



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ³: C08K 9/06; A61K 6/00; C03C 1/04	A1	(11) International Publication Number: WO 82/00827 (43) International Publication Date: 18 March 1982 (18.03.82)
(21) International Application Number: PCT/US81/01104 (22) International Filing Date: 18 August 1981 (18.08.81) (31) Priority Application Number: 184,916 (32) Priority Date: 8 September 1980 (08.09.80) (33) Priority Country: US (71) Applicant: MINNESOTA MINING AND MANUFACTURING COMPANY [US/US]; 3M Center, P. O. Box 33427, St. Paul, MN 55133 (US). (72) Inventor: RANDKLEV, Ronald, M.; P. O. Box 33427, St. Paul, MN 55133 (US). (74) Agents: EDMUNDSON, Dean, P. et al.; Office of Patent Counsel, Minnesota Mining and Manufacturing Company, P. O. Box 33427, St. Paul, MN 55133 (US).		(81) Designated States: AT (European patent), AU, BR, CH (European patent), DE (European patent), FR (European patent), GB (European patent), JP, LU (European patent), NL (European patent), SE (European patent). Published <i>With international search report</i>
(54) Title: ZINC-CONTAINING GLASS COMPOSITION (57) Abstract Novel glass composition and a dental filling composition for making dental restorations. More particularly, the invention provides a radiopaque dental filling material. Specifically, the dental filling material contains a zinc-containing glass as the component imparting opacity to X-rays.		

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DescriptionZinc-Containing Glass CompositionTechnical Field

This invention relates to zinc-containing glass compositions and to dental filling compositions containing such glass composition in the form of finely divided filler.

Background Art

A variety of substances has been used over the years to repair damaged teeth. The best known currently include silver amalgams, which are frequently first encountered at an early age as a filling for small cavities, even in deciduous teeth. Gold alloys are a particularly valuable filling material, used frequently when a tooth has been considerably damaged, such as after several cavities have occurred and a lot of tooth must be restored. Frequently, for example, several smaller extending cavities, e.g. in the occlusal surface, will be combined and a restoration made with a single gold inlay or onlay. The gold alloys have gained an excellent reputation for strength, reliability and long life in service. However, both the gold alloys, and the other metals, such as the stainless steels, which have been technically successful in dental reconstructions and crowns, do not impart a natural tooth appearance.

Gold and other metallic-looking restorations are used for molars and teeth which are not immediately open to view when the wearer opens his mouth or smiles. For anterior teeth, however, current practice is to use materials closer in appearance to natural teeth. These are known colloquially as porcelain or plastic fillings. They are composite materials characterized by containing usually predominantly inorganic materials, normally finely divided powders, inert to the oral environment,



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bound together with polymeric material. The inorganic materials are frequently finely-ground fused oxides, particularly glasses, or crystalline quartz, while the polymer moiety is commonly a polyacrylate. These composite systems are available, for example, as pastes which are polymerized in situ, after having been activated, e.g. by adding a catalyst to initiate a polymerization reaction, just before being placed in the prepared tooth.

Fillings and restorations of this kind can be made to look much like natural teeth. In particular, the color of the restoration can be adjusted to a shade quite close to that of a patient's natural teeth by tinting with pigments. In addition, the translucency or pearly appearance of the natural tooth can also be approximated through adjustment of the relative refractive indices of the materials used in the restoration. When color and refractive indices are well matched, it is possible to obtain a restoration that is barely perceptible to the glance. However, the attainment of good color and overall appearance is very difficult to achieve in practice. This is particularly true when one desires also to optimize other features of a good restoration, particularly radiopacity.

It is highly desirable for a filling or other restoration to be radiopaque, for it is by X-ray examination that a dentist determines whether or not a filling remains sound. From radiographs a dentist determines the condition of a filling, e.g. whether it has cracked, or whether decay is occurring at the interface between the tooth and the filling. Fillings and restorations which are made of metal are readily observable in X-rays. Fillings of the porcelain/plastic art are not observable by X-rays unless they have radiopaque materials therein.

