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(54) Title: AESTHETIC, OPALESCENT COLD-POLYMERIZABLE DENTAL RESTORATIVE

(57) Abrégé/Abstract:
A cold-polymerizable dental material is rendered opalescent by the addition of a small amount of microfine titanium dioxide. The material enhances the lifelike appearance of a dental restoration or appliance.

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ABSTRACT OF THE DISCLOSURE

A cold-polymerizable dental material is rendered opalescent by the addition of a small amount of microfine titanium dioxide. The material enhances the lifelike appearance of a dental restoration or appliance.

AESTHETIC, OPALESCENT COLD-POLYMERIZABLE DENTAL MATERIALS

TECHNICAL FIELD

This invention relates to filled dental materials. In another aspect, this invention relates to dental restoratives, composites and cements.

BACKGROUND ART

A variety of materials have been used to reinforce or to pigment cold-polymerizable (i.e., polymerizable without the use of elevated temperatures) dental composites, restoratives and cements. For example, U.S. Patent Nos. 4,281,991 and 4,029,632 describe dental prosthetic devices containing submicron silica (and in the case of the '991 patent, submicron aluminum oxide). The articles of the '991 patent are said to have opalescence.

OTHER ART

For brevity, titanium dioxide with a particle diameter less than 0.2 micrometers will be referred to in this application as "microfine titania". Degussa Technical Bulletin No. 56 entitled "Aluminum Oxide C, Titanium Dioxide P 25—Two Highly Dispersed Metal Oxides from Degussa Produced by the AEROSIL®-Process" refers at page 8 to various uses for the microfine titania "Titanium Dioxide P 25", and states:

> "In opposition to other pigments which are also used as stabilizers, Titanium Dioxide P 25 offers the advantage of being almost colorless and thus of having practically no effect on the shades of color specified.

"Because of its more opalescent than pigmenting effects, and because of the extreme fineness of its particles, Titanium Dioxide P 25 is used in cosmetics for the tinting of pigments, used in nail polishes and to improve the suspension properties of these pigments. Amounts of Titanium Dioxide P 25 varying from 0.5-1.0% are added and should be dispersed with the pigments in the polish. Ointments and creams can also be delustered with Titanium Dioxide P 25.

"In the field of dentistry, bulk materials used for the production of false teeth can be tinted with Titanium Dioxide P 25."

This publication does not specify what the "bulk materials used for the production of false teeth" might be made from. False teeth typically are made from porcelain and other ceramics, and from methyl methacrylate and other acrylic resins. If acrylic, these resins are generally polymerized using heat.

Microfine titania is said to be useful for the manufacture of pearlescent automotive paint formulations, as described in U.S. Patent Nos. 4,539,258 and 4,753,829, and in A. Blair Battistini, "Opalescent Colors for Automotive Coatings", American Paint and Coatings Journal, 43-45 (April 8, 1991).

Conventional pigment grade titanium dioxide typically has an average particle size of about 0.2 to 0.5 micrometers. Particles of that size provide optimal scattering of all wave lengths of visible light.

SUMMARY OF THE INVENTION

Although some cold-polymerizable dental materials contain pigment grade titanium dioxide, we are not aware of any cold-polymerizable dental materials which contain microfine titania.

Several dental manufacturers currently market cold-polymerizable dental restorative materials intended to replicate the optical properties of the dentin or enamel layers of teeth. These products

include "DENTACOLOR" restorative from Kulzer, Inc., "CONCEPT" restorative from Vivadent, Inc., "VISIO-GEM" restorative from Espe GmbH, "HERCULITE XR" restorative from the Kerr Division of Sybron, Inc., and "VALUX" and "SILUX PLUS" restoratives from 3M. VALUX restorative contains pigment grade titanium dioxide but no microfine titania. The other commercial materials are not believed to contain microfine titania.

The present invention provides, in one aspect, aesthetic cold-polymerizable dental materials that exhibit lifelike opalescence. The materials comprise:

a) a minor amount of polymerizable resin,

b) a major amount of organic or inorganic filler,

c) cold-polymerization initiator, and

d) sufficient microfine titania to enhance the opalescence of the material after the material has been polymerized.

