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PARTICLE SIZE SEDIMENTATION OF DENTAL AMALGAM ALLOY

by

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INTRODUCTION

In recent years investigators seem to have focused increasing interest on the effect of particle form and size on the properties of dental amalgam as a permanent filling material. Promising pioneer work has been carried out with spherical amalgam alloys (*Demaree & Taylor* 1962, *Nagai & al.* 1966, 1967). A review of the literature discloses a general trend towards a smaller particle size of dental amalgam alloys than that used a couple of decades ago (*Peyton* 1964, *Skinner* 1967). The reasons for this are, for instance, improved properties of the material and factors of convenience for the operator; fine-cut alloys are also more likely to be accurately dispensed and mixed mechanically in modern proportioner-amalgamator devices.

The immediate effect of vibration on particle size distribution is easily demonstrated by placing a coarse-cut alloy in a large test tube. By mere inspection, a rapid movement of the small particles towards the bottom and the large particles towards the top is observed during vigorous vibration. Another means to demonstrate particle size sedimentation is to put alloy powder on a smooth glass slab, and then to make it vibrate in oblique position. Small particles are very easily separated from the larger ones. The mobility between particles in the spherical alloys is very great — the term semi-liquid could be used. Sedimentation was used as a term by *Hargreaves* and *Davies*

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(1964) for uneven distribution of small and large particles of dental amalgam alloy in the container. Small vibrations during transportation may have the same sedimentation promoting effect. Thus, without homogenization of the alloy powder before use, different particle sizes may be obtained from the top and bottom layers of a big container. Consequently, the properties of the amalgam made will depend on the level from which the alloy is taken *Jörgensen* 1967, *Skinner* 1967). As far as the present author is aware, no detailed analysis of the possible sedimentation of amalgam fillings has so far been published.

An analysis of the particle size in two conventional commercial amalgam alloy brands was undertaken in order to ascertain the possible effects of vibration, i.e. sedimentation of the alloy particles.

MATERIALS AND METHOD

Two commercial amalgam alloy brands available in large containers, called clinic packages, 1 000 g in each, were chosen for analysis, one domestic, and the other imported.

1. Sterling, Mfg. Co. Oy Dentaldepot Ab, Batch No.V. 1, July, 1957.
2. Ardent Mfg. Co. Bååths (Swedish) Control No. 570 703, Sept. 1957.

A new spherical alloy available in bottles of 100 g each was also analyzed in respect of particle size distribution.

3. Shofu spherical amalgam alloy Non-Zinc, Shofu Dental Mfg. Co., Ltd. Kyoto, Japan. Batch No. 1/67.

Artificial vibration was applied with an electric »Porex» apparatus (40 W, 220 V/50 c.AC), designed for eliminating air bubbles from plaster of Paris mix.

Particle size analysis of the conventional alloys was carried out in two series. In series I, 10 successive fractions of 100 gm were weighed out *without any vibration* of the container. The 100 gm fractions were then vibrated in a standard sieve series for 10 minutes each. This equals 3 000 shakes or blows. After this the particles retained at different sieve levels, 0.061—0.246, were carefully collected and weighed to the nearest mg. Thus the particle size distribution of each of the successive 100 gm fractions was found. The numbering of the successive layers or factions begins from the top with 1, and the last one, indicated by 10, means the last portion in the bottle, or the bottom layer.

Series II comprises a similar analysis of the particle size distribution in the same container *after vibration* for 15 minutes. The whole content was returned to the glass container of 1 000 gm, which was then subjected to vibration for 15 minutes which equals to 4 500 single vibrations.

When pouring alloy powder, the container was rolled from side to side in order to facilitate the smooth running of the powder. This procedure to some extent promoted mixing of the subsequent portions rather than keeping them strictly separated. This was done deliberately in order to simulate, as closely as possible, the pouring procedure followed in daily practice. The aim was to study how much sedimentation may affect particle size distribution in everyday working conditions.

Spherical (Shofu) alloy was delivered in glass containers of 100 gm. Five bottles were weighed without vibration and the same content was vibrated in the same sieve series for comparison. The vibration time, however, was only 5 minutes.

RESULTS

The results are given in graphic form (Figs. 1 & 2). The dosis numerals 1—10 indicate the subsequent portions of 100 gm each from top to bottom.

As seen from these figures and the percentage distribution of powder in each portion, no marked sedimentation was discovered in this series of analyses. The explanation obviously lies in the pouring procedure, which in fact promoted homogenization of the vibrated alloy. The differences between successive portions seemingly have no definite tendency and are here attributed to the random variation in the particle size distribution.