Currently, dental filling materials are rendered radiopaque by incorporating barium into the inorganic powder moiety of the filling material. The most effective radiopaque agents are elements of high atomic number (i.e. the "heavy elements" of the periodic table); it is unfortunate, however, that most of these elements are either radioactive or toxic, such as thorium or lead.

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Barium is toxic also, but in certain medical uses it is present in a form so highly insoluble that the body is unable to metabolize enough of it to become intoxicated. In dental applications barium glasses have been used as components of dental restorations, on the hypothesis that barium ions within the structure of a glassy matrix will not be available to oral fluids (saliva, beverages, etc.) and will not, therefore, pose a problem of toxicity. Examples of the use of barium glass in dental restorations can be found in U.S. Patents 3,801,344; 3,808,170; 3,826,778; 3,911,581; 3,959,212; 3,975,203 and 4,032,504. Unfortunately, in practice, the barium glasses are not as stable as had originally been hoped, and they have not, therefore, found favor in the art on account of the risk they pose of poisoning the patient (see, e.g. U.S. Patent 3,971,754). A further problem encountered with the barium glasses is that of matching refractive indices to that of the other components of the restoration. For example, it would be desirable to use components with refractive indices in the range of about 1.5 to 1.6 (so as to closely match the refractive index of commonly used organic binders) but most barium glasses with refractive indices in this range are unsuitable for dental use according to U.S. Patent 4,032,504. It is difficult, therefore, to prepare restorations containing barium glass which present an unobtrusive appearance when used for anterior surface repair. An additional problem of the barium glasses is their alkalinity. Typically, barium glasses show alkalinity values of pH 9 or greater, whereas a pH of 7 is preferred. Highly alkaline fillers appear to degrade the siloxane coating resulting from etching of the prepared tooth cavity and also cause rapid decomposition of any peroxide catalyst present in the dental restorative composition during storage.

Recent efforts in the field of dental restoration materials have resulted in the use of fillers other than barium-containing compounds as an X-ray detectable component. For example, U.S. Patent 3,971,754 describes the use of certain oxides or carbonates, particularly



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those of lanthanum, strontium, tantalum and, less use-
fully, hafnium. These salts are mixed with glass-making
components at the time the glass is made, yielding a
lanthanum, strontium, tantalum or hafnium glass which
5 possesses a measure of radiopacity. U.S. Patents
3,973,972 and 4,017,454 describe glass ceramics which
possess both a low coefficient of thermal expansion (an
advantage in dental fillings) and a useful degree of
radiopacity, by virtue of a high content of rare earth
10 elements, particularly lanthanum. The rare earth
elements absorb X-rays in the wavelength range of 0.2 -
0.3A, a range commonly available from dental X-ray
machines. However, the cost and problems with availabi-
lity of these rare earth fillers make them generally
15 unsuitable for commercial use.

In another approach to preparing radiopaque
composites for dental use, organic halide (e.g. an alkyl
iodide) has been incorporated into plastic materials
(e.g. acrylate polymers), from which molded articles
20 are made (e.g. U.S. Patent 3,715,331). However, the
articles molded from such compositions lack the strength
of restorations made from glass or ceramic materials.

U.S. Patent 4,250,277 describes a glass composition
used for crosslinking polycarboxylic acid cement, wherein
25 the glass contains zinc oxide and a large amount of boric
oxide, in addition to other ingredients. This glass,
however, is too water soluble to be useful in dental
restorative compositions and prosthetic devices.

U.S. Patent 4,215,033 describes a composite dental
30 material containing a glass which in one embodiment is
described as single phase. However, this patent does not
appear to recognize that a single phase glass containing
zinc oxide can be made radiopaque. Also, the single
phase glass composition described in this patent is very
35 difficult to make. Furthermore, such glass does not
contain any aluminum fluoride.



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Disclosure of Invention

In accordance with the present invention there is provided a novel glass and a dental filling composition comprising a polymerizable resin binder and a finely divided inorganic glass filler which is X-ray opaque and single phase, wherein said X-ray opaque inorganic glass filler consists essentially of, in percent by weight:

	Zinc oxide	20 to 35%
	Silica	45 to 65%
10	Boric oxide	3 to 15%
	Aluminum oxide	0 to 10%
	Aluminum fluoride	At least 2%
	Alkali metal oxide	0 to 3%
	or alkaline	
15	earth metal oxide	

wherein the combined weight of aluminum oxide and aluminum fluoride is at least about 10%, and wherein said glass exhibits an "X-ray absorption characteristic" of at least 1/16 inch (0.16 cm).

