Indium Light Source for Curing Composite Resins

Indijev svjetlosni izvor za polimerizaciju kompozita

Jozo Šutalo
Andrej Meniga
Jadranka Rukavina*
Davorka Azinović**
Goran Pichler**

Zagreb University School of Dentistry, Zagreb
* Factory of Electric Lamps, TEŽ, Zagreb
** Institute of Physics of the University of Zagreb

Sumary

There is an existing problem of cummulative hazarduos effect of violet and near ultra-violet light which is produced by standard polymerisation units. Another restrict is shallow depth of cure, particularly of darker composite shades in premolar and molar region. Searching for better light source we used indium resonance lines from several indium high pressure lamps and tested curing effect on three different composite resins. The overall results are better with the lamp in which two strong resonance lines of indium are present, rather than with a lamp with just one strong resonance line. The improvements in lamp design are necessary to overcome conventional polymerisation lamps.

Key words: *composite resins, dental equipment*

Acta Stomatologica Croatica
1991; 25:77–82

ORIGINAL PAPER

UDK 616.314–08
CODEN: ASCRBK
YUISSN: 0001–7019
Received: 26. april 1991.
Accepted: 3. june 1991.

Introduction

In a recent experiment we investigated spectral distributions of several commercial light sources for the polymerisation of light cured composite materials (1). We were interested in the shape and extent of these spectral distributions, especially below 400 nm, where the human retina may be affected in clinical use (2, 3). We concluded that the development of a monochromatic source of incoherent or coherent light with narrow spectral distribution peaking at the wavelength of about 468 nm, where the polymerisation of the composite materials is most effective, would be highly prefered. In another experiment we have tested zinc high pressure lamp and compared it with sodium lamp filled with mercury or cadmium (4).

In this paper we would like to present the results of investigations in which we used a indium halide high pressure lamp.

Material and methods

The lamp is very similar to comercial In-Th-Na iodide high pressure lamps of 400 Watt, but without thallium and sodium iodides. Four lamps were investigated and the spectra of two are reported here. The first lamp had the dominant emission within two pronounced resonance spectral lines of indium atoms at 410.2 and 451.1 nm and the other only one strong line at 451.1 nm. The former lamp has violet-blue color and the latter more bluish color, relatively pleasant to the human eyes. In the present experiment we did not measure temperature effects of the investigated laps on the composite sample (5, 6, 7).

The lamps had a quartz burner 5 cm long and 2.5 cm in diameter. They were equiped with standard inductive ballast and ignition device. The light from the discharge laps was spectrally resolved by a monochromator (SPM-2, Carl

Zeiss) and detected at the exit slit by a sensitive photomultiplier (EMI 9558 QB). The signal was processed either by using a box-car averager or directly by dc amplifier and recorded on the strip chart recorder.

The composite resins used were: Polofil (Voco, Germany), Heliosit and Heliomolar (Vivalent, Liechtenstein). They were filled into the special forms made of dark plastic material with 3 mm in diameter and then illuminated by two different light sources as shown in Figure 1. Our studies are of comparabile nature, and no other quantitative or qualitative measure has been employed yet. We were primarily interesed in the depth of the hardening process.

Results

Spectral measurements

In Figures 2 and 3 we present the spectra of two selected discharge lamps in the spectral region from about 400 nm up to almost 600 nm.

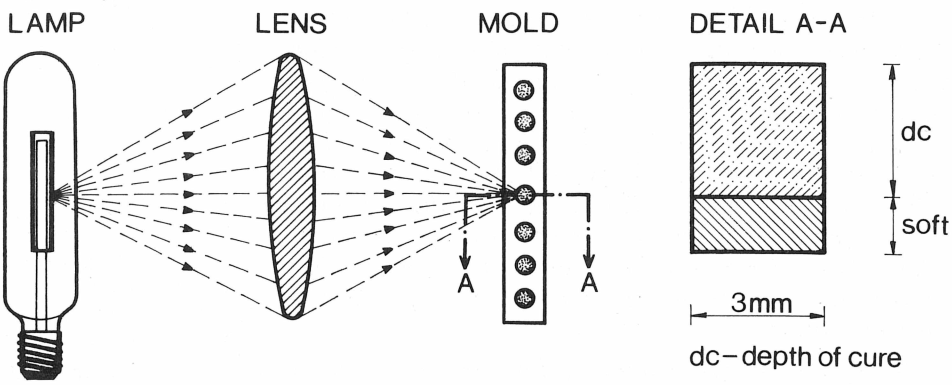

Figure 1. *Experimental arrangement and the molds for the composite samples*
Slika 1. *Eksperimentalna postava i kalupi za uzorke kompozita*

