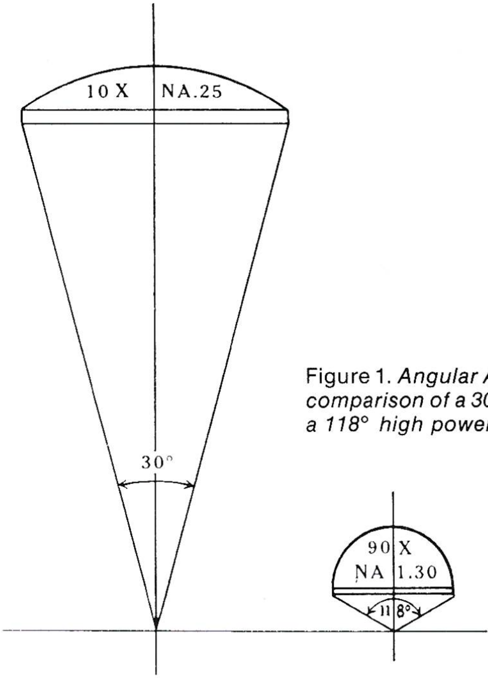


Figure 1. *Angular Aperture. Schematic shows comparison of a 30° low power objective with a 118° high power immersion objective.*

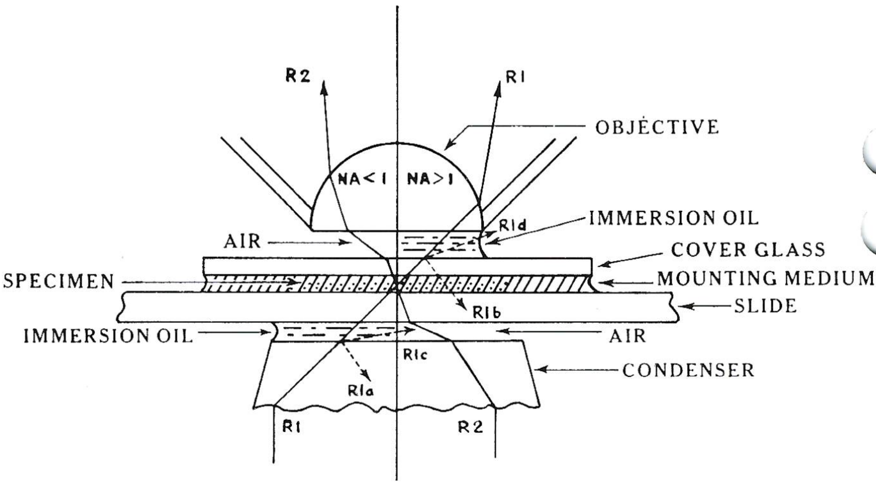


Figure 2. *Ray R1—Straight ray resulting from homogeneous path. (Optics oiled). Ray R2—Deviations in ray caused by air gaps. Notice R1 originates from a more oblique angle than R2 and forms a greater aperture angle at the specimen indicating more light reaches the objective and resolution will be greater. R1a and R1b show where reflection can take place, and R1c and R1d show where refraction can cause light loss, when optics are not oiled. Mounting medium is assumed to be the same index as the slide and the cover glass.*

This straight line path is disturbed by any material of different refractive index. Ideally, Fig. 2, progressing upward from the condenser there is air (index .00), slide (1.515), mounting media, cover glass (1.515), air, and finally the objective. Since most condensers and objective lenses are 1.515, a homogenous ath is obtained by filling the air gaps with an immersion oil (1.515) and using a mounting media (1.515). Mounting media other than 1.515 have advantages and disadvantages but are not a part of this discussion.

The resolution obtained is directly related to the angular aperture, the larger A.A. having a wider cone with more oblique rays. However, unless there is a homogenous optical path, the most oblique rays are lost by internal reflection within the slide or cover glass.

The oil immersion objective of medium angular aperture has more resolving power than a "dry" with larger angular aperture and the term, proposed by Ernst Abbe, "numerical aperture," (N.A.) must be considered. N.A. is equal to $n \times sin\ \frac{1}{2}$ A.A. where n is the lowest refractive index in the path. Therefore, the air gap between cover glass and objective gives a theoretical maximum N.A. of 1.00; water 1.33; immersion oil 1.515. Since other limitations permit only a practical N.A. of 1.40 with lens glass 1.515, the use of immersion oil permits full use of the resolving power of the objective. And, for a given angular aperture, immersion oil objectives increase the resolving power by approximately 50% over dry objectives of equivalent focal length.