The invention also provides a method for making a lifelike cold-polymerizable dental material comprising the step of adding to the material sufficient microfine titania to enhance the opalescence of the material after it has been polymerized.

Other small particle fillers such as submicron silica and submicron alumina can impart a small degree of opalescence to a cold-polymerizable dental material. However, microfine titania appears to be a particularly effective opalizer.

BRIEF DESCRIPTION OF THE DRAWING

The accompanying drawing is a graph showing transmission and reflection b^* color coordinates for cold-polymerizable restoratives containing microfine titania, microfine silica and microfine alumina, measured under standard daylight conditions.

DETAILED DESCRIPTION

A "cold-polymerizable" dental material is one that contains an initiator that can render the material polymerizable while in the mouth of a patient. The materials of the invention can, if desired, be polymerized outside the mouth (for example, in a dental laboratory).

The dental materials of the invention have "opalescence" when their b^* color coordinates exhibit greater yellow levels in transmission (i.e., higher b^* color coordinates) or lesser yellow levels in reflection (i.e., lower b^* color coordinates) when compared to a material containing no microfine titania, and evaluated using the technique described below in EXAMPLE 1. b^* Color coordinates can be obtained by CIELAB (CIE 1978) color determination as described in Billmeyer & Saltzman, Principles of Color Technology, 2nd Ed., pp. 62-65 (1981). Preferably the Δb^* value (that is, the transmission b^* color coordinate minus the reflection b^* color coordinate) for a 1 mm thick sample of the material (for example, the "modified restorative", that is, a restorative containing microfine titania) minus the Δb^* value for the unmodified material is greater than 9, more preferably greater than 15, and most preferably greater than 20.

The dental materials of the present invention contain polymerizable resin. The polymerized resin preferably has sufficient strength and hydrolytic stability to render it suitable for use in the mouth. Acceptable polymerizable resins will be familiar to those skilled in the art, and include acrylate, methacrylate, urethane acrylate and urethane methacrylate resins such as those referred to in column 3, lines 13-27 of U.S. Patent No. 4,503,169. A preferred polymerizable resin for use in the present invention is a mixture of diglycidylmethacrylate of bisphenol A (frequently referred to as "Bis-GMA") and

triethyleneglycol dimethacrylate (frequently referred to as "TEGDMA").

The dental materials of the present invention also contain organic or inorganic filler. The filler preferably has sufficient strength, translucency (or transparency), color, hydrolytic stability, particle size and shape to render it suitable for use in the mouth. Acceptable fillers will be familiar to those skilled in the art and include silica (e.g., quartz), aluminum oxide, barium oxide, aluminum silicate, lithium aluminum silicate, barium glasses, silicate glasses, fluoroaluminosilicate glasses, phosphate glasses, zinc glasses and zirconia:silica microparticles such as those described in U.S. Patent No. 4,503,169. Suitable organic fillers include ground polymerized acrylate and methacrylate resins. Preferably the ground polymerized resin contains an inorganic filler (e.g., finely-divided amorphous silica) of the type referred to in U.S. Patent No. 4,281,991.

Dental restorative materials of the so-called "hybrid" variety are particularly preferred for use in this invention. These contain fillers whose particles are small in size but not as small as those in the so-called "microfill" dental restoratives. In general, fillers for use in such hybrid dental restoratives have an average particle size between about 0.2 micrometers and about 10 micrometers. They have good physical properties but less than optimum aesthetics. If modified according to the present invention, a hybrid dental restorative can be made much more lifelike in appearance. Microfill dental restoratives (whose fillers typically have an average particle size less than about 0.1 micrometers) can also be rendered more opalescent by adding microfine titania according to the present invention. However, the improvement in

opalescence typically is less pronounced than is the case for hybrid dental restoratives.

The polymerizable resin and filler for both a restorative and a cement are present in "minor amount" and "major amount", respectively. By this is meant that the weight percent of the polymerizable resin is less than the weight percent of the filler. Expressed on a weight basis, a preferred resin amount is about 10 to about 40 percent of the restorative or cement, more preferably about 15 to about 30 percent. A preferred filler amount is about 85 to about 55 percent, more preferably about 85 to about 67 percent, including the weight of any silane treatment that may be present.