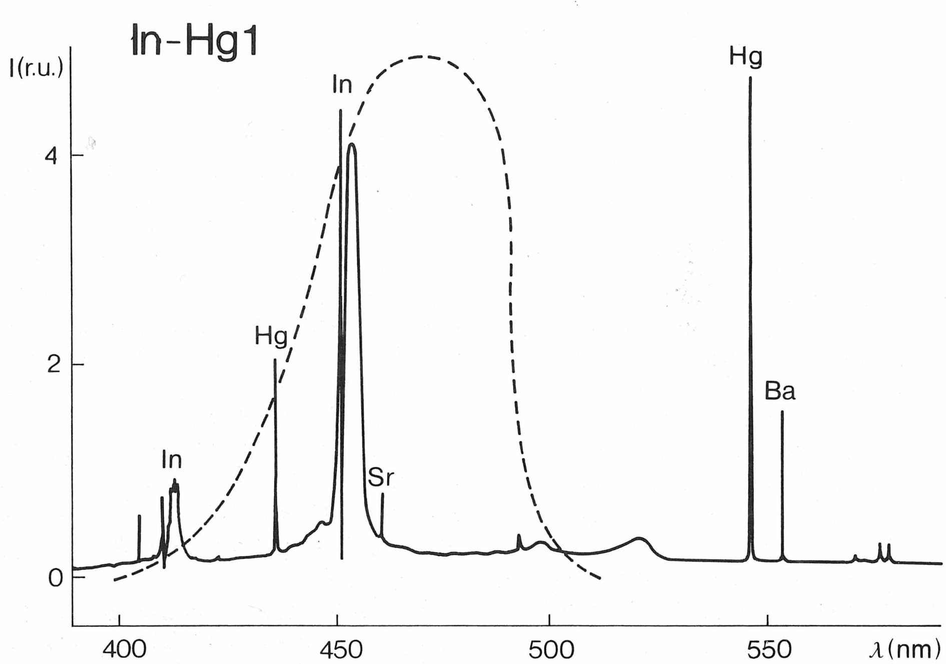

Figure 2. *Spectrum of the indium lamp with both resonance lines at 410 and 451 nm*
Slika 2. *Spektar indijeve žarulje s obje rezonantne linije na 410 i 451 nm*

In Fig. 2 we may readily observe that both blue and violet indium resonance lines are very strong, however with self-reversed line centers. In Fig. 3 the violet indium resonance line at 410.2 nm was almost totally absorbed, most probably by mercury iodide molecules in their ground states, which are located at the burner wall. Beside indium resonance lines, mercury spectral lines are also present. Sodium resonance lines at 589 nm are present as inevitable impurity, but barium strontium resonance lines come from the oxide layers on the electrodes. In both figures we have plotted absorption curve of the camphorquinone. It can be readily seen that indium resonance line at 451.1 nm lies within the broad maximum of the camphorquinone absorption curve. The resonance line at 410.2 nm, although lying at the short wavelength end of the absorptin curve, may still be involved in the curing process. However, its violet color may cause some cumulative hazard effects on the human eyes over a long period of time.

Polymerization

In Figure 4 we present the results of our photopolymerization studies with indium high pressure lamp, which spectrum is shown in Fig. 2. Three composite resins of the light shade were used, and the results represent mean values of three measurements. Actual errors were less than 5 percent. The depth of cure was measured immediately after the exposition by removing the soft material and using the Vernier scale. The lamps were run at 220 V and electric current of 4 Amps. The best results were obtained with Heliosit. It is interesting to note that without any special optimization we achieved relatively large curing depths already after half a minute of expositon time.