20 Best Mode for Carrying Out the Invention

It has been discovered that glasses containing high levels of zinc can be prepared which possess physical characteristics (e.g., refractive index, pH, coefficient of expansion) making them especially suitable for use in dental restorative compositions. Moreover, these glasses have been found to be radiopaque and to be capable of being made into dental composites which have greater radiopacity than those made with barium, the best known radiopacifying agent used heretofore. This is quite surprising, considering barium has an atomic number of 56, iodine an atomic number of 53, the

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lanthanides having atomic numbers of 57 to 71, and zinc having an atomic number of only 30. Moreover, it has been found possible to make the new zinc glasses with refractive indices in the desired range for dental restorative compositions. In addition, the new glasses can be prepared at a pH close to 7. This is a highly desirable feature in regard to the preparation of high quality dental composites. In particular, when the glass is near neutral in pH (i.e. 6.5 to 8), the stability of the dental composite is significantly enhanced. Improved color stability, and reliable setting characteristics after the activated composite is emplaced in the tooth being repaired. The new glasses are significantly better than the barium glasses of the prior art in this regard.

It is believed that the problems encountered with the barium glasses are contributed to by the relative alkalinity of these materials. Barium is an alkaline earth element in the periodic system, and, therefore, more electropositive than zinc, which is a transition element. The higher pHs characteristic of the barium glasses cause decomposition of the peroxide catalysts normally used in these formulations and thus greatly reduce storage stability. A significant advantage of the new glasses, which is an improvement over any known heretofore, is that they contain an element, namely, zinc, that has been in regular dental use for many years. Zinc oxide-containing ointments have long been used in medicine as safe and mild antibacterial agents and zinc oxide has long been used as a component in dental cements or adhesives. These latter agents are used for cementing prostheses, onlays, bridges, crowns, and the like, to the teeth. In this use they have proved safe and effective over many years. In other words, zinc compounds have a long history of being safe to use in the oral cavity, and are thus vastly preferable to use compared with those of unknown safety or known toxicity,



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such as compounds of barium.

The new single phase glasses used in this invention have the following composition in percent by weight:

	Zinc oxide	(ZnO)	20 to 35%
5	Silica	(SiO ₂)	45 to 65%
	Boric oxide	(B ₂ O ₃)	3 to 15%
	Aluminum oxide	(Al ₂ O ₃)	0 to 10%
	Aluminum fluoride	(AlF ₃)	At least 2%
	Alkali metal oxide		0 to 3%
10	or alkaline		
	earth metal oxide		

wherein the combined weight of aluminum oxide and aluminum fluoride is at least about 10%, and wherein the glass exhibits an "X-ray absorption characteristic" of at least 1/16 inch (0.16 cm). The alkali metal oxide or alkaline earth metal oxide may be, for example, sodium oxide, potassium oxide, lithium oxide, calcium oxide, magnesium oxide, or the like, or combinations thereof, so long as the combined weight of such oxides does not exceed about 3% of the glass, thus maintaining the pH of the glass in the desired range of about 6.5 to 8. Of course, as will be recognized by those skilled in the art, various other ingredients may also be present in minor amounts so long as the resulting glass exhibits the desired X-ray opacity and the desired pH. However, it is highly preferred to avoid the inclusion of toxic metals such as lead, cadmium, mercury, arsenic, etc.

A preferred embodiment of the new glass for use in dental restoratives intended for anterior applications has the following composition:

	Zinc oxide	25 to 28%
	Silica	46 to 48%
	Boric oxide	6 to 9%
	Aluminum oxide	1 to 3%
35	Aluminum fluoride	17 to 19%



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wherein the combined weight of aluminum oxide and aluminum fluoride is not greater than about 20%, and wherein the glass exhibits an X-ray absorption characteristic of at least 3/32 inch (0.24 cm).