The dental materials of the invention also contain a cold polymerization initiator. Suitable cold polymerization initiators include thermal initiators and photoinitiators. Representative thermal initiators include peroxide compounds alone or in combination with suitable amines, sulfur compounds, phosphorus compounds and other compounds capable of reacting with the peroxide to generate free radicals. Suitable photoinitiators include ketone or alpha diketone compounds alone or in combination with suitable amines, peroxides, sulfur compounds, phosphorus compounds and other compounds capable of reacting with or being sensitized by the ketone or alpha diketone to effect polymerization of the resin.

The amount of polymerization initiator should be sufficient to permit rapid polymerization at room temperature, e.g., in less than about 10 minutes, more preferably less than about 5 minutes. For polymerization carried out outside the mouth heat may, if desired, be used to accelerate polymerization. Preferably, the total amount of polymerization initiator is less than about 5 weight percent of the dental material, and more preferably about 0.1 to about 2 weight percent.

Suitable microfine titania is available from a variety of sources. Acceptable materials include "TITANIUM DIOXIDE P 25" from Degussa and "MICRO TITANIUM DIOXIDE" grades MT-100HD, -100S, -100SA, -100T, -150W, -500B, -500HD, -500SA, -600B and CT-70 from Teikoku Kako Co., Ltd. or from Dainichiseika Color and Chemicals America, Inc. The microfine titania particles have an average particle diameter less than one-half the shortest wave length of visible light, i.e., they have an average particle diameter less than about 0.2 micrometers. More preferably, the microfine titania particles have an average particle diameter less than about 0.1 micrometers, and more preferably less than about 0.06 micrometers. The particles can be made of rutile, anatase or brookite titanium dioxide. The particles can be essentially pure titania, or if desired can contain (or be coated with) or doped with materials such as alumina, silica, zirconia, laurates (e.g., aluminum laurate), stearates (e.g., aluminum stearate), and silanols (e.g., hydrolyzed gamma-methacryloxypropyl trimethoxysilane).

In general only very small amounts of microfine titania will be required. If too large an amount is employed then the dental material will become opaque and lose its lifelike appearance. For a restorative, the amount of microfine titania preferably is less than about 2 wt. %, more preferably about 0.01 to about 1 wt. %, and most preferably about 0.1 to about 0.6 wt. % of the dental restorative. For a cement, the amount of microfine titania preferably is less than about 5 wt. %, more preferably about 0.01 to about 4 wt. %, and most preferably about 0.05 to about 2.5 wt. % of the dental cement.

If desired, the compositions of the invention can contain other adjuvents such as polymerization accelerators, inhibitors, stabilizers, pigments, colorants, dyes, viscosity modifiers, extending or

reinforcing fillers, surface tension depressants and wetting aids, soluble fluorides, antioxidants, and other ingredients well known to those skilled in the art.

The ingredients of the dental material can be combined by mixing them in any convenient order using mixing devices of the type typically used in dental manufacturing. Preferably, the microfine titania and filler are dry-blended and then added to a mixture of the polymerizable resin and initiator.

The dental materials of the invention are packaged and dispensed using conventional techniques. They can be employed for posterior or anterior restorative applications, but are particularly preferred in anterior applications where aesthetics are paramount, (e.g., incisal edge applications). Such applications include coatings for dental metals and alloys (e.g., titanium, gold, palladium, chrome-cobalt alloys, and other nonprecious or semiprecious alloys commonly used in dentistry), coating for dental ceramics (e.g., alumina), implants, inlays, onlays, veneers, crowns, bridges, pontics, splints and other dental appliances that will be familiar to those skilled in the art. They can also be employed for anterior and posterior cement applications, including cementation of inlays and onlays and luting of veneers, crowns, bridges and other prosthetic devices to teeth. As noted above, the materials can be shaped and cured in the mouth or if desired, externally.

