Synopsis of Adhesive/Resin Composite System Photoinitiators (Project 03-23) (11/03)

Traditionally, adhesive and resin composite systems have contained camphoroquinone (CQ), a visible-light-sensitive diketone photoinitiator responsible for initiating free-radical polymerization. CQ absorbs energy in the visible-light region of 400 to 500 nanometers with a peak at 468 nanometers. Photons associated with this frequency range will be absorbed by camphoroquinone, raising it from the ground state to an excited, but short-lived, activated triplet state. When the excited triplet bumps into an amine co-initiator, an aminoalkyl free radical forms that is capable of initiating polymerization.[1,2] In a few products, new photoinitiators have been introduced by manufacturers to reduce the intensity of the yellow color of the composite resin restorative material typically produced with the addition of camphoroquinone or to prevent the inactivation of the amine co-initiator by acidic monomers contained in some enamel and dentin adhesives. These new photoinitiators absorb light energy in lower regions of the visible-light spectrum.[3] Examples would be phenyl-propanedione (PPD) and Lucirin TPO. Light energy may be provided by four types of curing lights: quartz-tungsten-halogen (QTH), light-emitting diode (LED), plasma-arc (PAC) or argon laser.

The most common dental curing light in use today is the QTH.[4] The relatively broad emission spectrum of QTH curing lights allows them to initiate the polymerization of all known composite resin materials available. The principle output from these lamps is infrared energy with the generation of high heat. Filters are used to reduce the heat energy to the oral structures and provide further restriction of visible light to the narrower spectrum of photoinitiators. Finally, a silver-coated dichroic reflector passes infrared energy out the back and reflects and focuses the light forward to provide a focal area of energy at a defined distance. Ultimately, 99.5% of the original radiation is eliminated. Due to the high operating temperatures, the QTH bulbs have a limited lifetime. The reflector, bulb and filters can break down over time, reducing the curing effectiveness.[5,6] DIS has evaluated many QTH curing lights over the past several years. They continue to provide a reliable and cost-effective method of photopolymerization.

At the same time that new photoinitiators were being introduced in restorative materials, dental product manufacturers began developing new curing lights with light-emitting diodes (LEDs). LED curing lights use special semiconductors for the electroluminescence of light rather than the hot filament found in QTH lights. This provides a longer life span, consistent output and lower power consumption.[7] No significant ultraviolet or infrared light is emitted thereby reducing lateral heat and minimizing the need for a noisy fan. Since the energy is clearly defined by the semiconductor, most of the light emitted is concentrated in a narrow band around 470 nanometers which is ideally suited for composite resins that use the photoinitiator camphoroquinone.[8] However, the emission spectrums from LED curing lights are so narrow, they may not be absorbed by the new photoinitiators. Without proper absorption, free radical polymerization may not occur. The instruction booklet found with photo-initiated dental materials may not always indicate the type of photoinitiator contained in the dental material. Fortunately, there are only a few resin materials that use other photoinitiators. DIS is testing many new LED curing lights and the results will be continually reported. See DIS 68, 69. The newest generation of LED lights have irradiance, degree-of-cure, and government pricing similar to the most popular QTH lights.

Plasma-arc (PAC) lights generate a high-voltage pulse that creates hot plasma between two electrodes in a xenon-filled bulb.[9] The irradiance (up to 2400 mW/cm^2) is much higher than typical QTH or LED lights, but the PAC lights generate very high heat with an inefficient emission spectrum similar to QTH curing lights. Filters limit the emission spectrum to the blue spectrum.[5] Most newer plasma-arc lights have broad spectrums and should be absorbed by all photoinitiators. DIS has reviewed several plasma-arc curing lights. Plasma-arc curing lights are expensive to purchase and maintain with replacement bulbs costing more than 10 times that of a typical QTH bulb. DIS testing found the reduced curing times claimed by the manufacturers may be insufficient to cure all types of composites, especially microfills.

Light emitted from an argon laser is very different from that emitted from QTH or PAC lights. The photons produced are coherent and do not diverge, therefore they concentrate more photons of specific frequency into a tiny area.5 The emission spectrum is very narrow and compatibility problems with some photoinitiators would be anticipated. Argon lasers are extremely expensive and may not be cost-effective for the visible-light curing of resin materials in federal dental clinics.