5. The compositions given above are written in terms of the salts (e.g. oxides and fluorides) which are used in preparing the melt from which the glass is obtained upon cooling. This is a common practice in the glass-making art. There is, of course, no oxide, fluoride, or other simple salt in the resultant glass. Glasses used in this invention all possess a useful degree of radiopacity.

- The refractive index of the glass may be varied, depending upon the particular amount of each ingredient present. It is preferred that the refractive index of the glass filler be substantially the same as that of the binder resin when the glass is used in a dental filling composition, i.e. within about 0.05, when the composition is used in anterior applications. When the binder resin comprises the well known BIS-GMA, the refractive index for the glass filler is preferably 1.556 ± 0.05 . Matching of the refractive indices of the glass filler and the binder resin is less important when the composition is intended for posterior dental applications.

- 25 When BIS-GMA resin is diluted with another acrylic resin (e.g. triethyleneglycol dimethacrylate) to facilitate higher filler loadings to make a composition having particular use for posterior filling applications, the resultant resin mixture may have a refractive index of 1.545, for example. Consequently, for such an application it may be preferred to use a glass composition having a refractive index of 1.545 if close matching of the resin and filler is desired. When it is desired to prepare a dental filling composition which is light curable it is important to obtain a close match of the refractive indices of the polymerizable resin and the



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glass filler so that complete and rapid cure of the resin will be achieved when it is exposed to the activating light. Of course, when the composition is intended for use elsewhere in the body (i.e. where esthetics are not a factor) and where the composition is not light curable, there is no need to attempt matching the refractive index of the glass to the refractive index of the binder resin.

Radiopacity, which reflects the materials's ability to attenuate X-rays, is conveniently measured by comparing the X-ray film image density values of a disc of the cured composite of a standard thickness, e.g. 0.040 inch (0.1 cm), with corresponding values of a known standard. Film image density measurements are made with a suitable densitometer, such as a Macbeth Transmission Densitometer, Model TD 504, with visible light filter (manufactured by Macbeth Div. of Kollmorgen Corp., Newburgh, N.Y.). A convenient standard is a stepped aluminum wedge, for example, a ten step wedge having a thickness of 1/32 inch (0.08 cm) at the thinnest step increasing to 5/16 inch (0.8 cm) at the thickest step. One empirically determines the X-ray film image density values corresponding to steps on the wedge, which indicate degrees of X-ray beam attenuation which provide, in actual practice, proper differentiation between a composite restoration and the surrounding tooth structure. A proper level of radiopacity will permit one skilled in the art to differentiate between the restoration and primary and recurrent caries in the tooth structure, and will also visualize defects in the restoration itself. By way of illustration, using a wedge, the glasses of this invention when tested in this manner give values of 1/16 inch (0.16 cm) at 26% ZnO; 3/32 - 1/8 inch (0.24 - 0.32 cm) at 26.5 - 28% ZnO. Typical barium glasses of the prior art, tested under identical conditions give values of 1/16 - 3/32 inch (0.16 - 0.24 cm). The typical "plastic" or "porcelain" filling materials (containing quartz or borosilicate filler) common in contemporary dental



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practive give values of zero. A silver amalgam gives a values of $> 5/16$ inch (0.8 cm). It will be understood, of course, that these values are completely empirical. Using different wedges and experimental apparatus, the actual numbers one gets may be different. For the purposes of this invention, useful glasses exhibit an X-ray absorption characteristic of at least $1/16$ inch (0.16 cm).

Insofar as the preparation of the zinc glass is concerned, standard techniques well-known in the glass-making art are used. See, for example, The Handbook of Glass Manufacture, Fay and Tooley, Volume I (1974). After the melt has cooled, the glass is comminuted to a size that passes through a 325-mesh standard sieve (44 microns). For grinding the glass into smaller sizes a ball mill is used, and grinding aids such as ammonium carbonate or alcohols may be present in an amount of approximately 0.5% based on the weight of the glass.

When making dental composite restorative, the glass powder is then prepared for incorporating into an organic binder matrix by treating the surface with a silane compound. This is a well-known technique for rendering relatively polar materials, such as siliceous powders, more compatible with relatively non-polar materials, such as organic polymers.

