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# FURTHER STUDIES ON THE LEAKAGE BETWEEN RESIN MATERIAL AND GOLD ALLOY IN RESIN FACED GOLD CUPS

*by*

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In a previous study it was demonstrated that sodium ions in water solution permeated through resin faced gold cups (*Söremark & Bergman,* 1961). It was concluded that a minute space between the resin material and the gold alloy in the window perforation of the cup was formed during the manufacture of the acrylic facing and thus responsible for the permeation. The acrylic facings varied in size, otherwise the tests were standardized.

The present investigation was undertaken in order to study the possible influence of the following three factors on the leakage of sodium ions between gold and resin material; namely

(1) the arrangement for retention of the resin facing,

(2) the shape of the resin facing,

(3) variations in temperature.

The first two factors were thought to be of influence on the direction of the curing-cooling shrinkage and accordingly they

might affect the size of the minute space between metal structure and acrylic facing. The third factor was included with regard to temperature changes occurring in the mouth.

## MATERIAL AND METHODS

### Radioactive nuclide used

The radioactive sodium nuclide, $Na^{22}$, used was supplied by the *Radiochemical Centre, Amersham*. In the present investigation $Na^{22}$ was used in the form of sodium chloride in isotonic solution.

### Test arrangements

The test cups were cast in a gold-platinum alloy (Sjöding's "C-gold") and were provided with a 3 mm thick acrylic facing in a circular cut-out with a diameter of 12 mm. The gold material under the facing material had been perforated in the centre, the hole being 1 mm in diameter.

The heat-cured resin material used throughout the investigation was *Justi's Dental Pearl, Crown and Bridge "S — R" Formula (Ivoclar Schaan, Liechtenstein)*. It was purchased in the open market. For further information regarding the treatment of the resin material the reader is referred to *Söremark & Bergman* (1961).

Forty (40) gold cups were used in the present study. In twenty of them (Group A), the retention for the resin facing was provided by a single wrought wire. In the remaining twenty (Group B) the retention was provided by numerous small gold beads attached to the bottom as well as to the wall of the cut-out. This latter arrangement for retention was provided by use of a cast-metal bonding material, Tentaform (Tentaform bonding liquid and spray bottle of powder). The powder consists of small resin globes, diameters about 0.3 mm. The adhesive liquid was brushed to the retention area of the wax model and immediately the powder was sprinkled onto the wet wax. The wax model was thereafter invested for casting. The retention for the resin facing

was thus provided by numerous small globes of cast metal. In both groups the curvature of the floor of the cut-out varied, five cups having a flat floor, five a slightly curved, and ten a strongly curved floor. In all cases the outer surfaces of the resin facings were parallel to the bottom of the cut-out. This way three different shapes of facings were tested.

In a *first series* fifteen test cups from each group were placed and kept in the radioactive solution ($Na^{22}$-labelled saline solution) of 20° C for forty days.

In a *second series* the remaining ten test cups, five from each group, all provided with a strongly curved facing, were tested during temperature changes for seven days. Two radioactive solution baths were used the temperatures being 20° C and 40° C, respectively. Transfer from one bath to the other was performed every third hour, day and night for seven days.

### Measurement of the penetration af $Na^{22}$ ions

Into each test cup inactive saline solution was pipetted so that the inner solution surface was equal in height with the surface of the bath containing the radioactive solution. The cups were covered with glass slides to prevent evaporation. In spite of this, a small evaporation of water occurred from the solution in the cups. To keep the inner solution surface level constant, distilled water now and then had to be added.

At the various time intervals indicated in the diagrams on the next page 0.5 ml of the saline solution in the test cups was taken for measuring of the radioactivity in a well-type scintillation crystal. The size of this NaI (Tl) crystal was 2″×1 7/8″ with a well of 5/8″×1 1/2″. The operating voltage was 1200 V. The solution was poured back into the test cup after measuring.

## RESULTS

The results are presented in Diagrams 1 and 2. In all test cups the inner solutions were contaminated with $Na^{22}$ after one day. The radioactivity increased up to about the twentieth day and thereafter no change seemed to take place (Diagram 1). The activity within the test cups reached about 1/10 of that of the

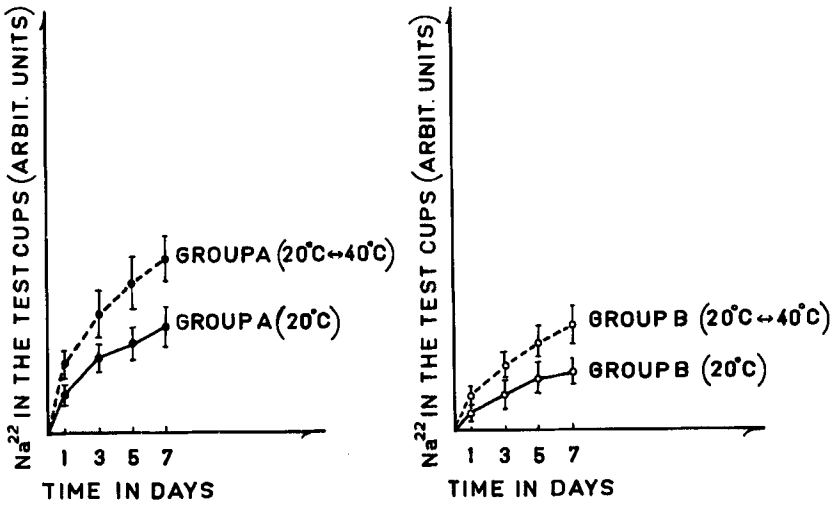


Diagram 1.

