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ZINK AND SODIUM HIGH PRESSURE LAMPS FOR CURING COMPOSITE RESINS

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Summary

Polimerisation caracteristics of conventional units for curing composite resins are insufficient considering handling feasibilities particularly in the premolar and molar region. There is also hazardous ocular effect of near ultra-violet part of visible spectra. Sodium high pressure lamp tehnology has been applied to develop a new high pressure zinc lamp, which is for the first time used for curing composite materials. The results of polymerisation measurements show that future improvements over the usual halogen light sources are possible. Zinc lamp was also compared with the high pressure sodium lamp filled with mercury or cadmium.

Key words: composite resins, high pressure lamps

INTRODUCTION

Since visible light-cured composite resins have been successfully introduced (1), the standard light source became the tungsten halogen lamp suited with appropriate mirror and filters to reduce the ultra-violet light. This light source has blue-violet color and it may still have some potential for the cumulative optical hazard, due to the small fraction of the near ultra-violet light (2, 3). On the other hand it was found (4, 5) that the lamps in everyday practice cause a temperature rise within the pulp chamber.

Considering these visible light induced effects we started a series of experiments with high-pressure discharge lamps from standard production or lamps with new composition and spectra. For the visible-light curing the absorption coefficient curve of camphorquinone is of essential importance (6, 7). Therefore we used the lamps that have the atomic or

molecular band spectra as close as possible to the region of maximum light absorption in the composite resins. In the present paper we present the results of curing three different composites with three high pressure lamps. We used high pressure Zn-Ar lamp from the experimental line in the development department of Lamp Factory in Zagreb. This zinc lamp has kind of purple color, a consequence of a group of strong lines in the blue-green and in the red part of the spectrum. For the comparison we used standard high pressure Na-Hg-Xe and Na-Cd-Xe discharge lamps known for the relatively poor spectrum in the blue spectral region, but strong yellow-red emission. However, we tried to make use of NaHg and NaCd excimer bands that lie in the blue spectral region within the maximum of the camphorquinone absorption curve.

MATERIALS AND METHODS

First we recorded the spectra of the three high pressure lamps in the visible spectrum by using the scanning monochromator and standard detection technique. The spectral resolution was better than 0,1 nm, and at present we did not attempt any corrections for the spectral sensitivity of the spectral apparatus. The molds were made from pieces of dark plastics with depth of 3,8 mm by drilling the holes 3 mm in diameter. The resins were filled in the holes (8). The total light from the high pressure lamps is focused onto the mold array with a lens as shown in Fig. 1.

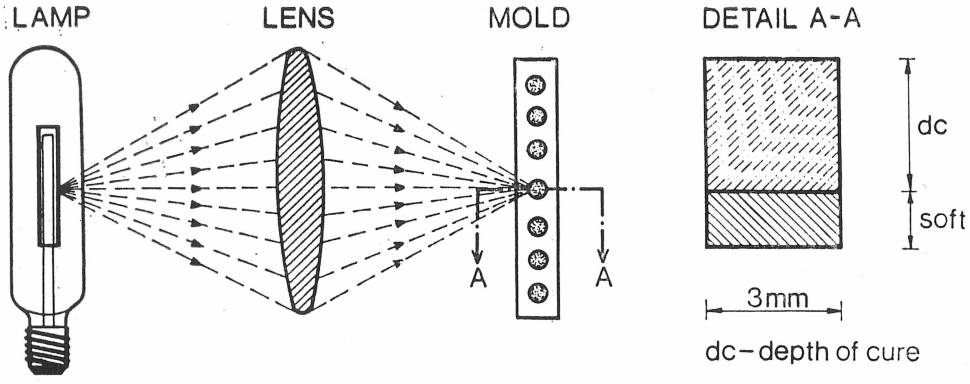

Figure 1. Experimental arrangement for the visible light curing
Slika 1. Eksperimentalna postava za fotopolimerizaciju

All lamps have been operated in the vertical position. The lens collected the light from the center of the lamp burner and focused onto the surface of the composite resin in the mold array. After a certain exposition time the curing depth (cd) was measured by using a Vernier micrometer. We

used three different types of resin material for the purpose of comparison between them. We did not use any filter combination, so that the visible lamp spectra were only slightly attenuated by the glass bulb and glass lens material. In such a case the joint effect of glass optics and camphorquinone absorption curve made use of the portion of the spectrum in between 400 and 500 nm.