The zinc glass is then mixed into a dental paste. The paste may be formed of any of the polymerizable resin systems useful in dentistry. Especially useful resin systems comprise free-radically polymerizable materials such as the polyfunctional acrylate systems. Particularly useful in the system is BIS-GMA, a well-known material which is the reaction product of bisphenol-A and glycidyl methacrylate, widely used in dentistry. Other commonly used resin binders include polyurethanes, methyl methacrylate, and isobutyl methacrylate.

The zinc glass may be used alone or it may be blended with other suitable materials, such as inert glass powders, when mixed into the binder - depending, for example, on the degree of radiopacity desired in the

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final composite. Along with the glass, other materials may also be mixed into the paste, such as pigments for making the restoration match the patient's natural tooth color, and reagents like hydroquinone monomethyl ether, as an inhibitor of premature polymerization of the binder. Immediately before use, and after the dentist has prepared the tooth for receiving the restoration, the paste is activated by mixing into it the appropriate amount of catalyst, such as benzoyl peroxide. For example, the dental restorative composition may be in the form of two pastes (one paste containing filler, resin binder and catalyst while the other contains filler, resin binder and accelerator), or a liquid resin and powdered filler system, or a paste-liquid resin, or any other desired form. The mixed composition is promptly emplaced in the tooth, hardening in the manner characteristic of the resin binder and catalyst system being used. For example, using the well-known BIS-GMA/benzoyl peroxide system, the composite becomes grossly rigid in about 5 minutes and may be finely ground and polished, to give the finished restoration, in about 10 minutes. At any time after emplacement, but more particularly after significant time has elapsed, such as many months or years afterwards, the condition of the restoration and the adjacent tooth structures can be determined by diagnostic dental X-rays.

Curable compositions which contain the novel glass and which are useful in other applications (e.g. medical and dental prostheses, pit and fissure sealants, hard tissue cements) may be prepared in similar fashion using polymerizable resin binders.

The invention is further illustrated by means of the following representative examples wherein the term "parts" refers to parts by weight unless otherwise indicated.



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Example 1

Silica (47 gms), zinc oxide (26 gms), boric oxide (8 gms), aluminum oxide (1 gm) and aluminum fluoride (18 gms) are thoroughly mixed, as fine powders, in a silica-lined crucible. The mixture is heated in a muffle furnace at 1450°F. (788°C.) until the powder has become a transparent melt.

The molten glass is then removed from the crucible through a small hole in the crucible wall, by tilting the crucible and allowing a thin stream of glass to flow through, giving a filament of glass of about 1/32 inch (0.08 cm) diameter. This filament is quenched rapidly in cold water, to give a completely clear glass (as opposed to being opalescent). Mere air cooling of the glass is not sufficiently rapid to prevent phase separation.

The clear glass is then ground, e.g. in a ball mill, to a mean particle size range of 0.5 - 15 μ m.

Example 2

Gamma-methacryloxy-propyltrimethoxy silane (2 gms) is mixed with glacial acetic acid (0.033 gms) and water (44.4 gms) in a plastic beaker. Glass powder (100 gms for example, from Example 1) is added to the mixture, and the system is stirred for 1.5 hours at room temperature. The glass slurry is dried by warming it at 140°F. (60 C.) for 24 hours, followed by heating it in an oven for 2.5 hours at 240°F. (115° C.).

Example 3

Two pastes, A and B, are prepared, having the following compositions:

<u>Ingredient</u>	<u>Paste A</u>	<u>Paste B</u>
BIS-GMA resin	14.48 gm	14.67 gm
Triethylene glycol dimethacrylates	4.67	4.63
Silane-treated filler (from Example 2)	30.0	30.0
Benzoyl peroxide	- - - -	.21
Dihydroxyethyl p-toluidine	.46	- - - -

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Ingredient	Paste A	Paste B
"Tinuvin P", a UV absorber	.16	- - - -
Phenylsalicylate glycidyl	.14	.16
methacrylate adduct, a UV absorber		
Butylated hydroxytoluene	- - - -	.16
Bisphenol A	- - - -	.14
Pigments-titanium dioxide and iron oxides - yellow raw sienna, burnt umber), ottalume	.17	.17

TOTAL 100.00 gm 100.00 gm

The pastes are prepared as follows:

For each paste, A and B, two preliminary mixes are made. The glass (from Example 2) and the pigments are mixed thoroughly to give an evenly colored powder. This mix is the same for each paste. The resins, accelerator, UV absorbers and inhibitor are mixed to give the mix for paste A. The resins, catalyst, UV absorber, and inhibitor are mixed to give the mix for paste B. After the two mixes, glass and resin based respectively, have been prepared, the procedure for preparing each paste, A and B, is the same.