In Figure 5 we present the curing depth for three composites illuminated by the lamp with the spectrum shown in Fig. 3. This lamp was almost blue in color, since the indium resonance line at 410.2 nm was entirely absent from the

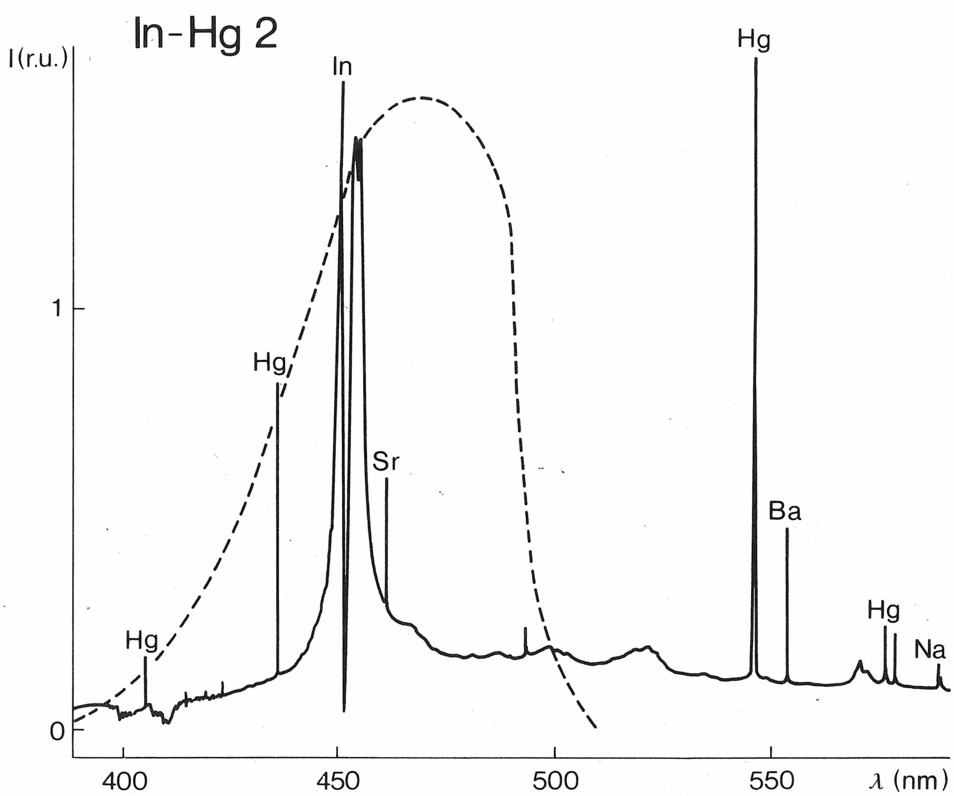

Figure 3. *Spectrum of the indium lamp with only one resonance line at 451 nm*
Slika 3. *Spektar indijeve žarulje s jednom rezonantnom linijom na 451 nm*

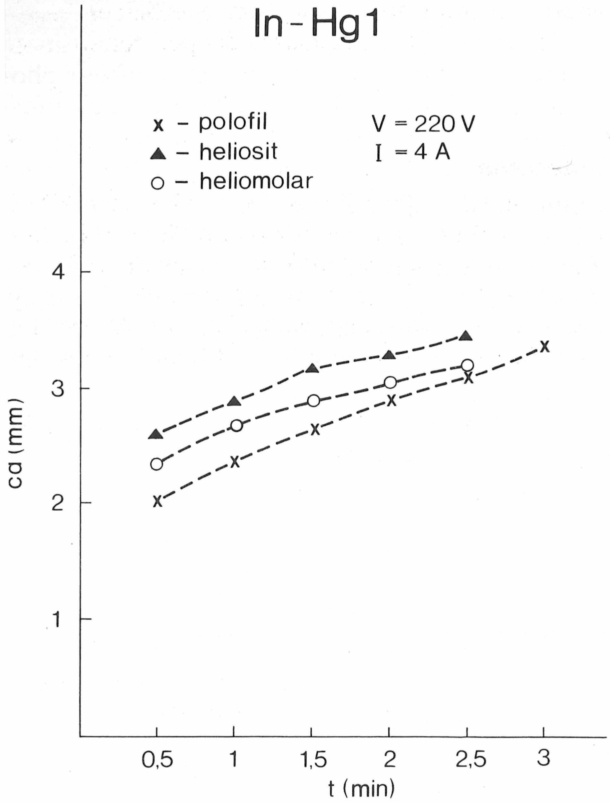

Figure 4. *Curing depth via exposition time for three composite materials illuminated by In-Hg 1 lamp*