The following examples are offered to aid understanding of the present invention and are not to be construed as limiting the invention's scope.

EXAMPLE 1

25.5 Parts silica sol ("LUDOX" LS, E. I. du Pont de Nemours & Co.) were acidified by the rapid addition of 0.255 parts concentrated nitric acid. In a

separate vessel, 12.9 parts ion-exchanged zirconyl acetate (Magnesium Elektron Inc.) were diluted with 20 parts deionized water and the resultant solution acidified with 0.255 parts concentrated nitric acid. The silica sol was pumped into the stirred zirconyl acetate solution and mixed for one hour while filtering the stirred mixture through "CUNO" 5 micrometer and 1 micrometer filters (Commercial Intertech Corp.). The stirred, filtered mixture was further filtered through a 1 micrometer "HYTREX" filter (Osmonics, Inc.) followed by a 0.22 micrometer "BALSTON" filter (Balston Inc.). The filtrate was poured into trays to a depth of about 25 mm and dried at 65°C in a forced air oven for about 24 hours. The resulting dried material was removed from the oven and tumbled through a rotary tube furnace (Harper Furnace Corporation) preheated to 600°C. 21 Parts of calcined microparticles were obtained. The calcined microparticles were comminuted in a tumbling ball mill until all of the microparticles were less than 10 micrometers in particle diameter. 0.3 Part portions of the milled microparticles were placed in ceramic saggers and fired in an electric kiln (Harper Furnace Corporation) in air at 825°C for 1 hour. The fired microparticles were allowed to cool in air. The cooled microparticles were slurried in hydrolyzed gamma-methacryloxypropyl trimethoxysilane, dried in a forced air oven and screened through a 74 micrometer screen. The treated filler particles contained 11.1% silane.

A cold-polymerizable dental restorative paste was prepared by mixing 78.2 parts of the fired, silane-treated microparticles with a resin solution containing 19.9 parts of a 50:50 mixture of Bis-GMA:TEGDMA, 1.5 parts "ELVACITE" 2042 poly(ethyl methacrylate) (200,000–250,000 molecular weight, E. I. du Pont de Nemours & Co.), 0.2 parts ethyl 4-N,N-dimethylaminobenzoate, 0.1 parts diphenyliodonium

hexafluorophosphate, 0.03 parts camphorquinone and 0.02 parts hydroxytoluene. The resulting dental material had a 69.5% filler particle loading level, not counting the silane.

Microfine titania ("MICRO TITANIUM DIOXIDE MT-500HD", Teikoku Kako Co., Ltd.) was hand-kneaded into the restorative paste at addition levels of 0.1, 0.2, 0.4, 0.8 and 1.0 weight %. Each paste was hand-loaded into syringes, degassed and formed into 1 mm thick disks by pressing the paste into a 1 mm thick x 30 mm diameter mold. Each disk was cured with a "VISILUX 2" dental curing light (3M) using a 60 second exposure to each side of the sample, and a 1 cm distance between the output end of the light guide and the sample. Each cured disk was removed from the mold and postcured with a 15 minute exposure to the lamps in a "VISIO BETA" dental curing chamber (Espe GmbH). The b^* color coordinates for standard daylight conditions were measured for each disk using a "DIANO MATCH SCAN II" color computer (Bausch & Lomb Inc.) with a 25 mm diameter sample port. The b^* transmission color coordinates were obtained using the standard white color tile in the reflection sample port. The b^* reflection color coordinates were obtained using the standard black color tile behind the cured disk.

As a comparison, microfine alumina ("ALUMINUM OXIDE C", Degussa) and microfine silica ("OX-50", Degussa) were independently substituted for the microfine titania at 0.1, 0.2, 0.4, 0.8 and 1.0 weight % addition levels. A disk of each sample was prepared, cured and color measurements performed in the same manner as for the disks containing microfine titania.

Set out below in TABLE I are the transmission b^* and reflection b^* color coordinates for microfine titania, microfine alumina and microfine silica. The table also shows Δb^* values, which are obtained by subtracting the reflection b^* from the transmission b^*.