Each resin mix is added to a vessel and then the respective glass mix is added. The two mixes are first roughly blended together, such as by shaking, and are then thoroughly mixed preferably by prolonged mechanical mixing.

The resultant homogeneous pastes, A and B, are the precursors to the dental restorations made from the materials of this invention. Pastes A and B are kept separate until immediately before the appropriate repair is made in a tooth which has been prepared to receive it. They are then mixed together thoroughly and promptly emplaced in the manner well-known in dental art.

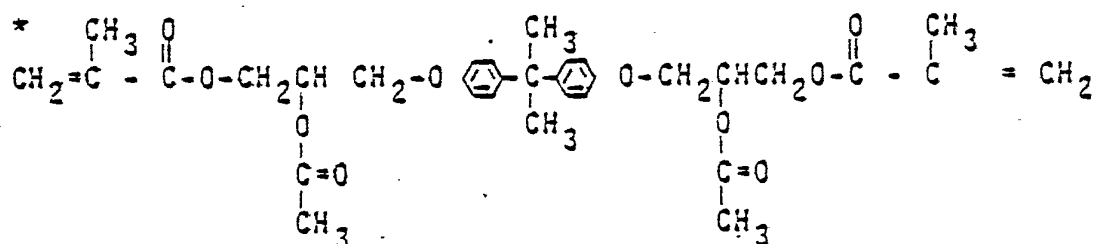
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Example 4

Using the procedure of Example 3, two pastes, A and B, are prepared having the following compositions:

<u>Ingredient</u>	<u>Paste A</u>	<u>Paste B</u>
Diacetyl BIS-GMA resin*	19.20 gm	19.57 gm
Silane treated filler	80.0	80.0
(from Example 2)		
Benzoyl peroxide	- - - -	.24
Dihydroxyethyl p-toluidine	.47	- - - -
"Tinuvin P" - a UV absorber	.16	- - - -
Butylated hydroxytoluene	- - - -	.02
Pigments - titanium dioxide and	.17	.17
iron oxides (yellow, raw sienna,		
burnt umber), ottalume		

TOTAL 100.00 gm 100.00 gm



The two pastes, when mixed together, form a very useful dental restorative composition.

Example 5

The glass filler of Example 1 was ball milled to a mean particle size of 4.5 microns and silane treated according to the method described in Example 2. A light-curable paste was prepared having the following compositions.

<u>Ingredient</u>	<u>Parts</u>
BIS-GMA resin	5.655
Triethylene glycol dimethacrylate	5.655
Triphenyl antimony	.002
N,N-diethylaminoethyl methacrylate	.47
dl - camphoroquinone	.048
Silane treated filler + 1.58% by weight "Aerosil R-972"	88.0

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<u>Ingredient</u>	<u>Parts</u>
Pigments - titanium dioxide, iron oxides (yellow, raw sienna, burnt umber) and ottalume	.17

5 TOTAL 100.00

The paste is prepared as follows:

The milled and treated filler (from Example 2), Aerosil R-972 (colloidal silica, commercially available from DeGussa Corporation, average particle diameter of 10 16 millimicrons, surface area of 110 square meters/gram) and the pigments are blended to give an evenly colored powder. The resins, inhibitor, accelerator and photoinitiator are mixed in a dark area in a vessel excluding light. The filler blend is then added to the 15 mixing vessel containing the resin mix. The filler, resins and other components are then thoroughly mixed by prolonged mechanical mixing, with the entire operation carried out in the absence of light.