RESULTS

The spectra from 400 to 650 of all three lamps are shown in Figures 2,3 and 4, for zinc, sodium-cadmium and sodium-mercury, respectively. The spectra have not been corrected for the spectral sensitivity of the detection system. This kind of mesaurements we postpone for some later time. In order to mark the spectral region of interest we added in all figures the absorption coefficient curve of camphorquinone. Zinc lamp has three strong atomic lines in the broad region of absorption maximum, while sodium lamps have there broad atomic lines with underlying continua from NaHg and NaCd excimers.

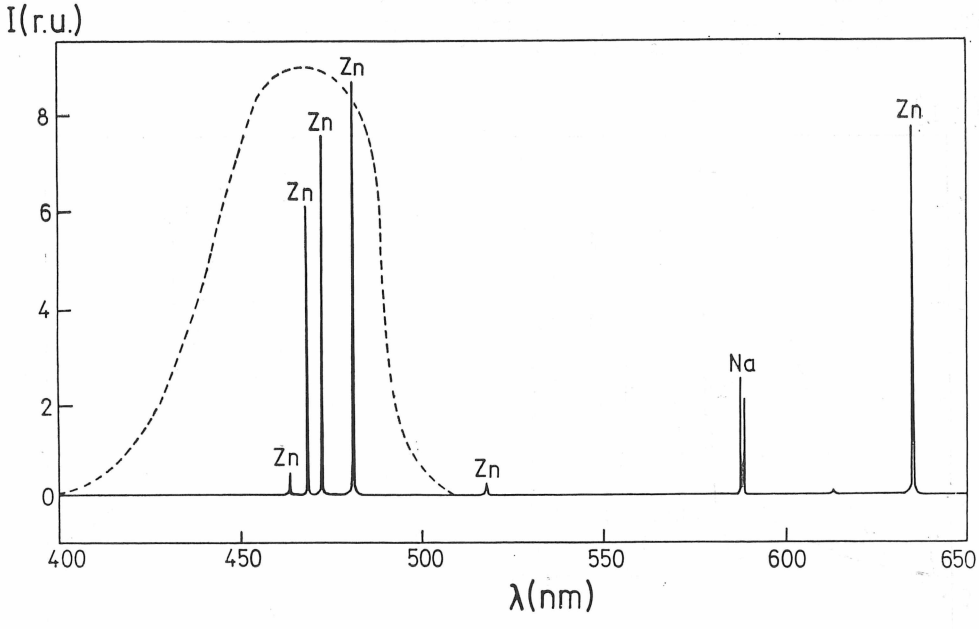

Figure 2. Spectrum of the high pressure zinc lamp (full line) with the absorption coefficient of the camphorquinone (dashed line)

Slika 2. Spektar visokotlačne cinkove žarulje (puna crta) s apsorpcijskim koeficijentom kamforkinona (isprekidana crta)

