Physical Properties of ZnO Base and Resin Cements

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Most of the tests on cements are carried out with a consistency suitable for cementing inlays or crowns. The consistency which is thin for this purpose is dictated by the requirement of minimal cement film thickness and the formation of a strong mechanical bonding between the restorations and the teeth by the free-flowing cements into minor fissures and cracks. However, the minimum cement film thickness requirement is not very stringent for cementing orthodontic bands. With the development of cements capable of forming chemical bonding to the teeth, the thin consistency of cements for the purpose of inducing strong mechanical bonding is not essential. Furthermore, it is noted that most practitioners prefer a thicker consistency of the cements for cementation of orthodontic bands than the one prescribed by specification No. 8 of the *American Dental Association* for cementation of inlays or crowns. Therefore, the purpose of the present investigation is to formulate an ideal consistency for band cementation and to determine the physical properties of the resin cement (Epoxylite-9080) and compare it with zinc phosphate and zinc polycarboxylate cements.

Materials and Methods

Table I shows the materials and batch number used in this investigation.

The Epoxylite-9080 is a resin cement[1] which was primarily developed for the adhesion of inlays and crowns, but the manufacturer also recommends possible use for cementing orthodontic bands. The exact formula for this resin cement is not known, but an Epikote-828 (Shell general purpose resin) is manufactured from the by-products of petroleum. Most of the epoxy resins are made by reacting epichlorhydrin with diphenylolpropane in an alkaline medium. Epikote 828 has been evaluated by Retief[2] et al. for possible use of bonding of orthodontic attachments to teeth, but no investigation of the physical properties of the type described in this report was undertaken.

All three materials were manipulated in accordance with accepted dental procedures and the manufacturer's directions. The consistency tests were performed as outlined in ADA specification[3] No. 8 except that the powder-liquid ratio was so manipulated that the size of the slumped discs were 26 ± 2 mm. This consistency was found to be ideal for the cementation of orthodontic bands. The powder-liquid ratios for obtaining this consistency were 1.5:0.5 for zinc phosphate, 1:0.5 for zinc polycarboxylate and 1.5:0.5 for resin, respectively.

Setting time was also measured according to ADA specifications. However, instead of a one-pound Gilmore needle for determining the setting time, a precision universal penetro-

TABLE I

Material	*Batch No.*
Zinc Phosphate Cement (Ames)	Powder B42 liquid Q3
Zinc Polycarboxylate cement (Durelon)	Powder 10476 liquid 015546
Epoxylite Crown & Bridge Adhesive-9080 (Resin)	Powder CB0005 liquid CB907

meter was employed. The diameter of the depth gauge rod was 0.7 mm and the load on it was so adjusted to give an equivalent stress as indicated in the ADA specifications. The penetration was measured to the nearest tenth of a millimeter. The setting time data are presented as time vs. penetration plots for all three cements.

The solubility and disintegration, and the compressive strength were measured according to the ADA specification No. 8. Compressive strength was determined on an Instron Universal testing machine. The specimens were loaded at the rate of 225 Kg per minute and were kept wet during the test. The value for the compressive strength reported is an average of five measurements from a lot of seven specimens and these have been determined to the nearest 10 Kg. per square centimeter.

Results and Discussion

Since the consistency adopted here for the cementing of orthodontic bands is thicker than the one used for cementing the inlays, it is expected that these cements would be superior in service performance, because from the standpoint of the physical properties, it is generally believed that a mix of a thick consistency is the best.[4]

Figure 1 shows the setting time versus penetration curves for the three cements. It can be seen that no noticeable decrease in penetration occurs for some time 't_w' (time at A, B and C in Fig. 1) after the mix is made, while after this time, rapid decrease in penetration depth occurs until time 't_i' (time at D, E and F in Fig. 1). After time t_i the decrease in penetration continues, but very slowly, and approaches to zero penetration at time 't_f' (time at J, K and L in Fig. 1). In other words, the kinetics of setting reaction as recorded by the penetration depth takes place in two stages after time t_w. The times t_w, t_i, and t_f actually represent and can be appropriately termed as the working time, initial setting time, and final setting time, respectively. Therefore, from these plots, t_i-t_w and t_f-t_i are the time durations in which initial and final settings take place. Furthermore, the time interval t_i-t_w should also be considered to represent the time duration for which an appliance that is to be cemented must be kept unmoved.

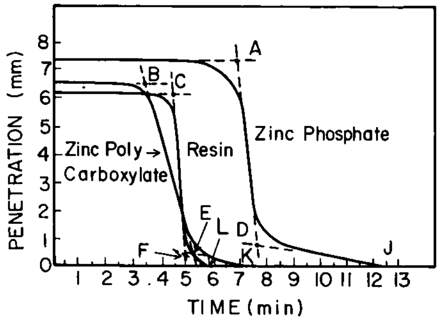

Fig. 1 Time vs. penetration curves for setting cements.