A commercially available "KULZER TRANSLUX" irradiation device with a light guiding rod is used to cure 20 the paste. Test samples are prepared by packing the paste into an open-ended Teflon mold with a cylindrical cavity. The loaded mold is then placed between 2 pieces of clear polyester film (each 25 microns thick). Test 25 samples of prescribed thickness are then irradiated for a period of exposure necessary to polymerize or cure the resin in the paste. Barcol hardness measurements are made on the top and bottom of the test sample to determine the extent of polymerization. The following Barcol 30 hardnesses are determined on cured test samples using two different sample thicknesses.

		<u>Hardness</u>	
		<u>1 Min. Post Cure</u>	<u>1 Hr. Post Cure</u>
35	2 mm sample thickness	81 - top side	91 - top side
	- 20 sec. exposure	64 - bottom side	82 - bottom side
	3 mm sample thickness	83 - top side	86 - top side
	- 20 sec. exposure	56 - bottom side	74 - bottom side

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Barcol hardness values in excess of 80 are considered outstanding. Standard, commercially available dental restorative composites typically have Barcol hardness values of 70 - 75 after 24 hours cure.

- 5 The filler loading levels of 88% attained with the zinc glass must also be considered to be extraordinary. Conventional radiopaque barium glass permits maximum filler loadings of 78 - 80% when using similar particle size distributions.

10

Example 6

- The glass filler of Example 1 was ball milled to a mean particle size of 1.8 microns and silane treated according to the method described in Example 2. A light-curable paste having the following composition was prepared using the procedure of Example 5:

<u>Ingredient</u>	<u>Parts</u>
BIS-GMA resin	7.09
Triethylene glycol dimethacrylate	7.09
Triphenyl antimony	.003
20 N,N-diethylaminoethyl methacrylate	.59
dl - camphoroquinone	.059
Silane treated filler + 10% by weight	85.0
"OX-50" (colloidal silica commercially available from DeGussa Corporation, average particle diameter of 40 millimicrons, surface area of 50 square meters/gram)	
25 Pigments - titanium dioxide, iron	.168
30 oxides (yellow, raw sienna, burnt umber) and ottalume	

TOTAL 100.00

- Barcol hardnesses were determined on 2 mm thick test samples of composition cured at two different exposure times:

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		<u>Hardness</u>	
		<u>1 Min. Post Cure</u>	<u>1 Hr. Post Cure</u>
	20 sec. exposure	83 - top side	-
		22 - bottom side	-
5	30 sec. exposure	83 - top side	84 - top side
		54 - bottom side	75 - bottom side

Example 7.

The glass filler of Example 1 was ball milled to a mean particle size of 4.5 - 5.0 microns. Radiopaque impression pastes, containing the ingredients listed below, were prepared by mixing the ingredients in a conventional Ross brand mixer:

<u>Ingredient</u>		<u>Paste A</u>	<u>Paste B</u>
15	Low molecular weight vinyl siloxane polymer (2300 cps)	2000 grams	1800 grams
	Filler of Example 1 (not silane treated)	1700 grams	1700 grams
	Chloroplatinic acid (catalyst)	4.2 grams	- - -
20	Hydrogen polysiloxane	- - -	70 grams

The concentration of the filler may be varied, as desired, to produce compositions having various viscosities. Compositions containing 30 - 40% filler are of low viscosity, while compositions containing 80 - 90% filler have a putty consistency.

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Claims

1. A single phase glass composition consisting essentially of, in percent by weight:
- | | |
|--|-------------|
| Zinc oxide | 20 to 35% |
| Silica | 45 to 65% |
| Boric oxide | 3 to 15% |
| Aluminum oxide | 0 to 10% |
| Aluminum fluoride | At least 2% |
| Alkali metal oxide or
alkaline earth metal
oxide | 0 to 5% |
2. A dental filling composition comprising a polymerizable resin binder and a finely divided inorganic glass filler which is X-ray opaque and single phase, wherein said glass filler has the composition of claim 1.
3. A composition in accordance with claim 2, wherein said binder comprises a free-radically polymerizable resin.
4. A composition in accordance with claim 3, wherein said polymerizable resin binder comprises BIS-GMA.
5. A composition in accordance with claim 2, wherein the index of refraction of said glass filler and said resin are substantially the same.
6. A composition in accordance with claim 2, wherein said composition is in the form of two pastes, the first said paste comprising polymerizable resin binder, inorganic glass filler, and a catalyst,



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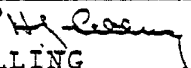
and the second said paste comprising polymerizable resin binder, inorganic glass filler, and an accelerator.

