WORKING WITH CURING OPTICAL GELS

Storage, Surface Preparation, Mixing, Deaeration, Controlling Pot Life, Dispensing, Clean-Up

Nye's Curing Optical Gels are crystal clear encapsulation materials which serve as a "bridge" for light signals by carrying light between different media such as transparent plastic or glass lenses or semiconductor electro-optic components. These products are available in two-part curing systems; the end user must mix the product components in the specified mix ratio and the product will then cure in place (with a cured consistency which can range from that of a stale gelatin to a medium hard rubber). Nye's curing optical gels flow easily into tight spaces and are more elastic than Nye's Non-Curing Optical Gels. Their disadvantage compared to non-curing gels is that they have a limited shelf life (typically, six months) and must be mixed and cured by the user.

Nye's curing optical gels have two main constituents: an optical fluid and thickening agents. Mixing the separate gel components allows the thickening agents to polymerize the fluid molecules, and harden and immobilize the gel. Prior to cure, the thickening agents in the gel are chemically active and hence their behavior can be effected by temperature or contamination with other reactive chemicals. Once fully cured, the reactive feature of the thickening agents is consumed and the gel is mechanically and chemically stable.

Storage Prior to Use

Store the curing gel components upright (dispensing orifice down) at room temperature, 18°C (65°F) to 27°C (80°F). In order to prevent contamination with moisture, solvent fumes, gases, dust, or other materials, do not unseal the product containers or their outer plastic bags until use.

Surface & Mixing Apparatus Preparation

Surfaces which will come in contact with the gel during the actual cure process must be properly cleaned in order to avoid changes in the cure speed or final cured consistency of the gel. This includes not only optical components but also any mixing vessels, beakers, dispensing apparatus, or stirring utensils which come in contact with the gel as it is mixed and dispensed. (Separate mixing containers are not required if the user procures the material in the Nye's "double-barrelled" 50cc static mixing cartridge). Standard laboratory ultrasonic/solvent cleaning/degreasing processes are usually acceptable, although subsequent rinses with water (three separate rinses with clean tap water followed by a final rinse with deionized water) is recommended. If the user's cleaning process is based on aqueous cleaners, the subsequent water rinses are strongly recommended. An alternative manual process using thorough scrubbing with soap and water is acceptable, again followed by water rinses as described above. If deionized water is not available, then filtered distilled water is usually acceptable. When wiping surfaces clean, be sure to use wipes or cloths which will not scratch any sensitive optics.

Metering the Component Ratio

In order to achieve the final cure properties indicated on the product bulletin, it is recommended that the proportions be held to the prescribed 50:50 ratio within +/- 2%. When mixing small quantities, more precise metering of the proportions is usually achieved by measuring out the components by weight, rather than by volume.

Mixing the Two Separate Gel Components

Nye offers a "double-barrelled" 50cc cartridge, used with a hand-operated dispenser and a *static mixer*, which is suitable for prototyping and small volume production, which meters and mixes the separate gel components in the correct 50:50 ratio. In a static mixing arrangement, side-by-side containers of the separate gel components are dispensed at an equal rate into a common outlet pipe which contains a counterwound double helix screw; the screw is static and the mixed components are forced to mix as they travel down the pipe. For large volume users, Nye recommends packaging of the components in separate containers (syringes or cartridges) which are suitable for use in automated static mixing and dispensing equipment. Regardless of the mixing technique used, thorough mixing of the gel components is critical for obtaining repeatable optical and mechanical properties. (When using very small quantities, mixing by hand is often the only practical method. For hand mixing, combine the materials in a properly cleaned beaker and stir steadily with a stainless steel utensil for at least two minutes). There are a number of manufacturers who offer precision automated static mixing equipment. Contact Nye for recommendations on equipment manufacturers.

