Energy dependent polymerization of resin-based composites
Halvorson, R.H.

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Appendix 1

Light Energy Affecting Polymerization

Most studies report conversion of RBC based on the incident irradiance, which frequently is taken to be the output of the light source. Such a relationship is, of course, most useful to a dentist but from the standpoint of understanding the true relationship between light energy and RBC conversion it is important to know the actual energy within the RBC. A number of factors affect the amount of light energy that exists within a sample of RBC, some of these are inherent to the RBC itself and others involve the physical conditions imposed by the operator. A discussion of these factors will be presented below.

Distance of the light-guide from the RBC surface

For most light-sources used to cure RBC, a light guide is used to direct the light to the surface. Often it has been, mistakenly, stated that the irradiance decreases as the distance from the light guide squared, which is the relationship of a point source of light and not a directed source; however the irradiance of the light guide does decrease with distance but not as rapidly as for a point source. The relationship of irradiance with distance was investigated for two light sources, a 3M™ ESPE™ Visilux™ II Curing Light (3M ESPE, St. Paul, MN) with a 7.0 mm diameter light guide and a 3M™ ESPE™ XL3000 Curing Light (3M ESPE, St. Paul, MN) with a 12.0 mm diameter light guide.

The lamps were clamped above a detector (351 Power Meter, UDT Instruments, Baltimore, MD, USA) with a 5mm diameter aperture accepting incident light. The detector was mounted on a sliding support to allow positioning at various distances away from the end of the light guide, remaining centered along the central axis of the light guide. Irradiance measurements were made over a 10mm range of distances, with three replicates of the measurements. Figure 1 shows the dependence of lamp irradiance with distance of separation from the end of the light guide as a percent of the full power at the end of the light guide.

It can be seen that a separation of 4.0mm reduced the surface irradiance
to about 75% of full irradiance (combined average) and at 7.0mm distance, which might be consistent with the gingival floor of a class II restoration, the irradiance is about 55% of full irradiance. Both clinically and in experimental situations it is not always possible to have the light guide immediately adjacent to the surface of RBC being photopolymerized, and so the decrease in actual power density must be considered.

**Reflectance considerations**

Not all the light energy reaching an RBC surface will participate in the polymerization process; there are reflectance losses from the RBC itself and from interposed objects, such as matrix strips. In Figure 2 the transmission relationship with depth are shown for two RBC materials. From the regression equations it can be seen that the surface reflectance (i.e. %T at d=0) ranges from about 27% to 30%.

**Figure 1.** Lamp attenuation as a function of light guide separation.

**Figure 2.** Effect of thickness on light transmission through RBC.
When a clear film is placed on top of an RBC an additional reflectance loss is incurred. Figure 3 shows the transmission curves for an RBC with and without a 25 micron thick polyester film on the surface.

![Figure 3. Effect of polyester film on light attenuation through RBC.](image)

In this particular case the surface reflectance is increased by about 7% when the film is in place. The same film roughened, results in about 17% greater surface reflectance than for no film. The particular film or clear covering object (e.g. glass slide etc.) will result in a varying reflectance but as a general rule, a clear object interposed between the light source and the RBC will cause about 10% reduction in the light reaching the RBC.