Table II indicates the various times for different cements as obtained from Figure 1.

It can be noted from this table that the working, initial, and final setting times for polycarboxylate and resin cements are comparable but are significantly greater for zinc phosphate cement. Furthermore, the data show

TABLE II

WORKING AND SETTING TIMES IN MINUTES

	Zinc Phosphate	*Zinc Polycarboxylate*	*Resin*
Working Time, t_w	7.0	3.5	4.5
Initial Setting Time t_i	7.7	5.2	5.0
Final Setting Time, t_f	12.5	7.0	5.8

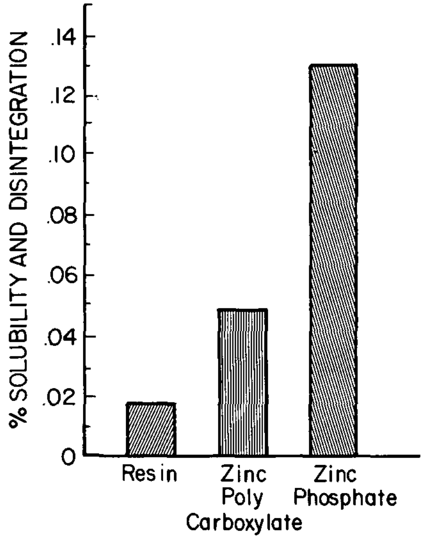

Fig. 2 Relative percent solubility and disintegration of resin, zinc polycarboxylate and zinc phosphate cements.

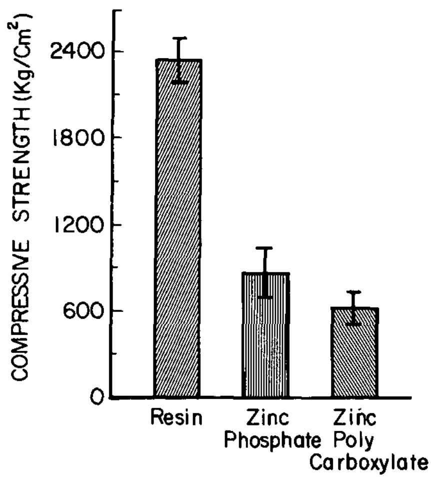

Fig. 3 Comparison of 24-hour compressive strength of resin, zinc polycarboxylate and zinc phosphate cements.

that the cement having a longer final setting time does not necessarily have longer working time. This is understandable knowing that the kinetics of setting of two chemically different cements ought to be different.

Based on the consideration of setting time, zinc phosphate cement would be ideal for cementing many bands before the cement becomes unworkable while polycarboxylate and resin should be considered suitable for cementing three to four bands in an area which is difficult to keep dry.

Figure 2 is the histogram representing the relative 24-hour percent solubility and disintegration of the cements in distilled water. The percent solubility and disintegration of resin is only about 13.4 percent of the percent solubility of zinc phosphate cement. The percent solubility of zinc polycarboxylate is about 37 percent of the corresponding value for zinc phosphate. A comparison of the present results of solubilities with those of Smith[5] shows that the results are in agreement for the case of zinc polycarboxylate, but the value of the percent solubility for zinc phosphate is slightly larger (about 1.3 times) than the value reported by Smith. This slight difference is very likely due to the difference in brands of cement used in the two investigations. The usefulness of short-term solubility and disintegration data in water has been seriously questioned,[5] but for satisfactory clinical performance, the solubility should be below the specification limit, which is 0.2 percent for zinc phosphate cement.

Figure 3 shows the 24-hour compressive strengths for the three cements. It can be noted that the compressive strengths of zinc phosphate and zinc polycarboxylate cements are in the same range but the strength of resin cement is about four times that of polycarboxylate cement. It is reported in the literature[5,6] that zinc phosphate cement is significantly superior to polycarboxylate cement in compressive strength. However, in the present investigation it is seen that the strength of zinc phosphate is only slightly greater than the polycarboxylate cement. But the strength value of zinc phosphate cement observed in this investigation agrees well with that reported by Shepherd et al.[7] It appears that the difference in strength values reported by various investigators is primarily due to the difference in brands, consistency and the other mixing techniques. At the same time, a comparison of present results with other data appears to show that an increase in percent solubility is associated with a decrease in strength. This indicates that a relationship exists between percent solubility and the compressive strengths of the cements.

Summary

Some physical properties of zinc phosphate, zinc polycarboxylate, and a resin cement of thick consistency suitable for cementation of orthodontic bands were evaluated. A new technique for evaluating the setting time is described. The setting times for resin and zinc polycarboxylate cements were about the same but less than that for zinc phosphate. The properties of percent solubility and compressive strength were significantly superior for resin cement.

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