Influx of $Na^{22}$ when the test cups were placed in a $Na^{22}$-labelled saline solution of 20°C for forty days. Standard deviations are shown.

bath. The influx of $Na^{22}$ was more rapid in cups with wire retention (Group A) than in those with metal bead retention (Group B).

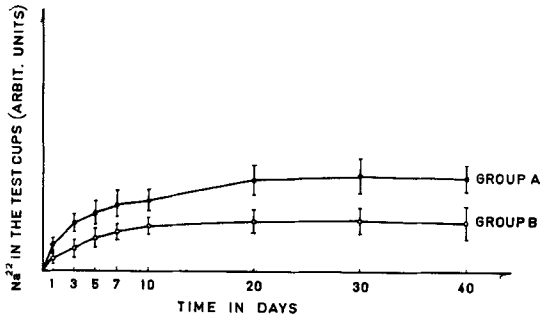


Diagram 2.

The effect of temperature variations on the influx of $Na^{22}$ into the test cups. Standard deviations are shown.

No significant differences could be found within the groups with regard to the various shapes of the facings.

With temperature changes the influx increased in both group A and group B (Diagram 2).

## DISCUSSION

The results of the present study confirmed those previously obtained, viz. that sodium ions will permeate into gold cups with resin facing material on perforated gold windows (*Söremark & Bergman,* 1961). Previously it was concluded that this permeation seemed to be due to leakage in the minute space between the acrylic resin and the gold. There is no reason to alter that opinion.

In the present study the rapidity of the permeation of sodium ions seemed to be related to the retention arrangement used for the resin facing. Thus, the permeation was less rapid when the retention was provided by numerous small gold beads in the cut-out (group B) than in the cases with a single wrought wire (group A). This may be due to a difference between the two groups in the shrinkage possibilities and directions, resulting in a better adaption of the resin to the metal surface in the cut-out with gold beads than in that with wrought wire.

After about twenty days no further influx of $Na^{22}$ seemed to take place. This is probably due to the fact that during its stay in the $Na^{22}$-labelled saline solution the resin material absorbs water which causes a swelling resulting in a better adaption of the facing to the wall and the floor of the cut-out. This is in agreement with the results of the studies by *Brauer & Sweeney* (1955), who followed the water absorption of polymethylacrylate by determining the weight increase of the resin per unit of surface area exposed to the water. The samples used in their investigation increased in weight during a time period of about thirty days.

Sodium ions move very fast in isotonic solutions. The fact that maximum concentration of sodium within the test cups was not reached until after about twenty days indicates that the space between gold and resin is minute.

In the experiments, in which the gold cups were exposed to test solutions of 20° C and of 40° C the influx of $Na^{22}$ ions was increased in both groups, A and B. These findings were not unexpected. They are most probably due to the differences in the dimensional changes for resin and gold alloy following tempera-

ture variations. The linear thermal expansion coefficient for heat-cured acrylic resins is about six times that of gold alloys (*Lamstein & Blechman*, 1956) and explains the possibility of leakage between the metal structure and the resin facing during temperature changes. Such a phenomenon has been observed when acrylic fillings are chilled and warmed (*Nelsen, Wolcott & Paffenbarger*, 1952; *Spreter v. Kreudenstein*, 1953). The "pumping" action thereby exerted has been termed "percolation". There is also the possibility of change in shape of the acrylic facing due to stress release; a factor that needs to be further studied.

The shape of the facing, as varied in the present study, does not seem to be a factor of importance for the speed of permeation of test solution.

## SUMMARY

In the present study permeation of radiosodium ions, into gold alloy cups with resin facing material on perforated gold windows could be demonstrated within one day. The rapidity of the permeation was related to the retention arrangement used for the acrylic facing and to variations in temperature. The shape of the facings did not influence the rapidity of the permeation.

## RÉSUMÉ

### ÉTUDES COMPLEMENTAIRES SUR L'ECOULEMENT SE PRODUISANT ENTRE LES RÉSINES ACRYLIQUES ET L'OR DANS DES CUPULES D'OR À FACETTE DE RÉSINE

La présente étude a permis de mettre en évidence en moins d'une journée la pénétration d'ions de radiosodium dans des cupules d'alliage d'ore à facette de résine sur fenêtre d'or perforée. La rapidité de la pénétration était en rapport avec le dispositif de rétention utilisé pour la facette de résine et avec la variation de la température. La forme des facettes était sans influence sur la rapidité de la pénétration.

ZUSAMMENFASSUNG

WEITERE UNTERSUCHUNGEN ÜBER DIE ANSCHLUSSDICHTE VON AKRYLAT AN GOLD BEI FAZETTENKRONEN

In der vorliegenden Untersuchung konnte das Eindringen von radioaktiven Natriumionen in akrylatverkleidete perforierte Goldhütcher innerhalb eines Tages gezeigt werden. Die Geschwindigkeit des Eindringens stand in direkter Beziehung zur Temperatur und zu der für das Akrylat gewählten Retentionsart. Die Fazettenform war dagegen bedeutungslos.

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