It may be assumed that in practice a satisfactorily homogeneous amalgam alloy particle size distribution of both conventional cut alloys occurs. The particle size distribution between these two alloys, however, was quite different. Any sedimentation is likely to disappear when a container is rolled from side to side.

The standard sieves used were not suitable for particle size analysis of the spherical alloy studied here. The whole content of all five bottles passed freely through the finest sieve level, with a rectangular mesh opening of 0.061×0.061 mm. Under the microscope the particle size range of this brand was found to be approximately 4—25 microns with spherical or ovoid shape. Several attempts were made to study the sedimentation of this particular brand of alloy, but without success.

DISCUSSION

The standard series of sieves used in this study seemed not quite suitable for analysis of the particle size found in these three brands of amalgam. However, the procedure yielded a clearly different pattern of particle size distribution

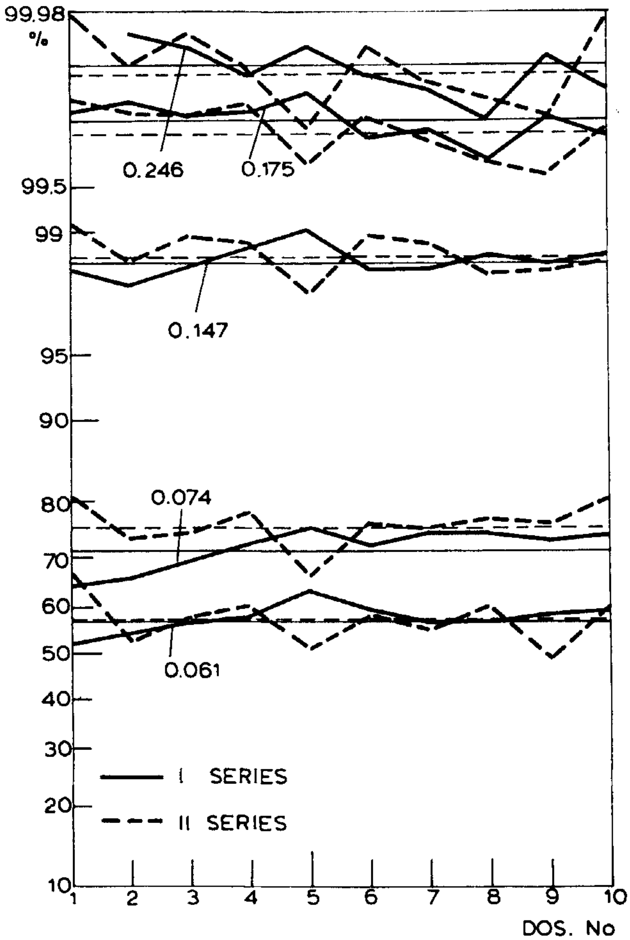

Fig. 1. Particle size distribution in a container of 1 000 gm. without (I series) and with (II series) artificial vibration. Sterling amalgam alloy brand. Sieves are indicated by inside figures from 0.061 to 0.246. Vertical marks 1—10 indicate successive portions of 100 gm.

between them, in spite of the fact that one-half or two-thirds of the cut particles were retained on the same level of 250. The other half or the last third, containing the largest particles, was differentiated into several small factions. For the purpose of this sedimentation analysis it may be considered satisfactory.

Sedimentation of the dental amalgam alloy may have unexpectedly deleterious effects on set dental amalgam, unless precautions are taken to prevent