Table I

b* Color Coordinates						
Additive	% Additive in Paste					
	0	0.1	0.2	0.4	0.8	1.0
Microfine Titania:						
Transmission	4.72	22.49	23.83	30.81	37.38	35.51
Reflection	10.80	-4.25	-5.93	-4.23	-2.29	-2.82
Δb^*	-6.08	26.74	29.76	35.04	39.67	38.33
Microfine Alumina:						
Transmission	4.72	6.94	7.78	7.73	9.46	8.51
Reflection	10.80	2.13	2.22	2.55	1.20	-0.35
Δb^*	-6.08	4.81	5.56	5.18	8.26	8.86
Microfine Silica:						
Transmission	4.72	-0.40	-0.29	-0.35	0.69	2.10
Reflection	10.80	-3.31	-3.92	-4.77	-5.73	-5.99
Δb^*	-6.08	2.96	3.63	4.42	6.42	8.09

The above data show a much greater difference in b^* transmission and reflection color coordinates (i.e., larger Δb^* values) when small amounts of microfine titania are added to the restorative paste than when like amounts of either microfine alumina or microfine silica are added to the paste. The large Δb^* values correspond to a visually evident opalescent quality in the cured dental material.

The data in Table I can be further appreciated in reviewing the drawing. In the drawing, curves are shown for b^* color coordinates versus the weight percent of microfine titania, microfine alumina and microfine silica in a dental restorative paste. Curves 1 and 5 show the microfine titania b^* values in transmission and reflection respectively. The magnitude of Δb^* for microfine titania can be appreciated by considering the difference in vertical height for the two curves at any given microfine titania concentration level. The

substantial divergence of curves 1 and 5 corresponds to significant opalescence.

Curves for microfine alumina in transmission (curve 2) and reflection (curve 4) and microfine silica in transmission (curve 3) and reflection (curve 6) are also shown in the drawing. These latter four curves show that microfine alumina or microfine silica can impart a small amount of opalescence to a cold-polymerizable dental restorative material. However, the degree of opalescence is much less than is observed using microfine titania, and is much less noticeable by visual inspection.

EXAMPLE 2

Modification of Commercial Restorative Pastes

In a series of 6 runs, 0.4 parts microfine titania were hand-kneaded into 99.6 parts of the commercially available cold-polymerizable dental restoratives set out below in Table II:

TABLE II

Dental Restorative	Manufacturer	Lot No.
"SILUX PLUS 5702I"	3M	OBE1
"VALUX 5601TI"	3M	1DY1VR2
"DENTACOLOR Enamel A10"	Kulzer	06.10992 46
"PRISMA AP.H I"	Caulk/Dentsply	092890
"HERCULITE XR Light Incisal	Kerr	1 1039
"HELIOMOLAR WE20"	Vivadent	419501

The resulting modified pastes were evaluated as described in EXAMPLE 1. The b^* color coordinates for the unmodified pastes were measured for comparison purposes. Set out below in TABLE III are the b^* color coordinates

in transmission and reflection for the unmodified and modified commercial pastes, and the corresponding Δb^* values.

TABLE III

Commercial restorative paste	b^* Color Coordinates		
	Transmission	Reflection	Δb^*
"SILUX PLUS"			
Unmodified	27.56	-0.91	28.47
Modified	37.11	-0.42	37.53
"VALUX"			
Unmodified	20.97	10.76	10.21
Modified	32.87	-0.44	33.31
"DENTACOLOR"			
Unmodified	14.00	-4.75	18.75
Modified	37.83	4.05	33.78
"PRISMA AP.H"			
Unmodified	5.74	1.88	3.86
Modified	21.90	-5.06	26.98
"HERCULITE XR"			
Unmodified	14.08	-2.46	16.54
Modified	28.78	-1.23	30.01
"HELIOMOLAR"			
Unmodified	28.02	7.44	20.58
Modified	41.98	5.18	36.80

The above data illustrate that addition of a small amount of microfine titania to these commercial cold-polymerizable dental restoratives noticeably increases opalescence. For example, for SILUX PLUS restorative, Δb^* for the modified restorative minus Δb^* for the unmodified restorative is 9.06, indicative of a very noticeable improvement in opalescence. For PRISMA AP.H restorative, Δb^* for the modified restorative minus Δb^*

for the unmodified restorative is 23.12, indicative of a substantial improvement in opalescence. The modified restorative pastes would therefore be particularly appropriate for use as anterior or posterior restoratives where a lifelike appearance is desirable.