Slika 4. *Dubina stvrdnjavanja u odnosu na ekspoziciju za tri kompozita osvijetljena s In-Hg 1 žaruljom*

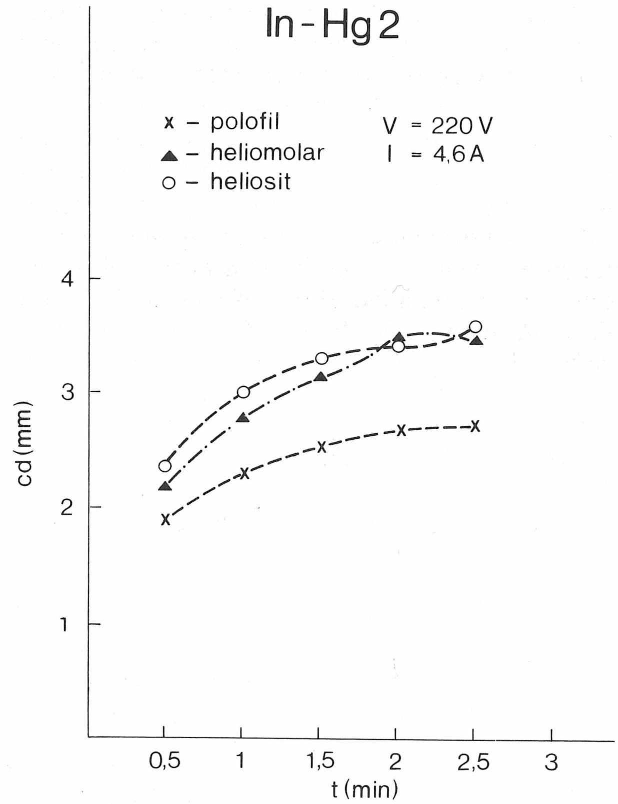

Figure 5. *Curing depth via exposition time for three composite materials illuminated by In-Hg 2 lamp*

Slika 5. *Dubina stvrdnjavanja u odnosu na ekspoziciju za tri kompozita osvijetljena s In-Hg 2 žaruljom*

pectrum, due to the absorption of the indium ɔdide molecules. Heliosit and Heliomolar exhiited almost the same behavior. However, at he early exposition times the curing depth was ɔwer than in the previous case with the violetlue lamp. Polofil exhibits much smaller depth f cure with saturation effect at exposition times ɔnger than 2 minutes.

iscussion

We believe that the differencies in the curing epth curves arise from the different degree of ıade in composite resins tested. On the other and, the percentage of filler particles and its ature may cause differencies among examined ıaterials (8, 9, 10). The lamp denoted as In-Hg gives larger curing depth and shows no saturaon behaviour. The indium resonance line at 51.1 nm of this lamp is 2.6 times stronger than ıe same line in the In-Hg 2 lamp. We believe ıat the absence of the 410.2 nm indium resonance line in In-Hg 2 lamp may cause the saturation of the curing depth curve. The indium resonance line 451.1 nm certainly lies within the broad maximum of the camphorquinone absorption curve and should be well suited for the photopolimerisation.

The large absorption coefficient means that this spectral line will not travel very far into the composite resin. On the other hand, the spectral line at 410.2 nm with a much smaller absorption coefficient could penetrate much further, causing polymerization in the deeper regions. It means that the lamp with two strong spectral lines of different absorption coefficient in camphorquinone should give a much better result in the curing process. As shown in Figure 5 all three curves exhibit a kind of saturation effect, most probably caused by the small penetration depth of just one strong resonance line.