Just as immersion oil permits utilizing the full N.A. (resolving power) of the objective, it is also a necessity for obtaining the maximum N.A. of the condenser. With a condenser N.A. 1.40 and an air gap between the condenser and the bottom of the slide, the limiting value is N.A. 1.00. The additional light being lost by internal reflection within the condenser.

Whereas an objective must be used "dry" or "oiled," depending on design, condenser will work oiled or dry, but will be limited to a working value. Full resolution of a condenser, N.A. 1.25, can be obtained by "oiling" with water (1.33), or immersion oil (1.515). A condenser of N.A. 1.40 must have a media of 1.40 or greater, such as immersion oil 1.515, to utilize its designed N.A.

The third consideration is the mounting media itself. An "air mounted" specimen can receive a light cone of 1.0 N.A. The excess of light is lost by total reflection at the top surface of the slide. So there is a second limiting or working N.A. value to be considered in determining the usable N.A. of the condenser.

The resolving power of an optical system is computed by averaging the N.A. value of the objective and the working N.A. of the condenser. The objective, as mentioned, must be used as designed, dry, watered or oiled. The condenser working N.A. is only equal to the designed N.A. when it is oiled to the slide, and a mounting media is used having an index greater than the condenser N.A.

Ideal Properties of Immersion Oil

Immersion Oil contributes to the homogenous path of light between the condenser and objective by having the same index as the glasses in the system.

But white light is, of course, composed of many wavelengths and immersion oil is only made to one, generally the D line, 5893 Å which is the mean for the two sodium lines at 5890 Å and 5896 Å. This value for sodium (D line) is used as a general reference point because it is the brightest line central to the visible spectrum, and is near its optical center (5500 Å).

For the refractive index of all wavelengths in the visible spectrum to match the glass, the dispersion value of the oil must match the glass. Dispersion is generally indicated by $n_F - n_C$, or Abbe ν which is computed from the expression:

$$\frac{n_D - 1}{n_F - n_C}.$$

The major formulating problem is not so much matching index for the D line, since a number of materials can be formulated to accomplish this, but finding materials with suitable dispersion values. To the knowledge of the author, no immersion oil matches the glass perfectly. One of the closest matches (and it breaks my heart to say this), is thickened cedarwood oil which, for many years was the most widely used, if not the only immersion oil available. The disadvantageous properties of cedarwood oil are: absorption because of color and color development, volatile content that permits hardening on lenses, acidity and changing viscosity (diluting with solvent changes the index and dispersion).

The synthetic immersion oils eliminate many of the disadvantages cited above and do satisfactorily approximate the dispersion. Being stable materials, they do offer consistency in their properties. (Cargille oils have been checked periodically for over 20 years by the Bureau of Standards. Variations in index reported were found to be within the range of error reported by the Bureau for the method used in making readings.)

Temperature is a factor often overlooked as it applies to immersion oil. Both solids and liquids change index in an inverse ratio to the change in temperature. The temperature for which the oil is adjusted is normally stated on the bottle. Since a difference of 1°C in room temperature from the stated value causes a change in index of the oil of approximately 0.0004, summer weather or overheated rooms can affect the index match considerably. The temperature coefficients are usually stated in data sheets or available from the manufacturer. Most manufacturers of microscopes use oil standardized for 25°C (77°F). Some use 20°C and oils have been made for 18°C and also 35°C for special applications.

The selection of this temperature is a choice of the manufacturer. Usually he tries to approximate the stage temperature condition under which most instruments are used. The 25°C value is higher than the ideal room temperature of 72°F (22.2°C) and allows for some increase in temperature for radiant heat from the microscope lamp and other sources. Often the simplest method of adjusting this temperature is increasing the room temperature slightly. The increase can usually be made easier than cooling a room.

When working at wavelengths other than D line, i.e. Green line (5460 Å), Blue line (4358 A), or in the near ultra-violet, the index can be brought to coincide with the glass by changing the temperature. This change required can be approximated from dispersion values and the temperature coefficients.

