PHOTOPOLYMERIZATION. PRINCIPLES OF OPERATION

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Abstract. *Photopolymerization Photopolymerization is the process of converting composite materials from a liquid state to a solid state under the influence of light. This technology is widely used in modern dentistry, especially in fillings, prosthetics, and aesthetic restorations. Photopolymerization is primarily carried out with the help of photoinitiators contained in composite materials.*

Keywords: *Halogen lamps, photoinitiator, light intensity, polymerization process.*

In 1970, lamps operating with ultraviolet (UV) light were invented. In 1977, a halogen lamp emitting visible light was developed. For the past 23 years, halogen lamps have been effectively, affordably, and reliably used to cure composite filling materials by transmitting blue light with a wavelength of 400–500 nm through a light filter.

Halogen lamps emit only 0.7% of useful energy within a short time. The remaining energy disperses into the surrounding environment and heats the tissue, which is why the device needs to be cooled using fans. The light intensity reaches 300 mW/cm².

One of the disadvantages of halogen lamps is that they generate a large amount of heat, which can lead to the heating of hard dental tissues. The lifespan of halogen lamps and their light filters is also limited, so they need to be regularly checked and replaced as needed.

The light output of activated lamps should be checked once a week. Halogen lamps gradually lose their radiation power, so they should be replaced when a decrease in light intensity is detected, even if the bulb has not burned out.

Currently, active efforts are being made to develop more advanced types of photopolymerization devices. In modern dentistry, various types of halogen lamps are available, incorporating the latest technologies in science and engineering.

1.Soft start” lamps
2.Pulsating technique lamps
3.Plasma lamps
4.Laser lamps
5.LED-based lamps

Slowed-down polymerization can also occur under sunlight, electric light, or light from dental equipment. Therefore, the duration of photopolymerization should not be unnecessarily prolonged, and the process should not be observed from a close distance or for an extended time. When working with photopolymer lamps, it is advisable to use protective glasses. These glasses block light with a wavelength longer than 500 nm (typically bluish light).

Additionally, the practitioner should avoid looking directly at the light-emitting tip of the device or the light reflected from the tooth. For patients who are sensitive to light, have had cataract surgery, or are taking photosensitizing medications, light-cured filling materials should not be used.

The light-curing handpiece must be handled with care. It should not be placed too close to the filling material, as contamination of the tip can reduce the performance of the halogen lamp. If filling material gets stuck to the light tip, it should be removed with a plastic instrument.

This procedure should not be performed with metal instruments, as they can damage the reflective surface of the light tip.

Polymerization is effective up to a depth of 3 mm of the filling material. If the light intensity is between 200–300 mW/cm², the exposure time of the halogen light should be increased. However, an intensity of 200 mW/cm² is not sufficient to ensure complete polymerization. In this case, the equipment should be replaced or checked for defects in the lamp or filter.

The quality of the photopolymerization process does not depend on the intensity of the lamp alone, but rather on the total amount of light energy in the 400–500 nm wavelength range that is absorbed by the material.

For example, to photopolymerize a small portion of filling material, 10 seconds of exposure is required at a radiation intensity of 600 mW/cm², while 20 seconds is sufficient at 300 mW/cm². It is important to remember that a higher degree of polymerization of the composite material leads to increased strength.

When the distance between the composite material and the light tip is 5 mm, a 30% reduction in light intensity is observed; at a distance of 10 mm, the reduction reaches 50%.

Modern photopolymerization devices are equipped with radiometers—devices for measuring light intensity. Based on the intensity of the halogen lamp, the required curing time for the composite is determined: the lower the intensity, the longer the curing time.In dentistry, the following photopolymerizers are used: Max, Optilux, Spectrum, Demetron, Aurora, and others.

"Soft start" lamps are halogen photopolymerizers with variable light output intensity. During the first 10–15 seconds, they emit reduced light intensity, after which the light intensity increases.

According to manufacturers, this mode of photopolymerization reduces the harmful effects of polymerization shrinkage on dental tissues and lowers the risk of post-operative complications. The shrinkage during polymerization is compensated by the material's viscosity and residual flowability. The stress that occurs at the interface between the tooth tissue and the filling due to shrinkage is significantly reduced at this stage. In the second stage of polymerization, the material transitions into a solid state.

LED-based lamps – In these lamps, light is generated through the release of energy by electrons activated by an electric current within small semiconductor crystals. This is a process that occurs without the release of heat. The light emitted depends on the color of the semiconductor crystal.

Features:

- Wireless, battery-powered;
- Does not emit heat, no need for a fan;
- Does not heat dental tissues;
- Unlimited service life;
- Light intensity does not decrease over time.

Characteristics of Polymerization Lamps:

✓ Halogen lamps last for about 4,000 cycles, which is equivalent to curing 500–800 fillings.

✓ Halogen lamp light is harmful to the eyes.

✓ The light intensity should be 300 mW/cm²; if it ranges between 200–300 mW/cm², the

exposure time must be adjusted. If it is lower than that, the lamp should be replaced.

✓ At 600 mW/cm², the filling is cured in 10 seconds; at 300 mW/cm², 20 seconds are required.

✓ Highly filled, microfill, and dark-colored composite materials require longer polymerization time.

✓ If the light tip is held 5 mm above the filling surface, light intensity drops by 30%; at 10 mm, it decreases by 50%.

✓ Initially, 50–60% of the filling polymerizes; 35–40% continues polymerizing over the next 24 hours; and 5–10% within 7 days.

Conclusion:

Photopolymerization is a widely used method in dentistry for hardening composite materials under light exposure. This method allows for restorations and fillings that are not only aesthetically pleasing but also functional and durable. Photopolymerization mainly utilizes LED or halogen lamps, each with its own advantages and disadvantages.

In modern dentistry, LED lamps are becoming more widespread due to their efficiency, long service life, and low heat emission. Additionally, factors such as the composition of photopolymer materials, polymerization depth, light intensity, and exposure time greatly influence the final result. Thus, photopolymerization technology enables high-quality and long-lasting outcomes in dental procedures.

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