Deaeration

Nye's optical gel components are thoroughly deaerated prior to shipment from the factory. Further deaeration is unnecessary if static mixing is employed (see *Mixing the Two Separate Gel Components,* above). However, air can be introduced into the uncured fluid components if they are decanted into secondary containers or when they are mixed in a vessel with a free air to fluid interface present; this is especially true during hand-mixing of very small samples. If the decanted or hand-mixed fluid is not deaerated, it may contain air bubbles which will become embedded in the cured gel. Deaeration may be achieved passively, by allowing the mixed fluid to sit undisturbed in a container prior to dispensing into the final cure location. If the fluid height is greater than 0.5 cm, then it is likely that air bubbles will not completely escape prior to final cure; for large fluid volumes, if passive deaeration is required, the fluid components should be cooled prior to and during mixing (pre-cool to 15°C or below). The lower temperature will dramatically increase the pot life of the fluid and allow more time for air bubbles to escape prior to dispensing of the mixed fluid into its final cure location. Deaeration may also be achieved actively, by placing the mixed fluid in a vacuum chamber in a rough vacuum at 150mmHg or better vacuum. It is advisable to visually monitor the fluid as the vacuum is applied so that the outgassing rate does not become so violent as to splatter material from the container. As with the passive deaeration approach, additional pot life for the mixed fluid can be obtained by cooling the fluid components prior to and during deaeration (see *Controlling Cure Rate & Pot Life*, below).

Controlling Cure Rate & Pot Life

Temperature is a convenient means for controlling the cure rate. Nye's standard curing gel products are designed for curing at room ambient temperature of 25°C (77°F). As a rough rule of thumb, a factor of 3 increase in pot life is obtained for a temperature reduction of 10 degrees centigrade from ambient. Conversely, the pot life may be decreased and the cure rate accelerated by a factor of 3 for every 10 degrees centigrade increase in temperature. Since the cure reaction for these gels is exothermic, a large volume of mixed gel will generate significant heat of its own, thereby raising its own bulk temperature and further accelerating the cure process. Similarly, if body heat is applied to a small mixing container (as for example when a small beaker is held by hand and used to mix a small volume of material) the cure rate will be increased at the wall of the container. Nye can engineer special versions of these materials which have slower cure rates (longer pot life) or do not cure at all until their temperature is increased to a particular elevated temperature. Contact Nye for more information on customizing these properties.

Dispensing

If the static mixing approach is used for mixing, the mixed gel fluid can be dispensed directly into the part from the outlet orifice of the static mixer. If hand mixing is used, the uncured fluid can be poured into a dispensing container such as a syringe or small beaker, deaerated (see *Deaeration*, above) and then poured or injected into the final cure location. Dispensing into the final cure location should be done in such a way as to avoid trapping additional air pockets or air bubbles in the fluid. The tip of the dispensing orifice should be positioned beneath the fluid level to avoid drawing air bubbles into the fluid. Dispensing speed is often an issue when filling a large volume through a small orifice (for example, when filling a display from one corner of the display-to-cover glass volume). If the filling process is not completed prior to the onset of cure it may be impossible to overcome the rapidly increasing viscosity of the curing fluid. The solution to this problem is to slow down the cure rate (see *Controlling Cure Rate & Pot Life*, above), and /or to decrease the flow resistance of the injection orifice (by increasing the injection orifice cross sectional area and decreasing the injection orifice length as much as possible).

Pre-Molded Shapes & Mold Release

An alternative to dispensing directly into the device is to pre-fabricate the gel in the correct shape in a mold and then transfer the cured gel from the mold to the final location. This approach is most convenient when the geometry is relatively simple and the desired shape is that of a flat gasket or spacer, but more complex shapes can be molded with proper attention to mold design. When molding a gel, the mold surfaces should be pre-treated with a release agent which will not inadvertently inhibit cure in the bulk fluid volume of the gel. (Nye recommends an inert transparent low surface energy barrier film such as NyeBar-K-0.5% for this purpose.)

Preventing Delamination

Delamination of the gel from the mating optical components in the light path can cause substantial attenuation and reflection of the light signal. The most common cause of delamination of a cured gel from a mating optical surface is surface contamination due to inadequate cleaning (see *Surface & Mixing Apparatus Preparation,* above). Delamination can also occur at the surface of a material which, although cleaned, is chemically active such as internally lubricated plastics, elastomers, sintered metals, or some types of cured adhesives (amine-cured epoxies, and UV cured adhesives are often culprits), or electronegative plastics such as teflon®. Once proper material selection and cleaning is achieved, further improvements in resistance to delamination can be obtained by preparing the surface with a primer. Contact Nye for assistance in selection of an appropriate primer.