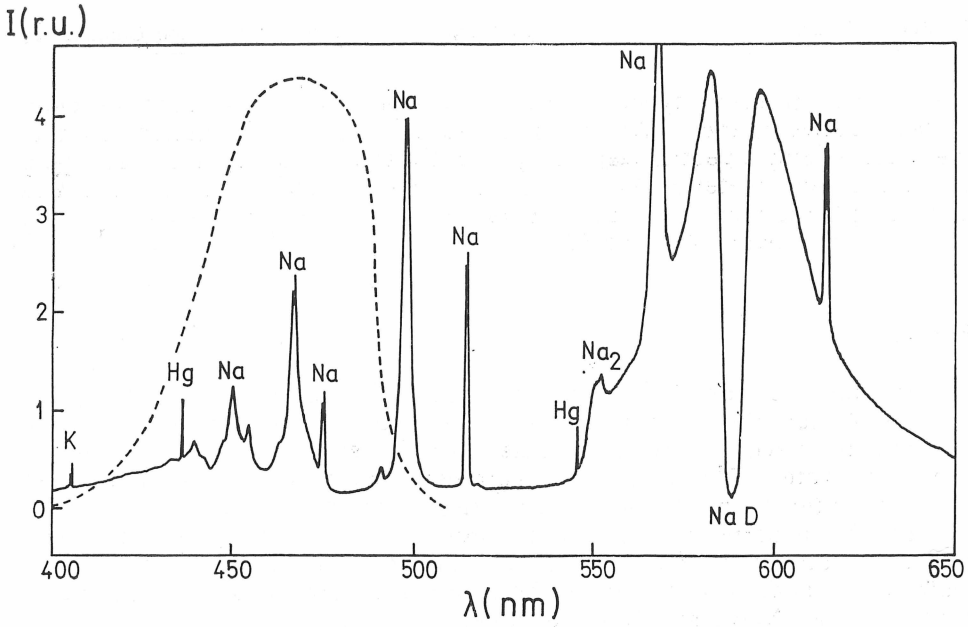

Figure 3. Spectrum of the high pressure sodium-mercury lamp (full line) with absorption coefficient of camphorquinone (dashed line)

Slika 3. Spektar visokotlačne natrij-živine žarulje (puna crta) s apsorpcijskim koeficijentom kamforkinona (isprekidana crta)

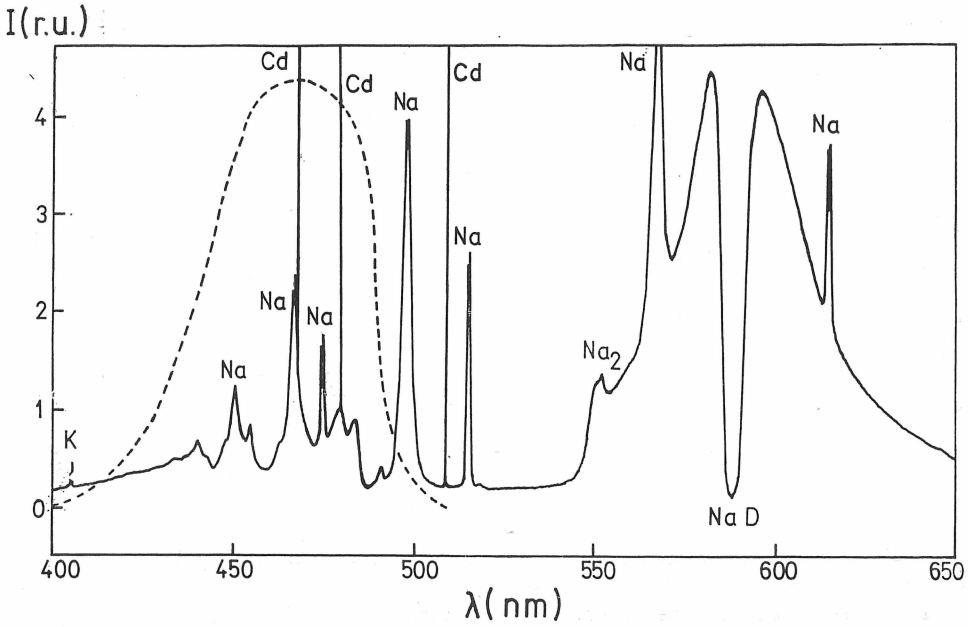

Figure 4. Spectrum of the high pressure sodium-cadmium lamp (full line) with absorption coefficient of camphorquinone (dashed line)

Slika 4. Spektar visokotlačne natrij-kadmijeve žarulje (puna crta) s apsorpcijskim koeficijentom kamforkinona (isprekidana crta)

The curing depths we measured for expositions between half and four minutes for all three lamps and three different kinds of composite resin material, as shown in Figures 5, 6 and 7. Curing depth measurements were made for three samples under same conditions, and the results are mean values. Actual errors were less than 5 percent.