It must be remembered that both the glass and the oil change index with temperature. However, the change in solids is generally so insignificant that it can be ignored.

Color is, of course, a consideration in formulating immersion oil because its presence denotes a loss of light through absorption. Just how critical color may be is an open question. That it is undesirable is accepted but the presence of some color, if it cannot be avoided, may be more than offset by having other desirable specifications.

The greatest problem created by color might be its creation of an absorption band at the wavelength of the monochromatic illumination being used.

The acid value of immersion oil should be very low. The synthetics usually have acid values lower than cedarwood oil. High acidity can, in time, affect the condition of the metal parts of the objective, and possibly more important, can cause deterioration of lens cements. The lens cement is also a seal that prevents oil from penetrating to the back of the lens. A crack or perforation in the cement draws oil by capillary attraction and a thin film of oil slowly creeps over the back of the objective lens; a poor image may develop without being immediately noticed. When the microscopist realizes the image has deteriorated, he may not realize the cause unless he has faced this problem before.

The defect in the lens cement should be repaired promptly by the manufacturer or a qualified repair service or the instrument will be used with inferior images and, when the oil spreads to cause an unusable image, time will be lost by successive cleanings. The cleaning of the back lens is awkward because of its relatively inaccessible position and the location of diaphragms which hinder access.

We have found that the manufacturers have placed objectives in an immersion oil and let it soak for 6 to 12 months before approving an oil for use with their instruments. The purpose is to be sure that the acidic, solvency, or any other properties will not injure their equipment in any way.

As each oil objective is made, it must be tested to insure the lens cement seals against entry of oil to the back of the lens. Immersion oil is used by some microscope manufacturers in this test work.

The synthetic oils should contain no volatiles, and be formulated from stable materials unaffected by oxidation, photo degradation or other forms of decomposition that might slowly change their properties. This stability means that the microscopist knows the material he is using and can rely on it having the same properties as when purchased initially. The stability is such that generally the quality control of the manufacturer has far more effect on the product than any shift in properties caused by age or exposure.

As pointed out earlier, the difference between the specification temperature and stage temperature causes changes in the optical properties. The deviations due to temperature can exceed by far any differences between batches of oil from the same manufacturer.

Any oil used with near ultra-violet should not fluoresce. The synthetic oils of different manufacturers have differing viscosities and, if a generalization can be made, fluorescence will increase with viscosity as the high viscosity compounds with medium or high index have a higher degree of fluorescence.

Though generally known and understood, it should be pointed out that the resolution of an optical system increases as the wavelength of the illumination decreases. Therefore, microscopists tend to shift from white mean 5500 Å to green (5460 Å), to blue (4358 Å) or to near ultra-violet light sources and, thereby, increase resolution. The next step is to ultra-violet (2750 Å) illumination.

Standard optics can be used in the near ultra-violet but a number of special optics are made, the finest of which are quartz which is a requirement for ultra violet. Work in the ultra violet and the use of quartz optics requires a good deal of experience to gain the best work the equipment is capable of producing.

The near ultra-violet and ultra-violet ranges fall into the category of fluorescent microscopy. Immersion oils for use in these wavelength ranges must have extremely low or no fluorescence. Any fluorescence only serves to "haze" the field and makes images indistinct. Sandalwood oil and several synthetic oils classified as "non-fluorescent" are made by fluorescent microscopy equipment manufacturers or have been approved by them for use with their equipment.

Quartz optics are generally immersed with a glycerine and water mixture, or to prevent evaporation, a solution of glycerine and sugar.

Viscosity of immersion oil is mostly a matter of choice of microscopists as long as other properties are not important to the particular application. Low viscosity oils are more likely to creep if applied over-abundantly. The low viscosity is preferred by some when the distance from the cover glass to the objective is very small.

Higher viscosities, (approximately 1250 centistokes), have been found to be the most in demand and are supplied by more microscope manufacturers than any other. The higher viscosity oils fill the larger gaps more satisfactorily and are also reusable in that a second slide can be positioned and swung into place and contact made with the oil drop remaining on the objective lens. The 1250 cs viscosity gives more latitude with oiled condensers since it will fill a larger gap without "beaking" and making reoiling unnecessary.