EXAMPLE 3

Preparation of a Dental Cement

Treated filler particles were prepared as detailed in EXAMPLE 1, except that the milled microparticles were fired at 1010°C for 2 hours and the treated filler particles contained 2.7% silane.

Paste "A" of a two part cold-polymerizable dental cement was prepared by mixing 84.0 parts of the fired, silane-treated microparticles with a resin solution containing 15.7 parts of a 50:50 mixture of Bis-GMA:TEGDMA, 0.1% dimethylaminophenethanol, 0.1 parts diphenyliodonium hexafluorophosphate, 0.03 parts camphorquinone and 0.01 parts hydroxytoluene. The resulting dental cement had a 81.7% filler particle loading level, not counting the silane.

Paste "B" of the cement was prepared by mixing 80.0 parts of the fired, silane-treated microparticles with a resin solution containing 19.7 parts of a 50:50 mixture of Bis-GMA:TEGDMA, 0.2 parts benzoyl peroxide and 0.02 parts hydroxytoluene. Part "B" had a 77.9% filler particle loading level, not counting the silane.

Microfine titania ("MICRO TITANIUM DIOXIDE MT-500HD", Teikoku Kako Co., Ltd.) was hand-kneaded into the "A" paste at addition levels of 0.4 and 2.2 weight %. Each "A" paste was formed into 30 mm in diameter disks of 1 mm and 0.3 mm thickness, cured and b^* color coordinates measured as described in EXAMPLE 1.

Set out below in TABLE IV are the transmission b^* and reflection b^* color coordinates for each addition level of microfine titania. The table also shows Δb^*

values, which are obtained by subtracting the reflection b^* from the transmission b^*.

Table IV

Disk Thickness	b^* Color Coordinates % Additive in Paste A		
	0	0.4	2.2
1 mm			
Transmission	12.04	27.15	39.63
Reflection	4.29	-2.30	0.00
Δb^*	7.75	29.45	39.63
0.3 mm			
Transmission	3.33	12.32	22.27
Reflection	-2.70	-10.15	-7.36
Δb^*	6.03	22.47	29.63

The data in TABLE IV show that the addition of a small amount of microfine titania to a cold-polymerizable dental cement paste noticeably increases opalescence. The large Δb^* values correspond to a visually evident opalescent quality in the cured dental cement. For example, the magnitude of the Δb^* values for the 0.4 and 2.2 wt. % addition levels is indicative of a very noticeable improvement in opalescence. Even when the thickness of the disks was reduced by two-thirds (i.e. 0.3 mm), a high degree of opalescence was retained. This is particularly important for veneer applications where only a thin layer of the dental cement paste (luting cement) may be present to contribute to enhancement of the lifelike appearance of the restoration.

One or both pastes can be modified with the addition of microfine titania, pigments, dyes, and viscosity modifiers (i.e., "AEROSIL R-972" from Degussa) to provide pastes with varying pigmentation for adjusting the shade of the final dental restoration. For example, the

amount of microfine titania, pigments, dyes and viscosity modifiers added to a luting cement can be adjusted by one skilled in the art to provide a desired opalescent quality as well as masking the coloration (i.e., tetracycine staining) or imperfections of the underlying tooth structure. This is particularly important for thin restorations such as veneers.

The "A" paste alone can be used for applications where light curing through a thin section of a composite or porcelain restorative material is desired. It has particular application for final placement of veneers. The "B" paste alone has application for provisional placement of a restorative material such as a veneer to determine shade acceptability. A mixture of paste "A" and paste "B" (preferably a 1:1 weight mixture) can be used for placement of veneers (particularly very thick or opaque veneers), inlays, onlays, crowns, bridges and other dental appliances where limited light curing capability can be utilized.