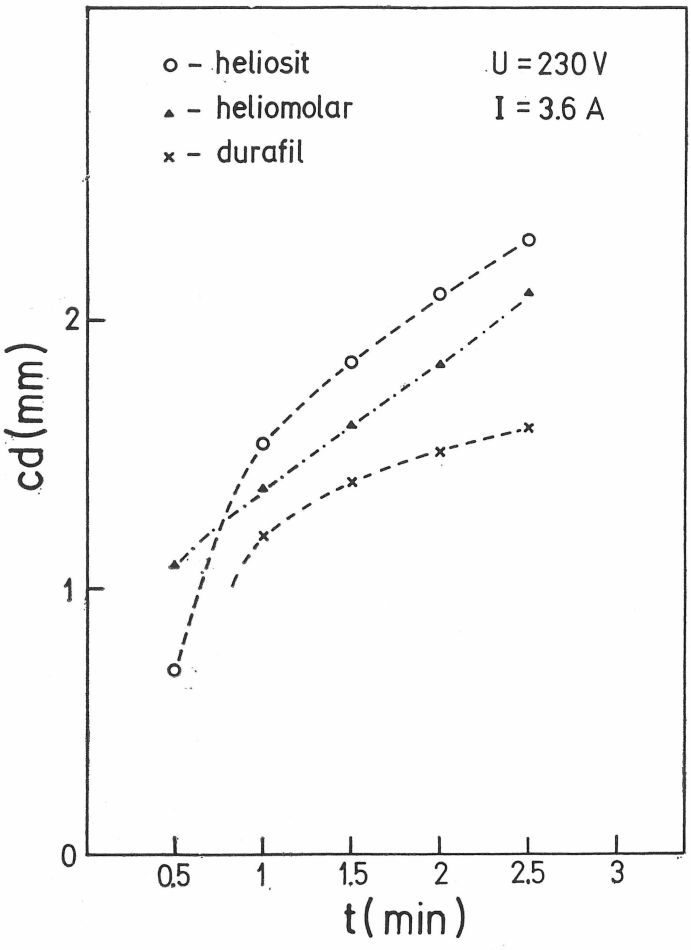

Figure 5. Curing depth via exposition time curve for the high pressure zinc lamp for three different compoiste resins

Slika 5. Dubina stvrdnjavanja uz visokotlačnu cinkovu žarulju za tri kompozitna materijala

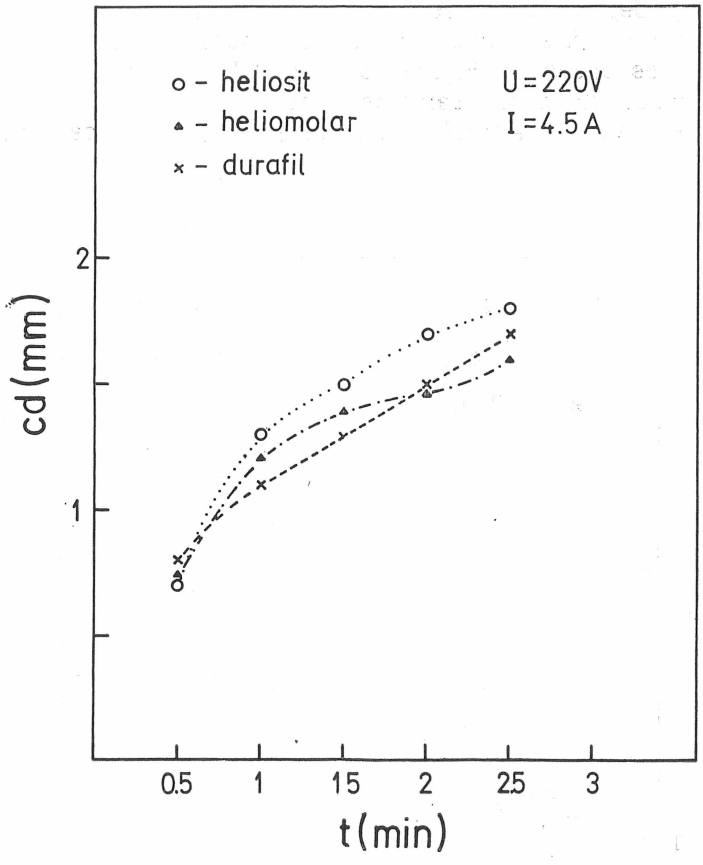

Figure 6. Curing depth via exposition time curve for the high pressure sodium-cadmium lamp for three different composite resins