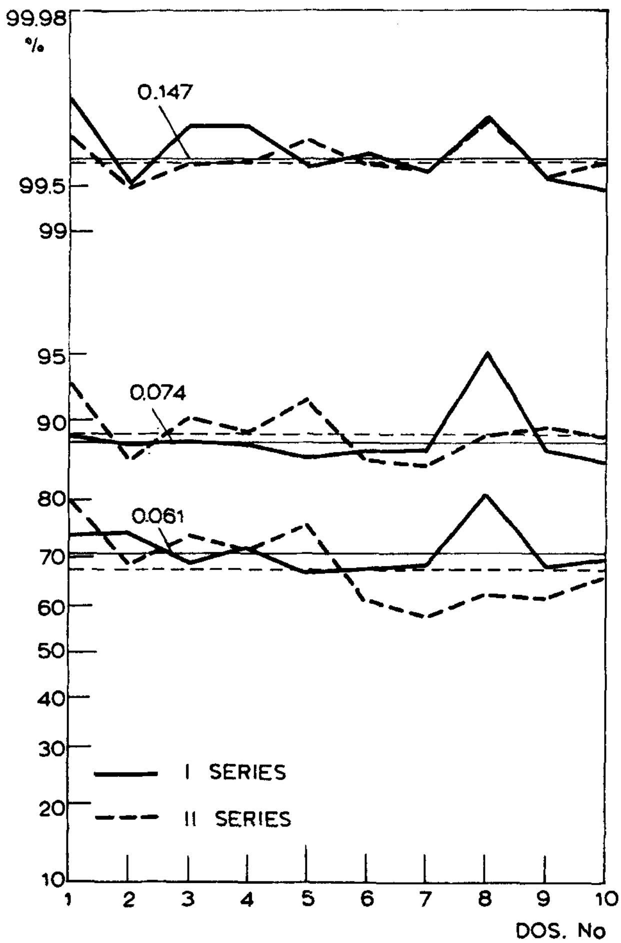

Fig. 2. Particle size distribution in a container of 1 000 gm. without (I series) and with (II series) artificial vibration. Ardent (Bååths) amalgam alloy brand. Sieves are indicated by inside figures from 0.061 to 0.147. Vertical marks 1—10 indicate successive portions of 100 gm.

it. Sedimentation is more liable to occur in big containers of coarse cut dental amalgam alloys during long transport and storage. However, the experiments reported here did not reveal any marked sedimentation after artificial vibration if the large containers were rolled when small quantities were measured for use. This procedure followed by pouring had the effect of homogenizing the particle size anew. The specific gravity properties of the heavy metal alloy powder also prevent sedimentation.

Sedimentation may be prevented or in any case minimized by using alloys of homogenous particle size, or of small particle size. The spherical amalgam alloys, which are more uniform and equal in size, seem to be superior in this respect. In preweighed and also in tablet amalgam alloys the responsibility for particle size homogeneity depends on the manufacturer, no longer on the dentist. In clinical practice this question is also of more concern to auxiliary employes rather than to dentists. However, the responsibility for the homogeneity of the amalgam alloy must be the dentists'.

SUMMARY

The author has analyzed the particle size distribution of two commercial amalgam alloys delivered in containers of 1 000 gm. The first series of successive portions of 100 gm each were weighed without any artificial vibration of the container and the second series after intentional vibration for 15 minutes. The analysis of successive portions, 100 gm each, revealed no marked sedimentation. When pouring, the big container was rolled from side to side in order to facilitate the smooth running of the powder. This procedure, similar to that followed in daily practice, seemed to have a homogenizing effect on particle size distribution.

These observations were made on two coarse cut alloys, and compared with one spherical alloy. The spherical alloy proved to be more homogeneous in this respect and showed no tendency to sediment.

RÉSUMÉ

LA SÉDIMENTATION DE PARTICULES D'ALLIAGES POUR AMALGAME

L'auteur a analysé le mode de distribution des particules de deux alliages commerciaux d'amalgame qui sont livrés dans les containers de 1 000 g. Les premières séries des portions successives de 100 g chacune furent pesées sans aucune vibration artificielle du container, et les autres séries après une vibration voulue de 15 minutes. Les résultats de l'analyse des portions successives de 100 g chacune, ne révélerent pas de sédimentation prononcée. Pour le vider, on roula le grand container d'un côté à l'autre afin de faciliter un écoulement uni de la poudre. Ce procédé, pareil à la pratique de chaque jour, apparament produit un effet homogénisateur sur la distribution des particules.

Ces observations ont été faites à partir de deux alliages conventionels, et comparées avec un alliage sphérique. L'alliage sphérique s'est révélé être plus homogène dans ce cas et difficile à rendre non homogène.

ZUSAMMENFASSUNG

ÜBER DIE SCHICHTUNG DER AMALGAMPARTIKEL

Der Verfasser hat die Verteiligung der Partikelgrössen in zwei im Handel befindlichen und in grossen, 1 000 g umfassenden Behältern verkauften Amalgampulvern analysiert. Die ersten Proben wurden ohne absichtliches Schütteln des Behälters und die zweite Serie nach 15 Minuten Schütteln gewogen. Die Ergebnisse werden in den Zeichnungen 1—2 wiedergeben. Die Analysenergebnisse zweier nacheinander gewogener, je 10 mal 100 g schwerer Serien wiesen keine deutliche Schichtung der Pulverpartikel auf. Beim Ausschütteln der gewogenen Pulvermengen aus dem grossen Behälter wurde er von einer Seite zu der anderen Seite gedreht, um das gleichmässige Ausfliessen des Pulvers zu erleichtern. Diese Methode, die dem Gebrauch entspricht, eliminiert wahrscheinlich die Schichtung der Pulverpartikel beim Ausschütteln.

Diese Beobachtungen wurden mit zwei Pulvern gemacht, die zu dem Feilspänetyp gehören, und mit einem Kugelamalgampulver verglichen. Die Partikelgrösse des Kugelamalgampulvers zeigte sich viel homogener und war auch nicht leicht unhomogen zu machen.

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