Information was obtained from manufacurers and compiled in a table making it easier for clinicians to obtain information on what products may not be properly polymerized with a narrow spectrum curing light. Not all manufacturers responded to the survey, however, because the information was considered proprietary. Attachment 1 is a summary of various photoinitiators found in many adhesive and composite formulations. Based on the information gained from the manufacturers, the following products may not be completely polymerized by many narrow-spectrum LED curing lights: Pyramid, neutral and translucent shades (Bisco); Biscover (Bisco); Cabrio (Discus Dental); and Touch and Bond (Parkell). Additionally, Clinical Research Associates recently identified the following products with similar incompatibilities: Panavia F (Kuraray), and Principle (Dentsply Caulk).[10] A new LED curing light was recently introduced (UltraLume 5, Ultradent Products) containing multi-spectrum LED lights that will reportedly cure all current photoinitiated dental materials.[10] However, providers not using broader spectrum curing lights, such as the QTH lights, should confirm the cure of their materials before clinical placement.

References

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Synopsis of Adhesive/Resin Composite System Photoinitiators*

Company	Address	Phone / Fax numbers	Adhesive or Composite	Photo-initiator	Absorption wavelength
Bisco	1100 W Irving Park Rd Schaumburg, IL 60193	(800) 247-3368 (847) 534-6000 (800) 959-9550 FAX www.bisco.com	All Bond 2 One-Step Tyrian/One-Step Renew Aelite LS Aelite Flo Pyramid - Enamel - translucent - neutral Biscover	CQ TPO	400-500 nm 400-420 nm
SDI	729 N Route 83 Suite 315 Bensenville, IL 60106	(800) 228-5166 (630) 238-8300 (630) 238-9200 FAX www.sdi.com.au	PAAMA 2 STAE Glacier Ice Rok Wave	CQ	400–500 nm
Heraeus Kulzer	99 Business Park Dr Armonk, NY 10504	(800) 431-1784 (914) 273-8600 (914) 273-9379 FAX www.Heraeus-Kulzer-US.com	iBond Gluma Comfort Bond Gluma Solid Bond Venus Charisma Durafill VS Flowline Solitare 2	CQ	400-500 nm
Dentsply Caulk	P.O. Box 359 Milford, DE 19963-0359	(800) 532-2855 (302) 422-4511 (800) 788-4110 FAX www.dentsply.com	Prime & Bond NT Xeno III Esthet-X APH TPH / TPH Spectrum Surefil	CQ	400-500 nm
GC America	3737 W. 127th Street Alsip, IL 60803	(800) 323-7063 (708) 597-0900 (708) 371-5103 FAX www.gcamerica.com	Unifil Bond Gradia Direct Unifil Flow	CQ	400-500 nm

*The manufacturers provided information in this table.

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Company	Address	Phone / Fax numbers	Adhesive or Composite	Photo-initiator	Absorption wavelength
Kerr	1717 W. Collins Ave Orange, CA 92867	(800) 537-7123 (714) 516-7400 (714) 516-7633 FAX www.kerrdental.com	Optibond Optibond Solo Herculite Prodigy Prodigy Condensable Point 4	CQ	400-500 nm
3M ESPE	3M Dental Products Division 3M Center, Bldg 275-2SE-03 St. Paul, MN 55144	(800) 237-1650 (612) 733-8524 (800) 888-3132 FAX www.3MESPE.com	Scotchbond MP Single Bond Prompt L-Pop Filtek Supreme Filtek Z250 Filtek Z100 Filtek P60	CQ	400–500 nm
Parkell	155 Schmitt Blvd. P.O. Box 376 Farmingdale, NY 11735	(800) 243-7446 (631) 249-1134 (631) 249-1242 FAX www.parkell.com	Touch & Bond Brush & Bond TotalBond EPIC – A/P EPIC-TMPT	Proprietary	300-430 nm 300-500 nm 380-510 nm 380-510 nm 380-510 nm
J Morita	9 Mason Irvine, CA 92618	(888) 566-7428 (949) 581-9600 (949) 465-1095 FAX www.jmoritausa.com	One Up Bond F Palfique Estelite Palfique Estelite LV	Borate derivative CQ	peak 478 nm peak 470 nm
Discus Dental	8550 Higuera Street Culver City, CA 90232	(800) 422-9448 (310) 845-1537 FAX www.discusdental.com	Cabrio Cabrio CQ Matrixx Microfill Matrixx Hybrid Matrixx Posterior Matrixx Flowable	PPD CQ	peak 410 nm peak 468 nm

*The manufacturers provided information in this table.