Slika 6. Dubina stvrdnjavanja uz visokotlačnu natrij-kadmij žarulju za tri kompozitna materijala

DISCUSSION

There is no doubt that even in the present cases we obtained the visible light curing effect. In future experiments we shall try to improve curing characteristics by different lamp design and optical arrangement. The zinc lamp has the color which might be more pleasant to the human eye over longer time in the clinical practice. Sodium based lamps in the present form, although also not very effective, may be greatly improved if other sodium-mercury compisition ratio were employed. In the case of pure high pressure sodium lamp (which is already in the production at Philips, Eindhoven), the blue spectral region is essentialy enhanced,

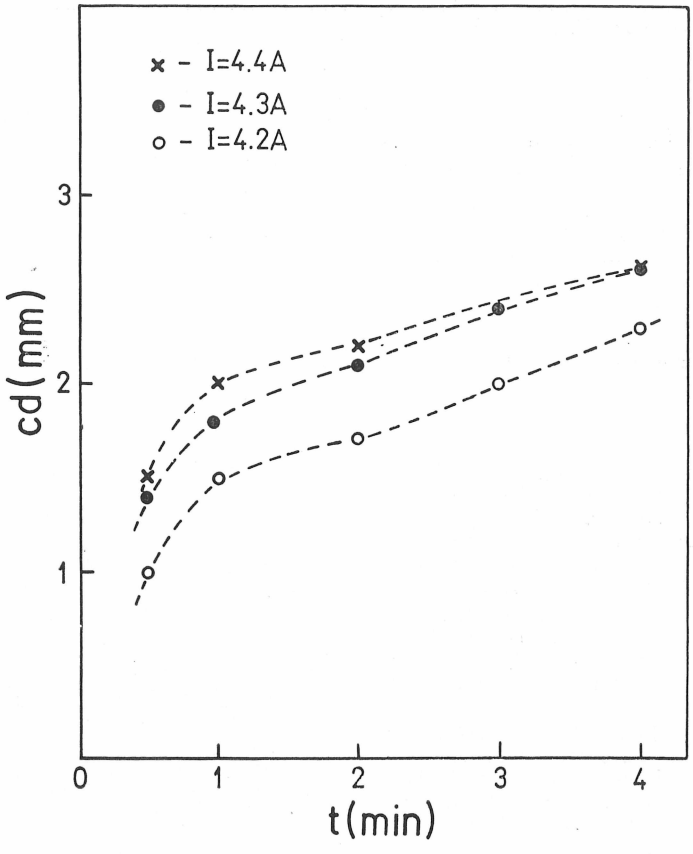

Figure 7. Curing depth via exposition time curve for the high pressure sodium-mercury lamp for different electric current through the lamp

Slika 7. Dubina stvrdnjavanja uz visokotlačnu natrij-živinu žarulju uz različite snage električne struje kroz žarulju

and the lamp exhibits bright white color. We believe that it could be possible to taylor such a high pressure sodium-mercury or sodium cadmium lamp in which NaHg or NaCd excimer bands could be the dominant spectral features. We showed that three different high pressure lamps exhibit the visible light induced curing effect in several composite resins. Although the curing depths appeared to be rather small, some future improvements are possible.

VISOKOTLAČNA CINK-NATRIJEVA ŽARULJA ZA POLIMERIZACIJU KOMPOZITNIH MATERIJALA

Sažetak

Polimerizacijske karakteristike komercijalnih uređaja za stvrdnjavanje jednokomponentnih kompozitnih materijala su nedostatne, zbog poteškoća koje se javljaju pri polimerizaciji aproksimalnih ispuna na premolarima i molarima. Postoji i opasnost od oštećenja oka svjetlošću bliskoj ultraljubičastoj. Nova visokotlačna cinkova žarulja proizvedena je tehnologijom za natrijeve visokotlačne žarulje i po prvi puta korištena za polimerizaciju kompozitnih materijala. Rezultati mjerenja dubine polimerizacije pokazuju da su moguća poboljšanja u odnosu na uobičajene halogene svjetlosne izvore. Cinkova žarulja je uspoređena s natrijevim visokotlačnim žaruljama punjenim živom ili kadmijem.

Ključne riječi: kompozitni materijali, visokotlačna žarulja

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