"Very high viscosity" (120,000 cs) oils are particularly useful for wide condenser gaps, long focus (low power) oil immersion objectives, horizontal or sharply inclined instruments and some micro projectors. If the manufactured viscosity is not the most suitable, blends can be made. If a blend is desirable, an immersion oil manufacturer may mix a small special lot when the material is ordered as a percentage of different types of his regular line.

Application and Packaging

Immersion oil bottles having good weight, stability, an applicator and a glass drop-on cover are available from some scientific supply houses. These bottles can be filled from stock bottles in which the oil is purchased.

Microscope manufacturers use several types of packaging for the small oil bottle shipped as an accessory. The glass bottle with screw well-cap and glass applicator rod predominates. Polyethylene squeeze bottles or tubes are also supplied.

Plastic squeeze packages avoid breakage and mess if knocked over or dropped. The weight of the glass containers tend to make them more stable. The squeeze type are generally a little more awkward to point in over a positioned slide and an over-squeeze can put too much oil on the slide, but the orifices are generally small enough so this is not too likely to happen.

The applicator rods with a taper-point or ball-end are easily inserted to the positioned slide. The rods also have the advantage of measuring the drop by "tipping-off" inside the neck of the immersion oil bottle to get the drop size experience indicates is right. Tipping-off inside the neck prevents creep outside and down the bottle with resulting oil-soiled label and fingers.

Manufacturers generally package in small applicator bottles, and stock bottles from which the applicator bottles can be refilled. The stock bottle reduces the cost of oil, but the refilling must be done.

Applying Immersion Oil

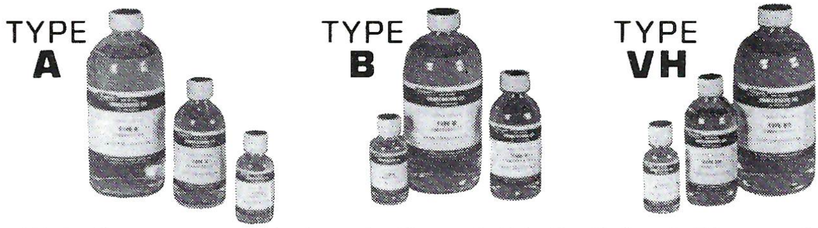
Entraining air in the oil when applying it to the microscope must be avoided. The bubbles, acting as lenses, destroy the image or reduce its clarity. The problem is usually avoided if the drop is touched to the condenser or slide and permitted to flow from the applicator. Dabbing increases the likelihood of bubbles.

The condenser should be oiled in a low position and, after positioning the slide, raised slowly to make contact. Oiling the objective is done by putting the drop on the slide and slowly lowering the objective into it, or with a parfocaled turret, slowly rotating the oil objective into the drop of oil. Once the optics are oiled and slides are changed, there may be enough oil on the objective to avoid reoiling and possibly over-oiling.

Drying types, such as cedarwood or other natural oils, should be removed immediately after use. If these oils harden they are difficult to remove and lenses can be damaged. The non-drying synthetics can be left on lenses indefinitely since damage through hardening cannot occur; however, being oily, they will attract and hold dust. The time-honored solvent is, of course, Xylol. A small amount on lens tissue for a final wipe leaves optics in good order.

Cargille

NON-DRYING, PCB-FREE IMMERSION OILS* FOR MICROSCOPY



In 1940, Cargille synthetic, non-drying Immersion Oils were first introduced to the scientific community. This innovative development was inspired by the need for improved properties and characteristics over cedarwood oil. Since then, Cargille Immersion Oils have been serving microscopists in many disciplines and widely accepted throughout the world.

CARGILLE REMOVES PCB FROM IMMERSION OIL

In 1972, R.P. Cargille Laboratories, Inc. responded to another need having considerable importance and world-wide implications. The long-term effect of voluminous usage of polychlorinated biphenyl (PCB) compounds became evident from environmental pollution and health studies. Despite the comparatively limited consumption of PCB formulations in microscopy, increasing concern prompted the development of the first Cargille PCB-Free synthetic Immersion Oils.