Although this invention has been described using certain illustrative examples, it should be understood that the invention is not limited to the specific exemplary embodiments shown in this specification.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A cold-polymerizable dental material comprising:

a) a minor amount of polymerizable resin,

b) a major amount of organic or inorganic filler,

c) cold-polymerization initiator, and

d) sufficient microfine titania to enhance the opalescence of the material after the material has been polymerized.

2. A material according to Claim 1, wherein the transmission b^* color coordinate is greater than that of a like material containing no microfine titania.

3. A material according to Claim 1, wherein the reflection b^* color coordinate is less than that of a like material containing no microfine titania.

4. A material according to Claim 1, wherein the transmission b^* color coordinate is greater and the reflection b^* color coordinate is less than that of a like material containing no microfine titania.

5. A material according to Claim 1, wherein the Δb^* value of the material minus the Δb^* value of a like material containing no microfine titania is greater than 9.

6. A material according to Claim 1, wherein the Δb^* value of the material minus the Δb^* value of a like material containing no microfine titania is greater than 15.

7. A material according to Claim 1, wherein the Δb^* value of the material minus the Δb^* value of a like material containing no microfine titania is greater than 20.

8. A material according to Claim 1, wherein the material is a restorative and comprises a hybrid whose filler has an average particle size between about 0.2 micrometers and about 10 micrometers.

9. A material according to Claim 1, wherein the material is a restorative and comprises a microfill whose filler has an average particle size less than about 0.1 micrometers.

10. A material according to Claim 1, wherein the microfine titania particles have an average particle diameter less than about 0.1 micrometers.

11. A material according to Claim 1, wherein the amount of resin is about 10 to about 40 weight percent, the amount of filler is about 85 to about 55 weight percent, and the amount of initiator is less than about 5 weight percent.

12. A material according to Claim 11, wherein the material is a restorative and the amount of microfine titania is less than about 2 weight percent of the restorative.

13. A material according to Claim 11, wherein the material is a cement and the amount of microfine titania is less than about 5 weight percent of the cement.

14. A material according to Claim 1, wherein the amount of resin is about 15 to about 30 weight percent, the amount of filler is about 85 to about 67 weight percent,

and the amount of initiator is about 0.1 to about 2 weight percent.

15. A material according to Claim 14, wherein the material is a restorative and the amount of microfine titania is about 0.01 to about 1 weight percent of the restorative.

16. A material according to Claim 14 ,wherein the material is a cement and the amount of microfine titania is about 0.01 to about 4 weight percent of the cement.

17. A material according to Claim 14, wherein material is a restorative and the amount of microfine titania is about 0.1 to about 0.6 weight percent of the restorative.

18. A material according to Claim 14, wherein the material is a cement and the amount of microfine titania is about 0.05 to about 2.5 weight percent of the cement.

19. A material according to Claim 1, wherein the material is a restorative and comprises a coating on a dental metal, alloy or ceramic.

20. A restorative according to Claim 19, wherein the metal or alloy comprises titanium, gold, palladium, or a chrome-cobalt alloy.

21. A material according to Claim 1, wherein the material is a cement and is used for cementation of a veneer, inlay, onlay, crown, bridge or other dental appliance.

22. A method for making a lifelike cold-polymerizable dental material, comprising the step of adding to the material sufficient microfine titania to enhance the opalescence of the material after it has been polymerized.

23. A method according to Claim 22, wherein the material is a restorative and the amount of microfine titania is less than about 2 weight percent of the restorative material.

24. A method according to Claim 22, wherein the material is a restorative and the amount of microfine titania is about 0.01 to about 1 weight percent of the restorative material.

25. A method according to Claim 22, wherein the material is a restorative and the amount of microfine titania is about 0.1 to about 0.6 weight percent of the restorative material.

26. A method according to Claim 22, wherein the material is a cement and the amount of microfine titania is less than about 5 weight percent of the cement.

27. A method according to Claim 22, wherein the material is a cement and the amount of microfine titania is about 0.01 to about 4 weight percent of the cement.