In the present studies we have seen that the depth of cure is not especially large, but we hope that the further progress in lamp construction and the appropriate optical system, should lead to the essential improvement, which may be used in the dental applications.

These findings give us a good hope that indium high pressure lamp could be developed into a practical dental appliance. However, if 410.2 nm resonance lie presents by any mean a potential hazard for the human eyes due to the long term cumulative effect, we must turn to a different lamp. As the results of the present experiment show, it should be a lamp with at least one strong line within the maximum of the camphorquinone absorption curve, and at least one strong line in the blue-green spectral region, where the relevant absorption coefficient becomes much smaller, but asures deeper penetration effect.

Conclusion

Our results clearly show that the search for the new light sources is justified in view of higher efficacy and lower vital tissue hazard considerations. Although the presently attained curing depth are not satisfactorily large, we hope that the further improvement of the indium lamp will soon bring about the device of coparable or better features than the presently used halogen lamp based units (11).

INDIJEV SVJETLOSNI IZVOR ZA POLIMERIZACIJU KOMPOZITA

Sažetak

Kod postojećih uređaja za polimerizaciju kompozita postoji problem komulativnog djelovanja svjetla bliskog ultraljubičastom, koje je opasno za oči. Drugo ograničenje je plitoća stvrdnjavanja, posebice izražena kod tamnijih boja kompozita u području predkutnjaka i kutnjaka. Tražeći optimalniji izvor svjetla, koristeći se indijevim visokotlačnim žaruljama, ispitali smo stvrdnjavanje tri različita kompozita. Ukupni rezultati su bolji s žaruljom koja ima dvije jake rezonantne linije, nego kod žarulje s jednom linijom. Potrebno je poboljšanje konstrukcije žarulje, da bi se rezultati mogli usporediti s postojećim polimerizacijskim uređajima.

Ključne riječi: kompoziti, fotopolimerizacija

Addres for correspondence:
Adresa autora:

Prof. Jozo Šutalo, Ph. D.
Stomatološki fakultet
Gundulićeva 5,
41000 Zagreb

References

1. ŠUTALO J, MENIGA A, FIJAN D, PICHLER G. Analysis of spectral distribution of some commercial light sources for curing composite resins. Acta Stomatol Croat 1989; 23:145–150.
2. DAVIS LG, BAKER WT, COX EA, MARSHALL J, MOSELEY TJ. Optical hazards of blue light curing units: preliminary results. Br Dent J 1985; 19:259–262.
3. KULLMANN W. Emissionsspektren und oberflachenhaertungsmuster von 35 vershiedene photopolymerisationsgeraeten. ZWR 1987; 96:320–328.
4. MENIGA A, ŠUTALO J, RUKAVINA J, AZINOVIĆ D, PICHLER G. Zinc and sodium high pressure lamps for curing composite resins. Acta Stomatol Croat 1990; 24:233–240.
5. ABADIE MJM, APPELT BK. Photocalorimetry of light-cured dental composites. Dent Mater 1989; 5:6–9.
6. GOODIS HE, WHITE JM, ANDREWS J, WATANABE LG. Measurement of temperature generated by visible light-cure lamps in an in vitro model. Dent Mater 1989; 5:230–234.

7. MASUTANI S, SETCOS JC, SCHNELL RJ, PHILLIPS RW. Temperature rise during polymerization of visible light-activated composite resins. Dent Mater 1988; 4:174–178.
8. ONOSE H, SANO H, KANTO H, ANDO S, HASUIKE T. Selected curing characteristics of light-activated composite resins. Dent Mater 1985; 1:48–54.
9. SHINTANI H, INOUE T, YAMAKI M. Analysis of camphorquinone in visible light-cured composite resins. Dent Mater 1985; 1:124–126.
10. STRANG R, MACDONALD I, O'HAGAN S, MURRAY J, STEPHEN KW. Variation in performance of curing light units by determinations of composite resin setting time. Br Dent J 1987; 63:162–165.
11. ŠUTALO J. Composite materials in dentistry (in croatian). Zagreb: Grafički Zavod Hrvatske, 1988.