- 5 7. A composition in accordance with claim 6, wherein said filler represents at least about 70% by weight of each said paste.
8. A composition in accordance with claim 6, wherein said binder in each said paste comprises BIS-GMA.
- 10 9. A composition in accordance with claim 4, wherein said glass filler consists essentially of, in percent by weight:
- | | | |
|----|-------------------|-----------|
| 15 | Zinc oxide | 25 to 28% |
| | Silica | 46 to 48% |
| | Boric oxide | 6 to 9% |
| | Aluminum oxide | 1 to 3% |
| | Aluminum fluoride | 17 to 19% |
- wherein the combined weight of aluminum oxide and aluminum fluoride is not greater than about 20%.



INTERNATIONAL SEARCH REPORT

International Application No. PCT/US81/01104

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ¹					
According to International Patent Classification (IPC) or to both National Classification and IPC					
INT. CL. ²	C08K- 9/06	A61K- 6/00	C03C- 1/04	U.S. 260/42.15 260/42.52	260/42.53 260/D1636 260/998.11
II. FIELDS SEARCHED					
Minimum Documentation Searched ⁴					
Classification System	Classification Symbols				
U.S. CL.	260/42.15 106/35	260/42.52 106/52	260/42.53 106/54	260/998.11	260/D1636
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵					
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴					
Category ⁶	Citation of Document, ¹⁵ with indication, where appropriate, of the relevant passages ¹⁷				Relevant to Claim No. ¹⁸
A	US, A, 3,715,331 PUBLISHED FEBRUARY 6, 1973, MOLNAR				
A	US, A, 3,826,778 PUBLISHED JULY 30, 1974, DIETZ				
A	US, A, 3,873,327 PUBLISHED MARCH 25, 1975, DUFF				
A	US, A, 3,882,080 PUBLISHED MAY 6, 1975, SCHMITT ET AL				
A	US, A, 3,911,581 PUBLISHED OCTOBER 14, 1975, DIETZ				
X	US, A, 3,971,754 PUBLISHED JULY 27, 1976, JURECIC				1-8
A	US, A, 3,973,972 PUBLISHED AUGUST 10, 1976, MULLER				
A	US, A, 4,017,454 PUBLISHED APRIL 12, 1977, MULLER				
¹⁶ Special categories of cited documents: ¹⁵					
¹⁶ "A" document defining the general state of the art ¹⁶ "E" earlier document but published on or after the international filing date ¹⁶ "L" document cited for special reason other than those referred to in the other categories ¹⁶ "O" document referring to an oral disclosure, use, exhibition or other means			¹⁶ "P" document published prior to the international filing date but on or after the priority date claimed ¹⁶ "T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention ¹⁶ "X" document of particular relevance		
IV. CERTIFICATION					
Date of the Actual Completion of the International Search ¹ 12 OCTOBER 1981			Date of Mailing of this International Search Report ¹ 30 OCT 1981		
International Searching Authority ¹ ISA/US			Signature of Authorized Officer ¹⁹  H. J. LILLING		

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	US, A, 4,028,325 PUBLISHED JUNE 7, 1977, KING ET AL	
A	US, A, 4,050,947 PUBLISHED SEPTEMBER 27, 1977, AHLGREN ET AL	1-8
A	US, A, 4,215,033 PUBLISHED JULY 29, 1980, BOWEN	
A, ^p	US, A, 4,250,277 PUBLISHED FEBRUARY 10, 1981, MARIES ET AL SEE EXAMPLES ESPECIALLY #15 (K437), COLUMN 13 - LINE 60 THROUGH COLUMN 14, LINE 8, AND COLUMN 2, LINE 40.	1-8

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE ¹⁰

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers _____, because they relate to subject matter ¹² not required to be searched by this Authority, namely:

2. ☐ Claim numbers _____, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out ¹³, specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING ¹⁴

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.
☐ No protest accompanied the payment of additional search fees.