CARGILLE IMMERSION OILS CONFORM TO DIN 58 884 SPECIFICATIONS

R.P. Cargille Laboratories, Inc. was also instrumental in unifying European and American microscope manufacturers specifications for an internationally acceptable immersion oil standardization temperature. Concurring with both European and American microscope manufacturers, Cargille Immersion Oils are now internationally standardized at 23°C, conform to the Deutsch Industries Norm DIN 58 884 specifications and provide a temperature standard and tolerances more realistic to actual laboratory conditions.

CARGILLE IMMERSION OILS ARE LABORATORY AND FIELD TESTED

Prior to commercial introduction, the new Cargille PCB-Free Immersion Oil formulations were subjected to extensive laboratory tests. A comprehensive field-testing program extending over a two year term was also instituted. Samples were issued to key microscopists and microscope manufacturers throughout the world for further testing, evaluation and approval. And now, Cargille PCB-Free Immersion Oils are available to all microscopists and firms equally concerned with the polychlorinated biphenyl problem.

CARGILLE CODE 1248 IMMERSION OILS*

The present PCB-Free Immersion Oil formulations are designated as Code 1248 and are available in three viscosities: low (Type A), high (Type B) and very high (Type VH). They are formulated from synthetic hydrocarbons and natural petroleum derivatives and contain no solvents, rosins or hardening constituents. The Code 1248 PCB-Free Immersion Oils provide all of the necessary properties and characteristics for diversified microscopy applications. They are stable, chemically inert, non-drying, non-hardening, clear, odorless, low fluorescent, safe-for-lens, safe-to-handle, easily removable and miscible for intermediate viscosities. Complete technical data is furnished on page 3.

Type A, Cat. #16482 • Lowest viscosity. Low fluorescence - for short focus objectives. Does not easily entrain air.

Type B, Cat. #16484 • High viscosity. Generally accepted for medical work. Supplied by Bausch & Lomb as a standard accessory.

Type VH, Cat. #16486 • Very high viscosity. Especially applicable for inverted, horizontal and inclined instruments, very long focus objectives and wide condenser gaps. Originally developed for the Department of Health, Education and Welfare for tissue culture examination with inverted microscopes.

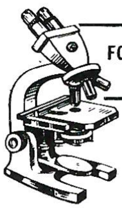
FLUORESCENCE

The low fluorescent property of Cargille PCB-Free Immersion Oils warrants special discussion based on field-testing reports. This formulation has been approved by prominent microscopists and instrument manufacturers for most optical and fluorescence investigations. Reportedly, the fluorescence quality of Code 1248 Immersion Oils is different from the old Regular Types. This has generated an unresolved difference in opinion concerning their suitability for fluorescent applications. It is contended, however, that this fluorescence quality will vary with the type of equipment, technique and application.

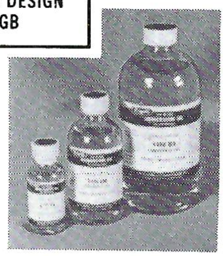
TYPE LF, A VERY, VERY LOW FLUORESCENT IMMERSION OIL

In some instances, there may be a preference for Type LF Immersion Oil, which has a very, very low fluorescence as compared to cedarwood oil. Type LF, formerly the old Regular Type A, contains 34% polychlorinated biphenyls. Because of unknown health effects from PCBs, contact with Type LF should be avoided. The "Type" designation was intentionally changed from "A" to "LF" to: avoid routine ordering for investigations not requiring a very, very low fluorescent immersion oil; and, to conserve non-replaceable raw materials, reserving them for fluorescent applications only.

Type LF, Cat. #16161 • Lowest viscosity. Very, very low fluorescence. Previously designated as Regular Type A. Supplied by American Optical as a standard accessory.



FOR IMMERSION OILS MEETING BRITISH MICROSCOPE DESIGN SPECIFICATIONS OF 1.524, SEE DATA SHEET 10-GB



SPECIAL APPLICATIONS OF CARGILLE IMMERSION OIL

The stability of the optical and physical properties of Cargille Oils have led to uses other than the oiling of immersion lenses. Some of these are:

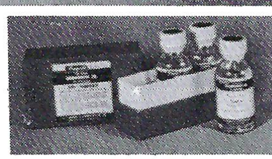
1. **TEMPORARY MOUNTING MEDIA** (index 1.5150).
2. **FLUID MOUNTING MEDIA.** Particularly Type **VH** (Very high viscosity) which is lighter in color than a number of other media, and is stable. Permits rotation of mounted crystals and microfossils by slight shifting of the cover glass.
3. **CALIBRATION LIQUID.** The index of Cargille Immersion Oils is adjusted to 1.5150 with a tolerance of ±0.0002, making a reliable standard for calibration of many pieces of optical equipment.
4. **OPTICAL COUPLING AGENT.** Type **VH**, again because of its high viscosity, has been used both as a sealant and a coupling fluid, being applied between two optical elements.
5. **PROTECTIVE COATINGS AND EXAMINATION FLUID.** Type **A** has been used by electronics companies for protection against atmospheric degeneration of cathode emission coatings. The low neutralization equivalents, stability, and the fact that it can be easily stripped with organic solvents made it suitable for this purpose. Since the coating crystals were approximately 1.515, and decomposition residues had a different index, the Type **A** oil also served as an examination fluid, making the residues identifiable because of the index difference. The oil, serving both as a protective fluid and an examination fluid, made stripping and reimmersing for examination unnecessary.
6. **TRANSPARENCY MEDIUM.** Transparent materials and those with etched, ground, or translucent surfaces become transparent when immersed in an oil of the same index. Since many glasses, plastics and fibers are approximately 1.5150, immersion oil has proven an excellent transparency medium for many materials. Type **B** is recommended by the Millipore Filter Corp. for use on their filters for transmitted light microscopy methods — with or without oil immersion objective lenses.
7. Cargille Immersion Oil is used by some major microscope manufacturers to test immersion objective lens mountings for oil leakage.

PROPERTIES AND CHARACTERISTICS OF CARGILLE IMMERSION OILS

Continuing to supply the most often requested properties as well as those related to hazzard appraisal and transport, the following table lists the characteristics of Cargille Immersion Oils. Should any additional data be required, please contact our technical staff; inquiries and suggestions for new applications and expansion of properties listed will always be considered.

	Type A Cat. No. 16482	Type B Cat. No. 16484	Type VH Cat. No. 16486	Type LF Cat. No. 16161
Refractive Index @ 23°C:				
F line (4861 Å)	1.5236	1.5236	1.5227	1.5238
e line (5461 Å)	1.5180	1.5180	1.5176	1.5180
D line (5893 Å)	1.5150	1.5150	1.5150	1.5150
C line (6563 Å)	1.5115	1.5115	1.5115	1.5116
Dispersion:				
$n_F - n_C$	0.0122	0.0122	0.0109	0.0122
Abbe V	42.6	42.6	47.2	42.2
Temperature Coefficients: $\left(-\frac{dn}{dt}\right)$ 15-35°C	0.00033	0.00031	0.00031	0.00036
Stability (dn_D 25°C after 24 hrs. at temp.)				
60°C	0	0	0	0
100°C	0	0	0	+0.0002
Fluorescence [1] (Ultra-Violet) Short Wave	Low	Low	Low	Very, Very Low
Long Wave	Low	Low	Low	Very Low
Color (Gardener)	1	1	1	< 1
Viscosity (23°C)	150 cs (Low)	1250 cs (High)	120,000 cs (Very High)	150 cs (Low)
Density @ 20°C:				
gm/ml	0.920	0.922	0.911	1.03
lb/gal (U.S.)	7.60	7.62	7.52	8.59
Cloud Point	0°C	0°C	0°C	0°C
Flash Point (Cleveland Open Cup)	325°F	325°F	325°F	410°F
Neutralization Equiv. (mg KOH)	0.01 Max.	0.01 Max.	0.01 Max.	0.01 Max.

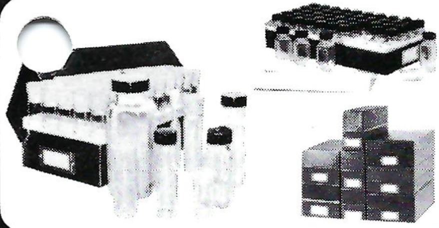
[1] Relative to Cedarwood Oil



Cargille Immersion Oils are available in 1, 4 and 16 fl. oz. quantities. Combination Packets containing Types **A** and **B** and Tri-Packets containing Types **A, B** and **VH** all in refillable 1 oz. bottles with glass applicator rods provide a convenient means for experimenting with different types.