Cleaning Used Gel Materials

Uncured gel components can be cleaned off of containers and optics parts using reagent grade mineral spirits, followed by a rinse with reagent grade isopropanol to remove the mineral spirits residue. Cured gel is most effectively removed from parts with acetone, followed by a rinse with isopropanol. (Exposure to acetone can craze or soften some types of optical plastic; if acetone cannot be used, reagent grade mineral spirits is compatible with most plastics and is a good substitute solvent). If solvents are not available, then thorough scrubbing with soap and water will also suffice. When wiping surfaces clean, be sure to use wipes or cloths which will not scratch any sensitive optics. Suitable cleaning materials are available from optical catalogue supply houses such as Edmund Scientific (tel. 800-363-1992, www.edmundoptics.com).

Preventing Fogging of Curing Gels

At the molecular level, Nye's curing gels comprise a three dimensional matrix of molecules with spaces between molecules which are sufficient to allow for flexibility of the gel. This spacing also allows permeation of trace amounts of gaseous water vapor and other gases through physical diffusion. The most common problem associated with this effect is the unintended take-up of small amounts of water vapor when the gel is subjected to high relative humidity at elevated temperatures (e.g. >80%RH at 80°C, > 1 hour). Under these conditions the gel will remain clear while it is held at the high temperature, but once the temperature is reduced back to room temperature, the gel may exhibit a fog or haze appearance. The effect is reversible in that further exposure to low relative humidity will allow the fog to dissipate within a few days at room temperature or within a few hours at elevated temperature. The fogging effect may be prevented altogether by sealing off the source of high relative humidity from the gel by means of low moisture permeability gasketing, humidity barrier paints, hermetic seals, or desiccating media. If a fogging symptom persists it may be due to contamination of the gel fluids prior to cure; the most common source of contamination is small droplets of fluid water or cleaning solvents inadvertently left on the containers used to mix the gel components.

Nye offers the following Curing Optical Gel products

CURING GELS	Index of Refraction	Typical Applications
OCK-433	1.46	telecommunication splices and connectors (Bellcore GR-2919)
OCK-451-LP	1.51	plastic light guides splices & connectors, electro-optic devices, transceivers
OCK-451-LPH	1.51	LCD, plastic light guides splices & connectors, electro-optic devices, transceivers
OCK-419-1	1.55	Encapsulant

Nye also offers material evaluation kits

OPTICAL COUPLING KIT contains:	Index of Refraction
OC-431A-LVP, non-curing gel, 1.5cc syringe	1.46
OCK-451-LP, curing gel, 20cc dual syringe (mix 1:1 by weight)	1.51
OCK-451, pre-cured in sheets, (4 ea., 10mm x 10mm x 1 mm)	1.51
OC-440A, non-curing gel, 1.5cc syringe	1.51
Index of Refraction Chart for optical plastics & glasses	
Assortment of syringe tips	
Technical Data Sheets for all three products	
Material Safety Data Sheets for all three products	
Static Mixers	

TELECOM KIT contains:	Index of Refraction
OC-431A-LVP, non-curing gel, 1.5cc syringe	1.46
OCF-446, optical fluid, 1.5cc syringe	1.46
OCK-433, curing gel, 20cc dual syringe	1.46
OCK-451, pre-cured in sheets, (4 ea., 10mm x 10mm x 1 mm)	1.51
Index of Refraction Chart for optical plastics & glasses	
Assortment of syringe tips	
Technical Data sheets for all three products	
Material Safety Data Sheets for all three products	
Static Mixers	

LED ENCAPSULANT KIT contains:	Index of Refraction
OCK-451-LP, curing gel, 20cc dual syringe	1.51
OCK-451-LPH, curing gel, 20cc dual syringe	1.51
OCK-419-1, curing gel, 20cc dual syringe	1.51
Index of Refraction Chart for optical plastics & glasses	
Technical Data sheets for all three products	
Material Safety Data Sheets for all three products	
Static Mixers	

To Purchase a small quantity of Curing Optical Gel or an Optical Coupling Kit:

Contact Nye's authorized small volume distributor, TAI Lubricants, Monday through Friday 8:00am to 5:00 pm (Eastern Time), at tel. 1-302-326-0200, fax. 1-302-326-0400. MasterCard and VISA accepted.

For More Information:

For a more detailed description of these Optical Coupling Kits, product bulletins, reprints of technical articles, evaluation samples, or questions about any Nye products – or to discuss an optical coupling material custom-designed for your application – call us at (508) 996-6721, visit our website: www.nyeoptical.com, or contact us by email at: techhelp@nyeoptical.com.

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