Cargille MICROSCOPE ACCESSORIES

For The Novice And Experienced Microscopist



SAMPLE STORAGE SETS

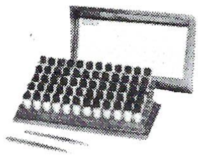
Catalog, index and store liquid, powdered and solid samples in labeled glass vials. Vials store in alpha-numerically indexed compartments for rapid sample location and retrieval. Strong fibre board boxes have abrasion and moisture resistant dark green covering and suitable for deep-freeze sample storage. Over 25 different models. Sets supplied with vials, gummed labels, closures, reference chart for recording pertinent sample information, and exterior identification card. Also available without glass vials and closures with many other special sample storage boxes. Fully illustrated in Data Sheet SS.

PCB-FREE IMMERSION OILS

Synthetic, non-drying immersion oil formulation, free of polychlorinated biphenyl (PCB), is available in three different viscosities: 150 cs (Type A), 1250 (Type B), and 120,000 cs (Type VA). These PCB-Free Immersion Oils conform to the Deutsch Industries Norm DIN 58 884 Specifications and are standardized at 23°C. Oils contain no solvents, rosins or hardening constituents. They are stable, chemically inert, non-drying, non-hardening, clear, odorless, low fluorescent, safe-for-lens, safe-to-handle, easily removable and miscible for intermediate viscosities.

REAGENTS FOR CHEMICAL MICROSCOPY

A unique assemblage of 120 reagents and standard materials for classical chemical microscopy tests. Two sets: each consisting of 60 different materials organized as originally proposed by E. M. Chamot and C. W. Mason in their "Handbook of Chemical Microscopy". The Sets correspond to Volumes 1 and 2. Complete listing of materials in Data Sheet RCM.



MICRO SLIDE FILES

Partitioned, hinged-lid fibre board boxes for cataloging and storing microscope slides. Accommodates up to 480 3"x1" or 240 3"x2" slides. Numerically indexed lid chart for recording pertinent specimen information and locating slides. Exterior identification card describes general contents. Compact for shelf, drawer, cabinet or stacked storage. Fully described in Data Sheet MSF.

INDEX OF REFRACTION & IMMERSION LIQUIDS

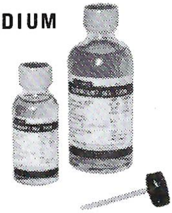
The most comprehensive line available. Over 251 standard liquids from 1.30 to 2.31 in sets or individual bottles, or many special application formulations. Calibration, optical coupling, thixotropic, melts, laser liquids and other refractive index products. Send for Data Sheet IR.

REFERENCE SETS FOR MICROSCOPY

Comminuted optical glass and minerals provide a graded series in increments of 0.01 of solid index of refraction standards from 1.34 to 2.40. Other available series include comminuted minerals for optical microchemical and instrumentation comparisons; comminuted minerals, furs, fibers, starches and condiments mounted on slides. Full particulars in Data Sheet RS and FFF.

MOUNTING MEDIUM

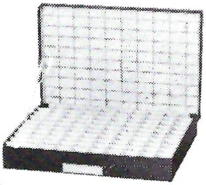
Permanent, inert, synthetic microscopy mounting medium dries hard to a refractive index of 1.65 to 1.66. In liquid form, index is not less than 1.63 and gradually attains maximum value with solvent evaporation. Available in three different viscosities. Send for Carmount 165 Data Sheet.



EPOXY EMBEDDING KITS

Supplied complete with all necessary components and instructions for electron microscopic embedment applications for all five systems in general use. Copies of references, the Cargille (NYSEM) and the four systems described by Luft, Glauert and Glauert, Spurlock et al, and Finck sent free on request with Data Sheet EEK.

TISSUE FILES



Collect, index and store histological sample embedment blocks in partitioned fibre board boxes. Hinged-lid contains chart numerically indexed to compartments for recording sample data; facilitates locating and retrieving stored embedments. Exterior identification card describes general contents. Send for Data Sheet TF.

SEND FOR MICROSCOPIST PACKET 449 WITH DATA SHEETS ON ALL CARGILLE MICROSCOPE ACCESSORIES

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NOTES

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