28. A method according to Claim 22, wherein the material is a cement and the amount of microfine titania is about 0.05 to about 2.5 weight percent of the cement.

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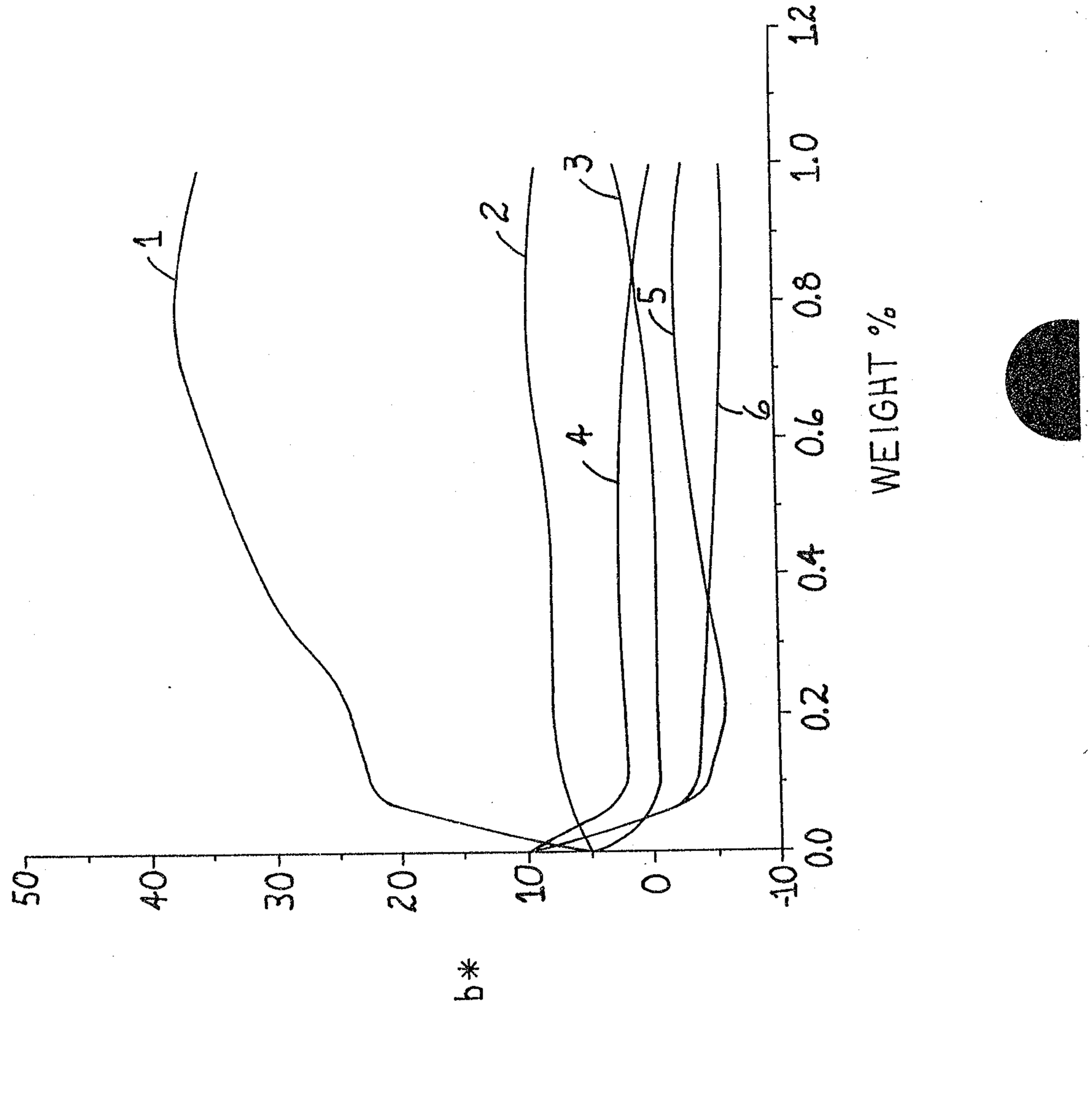

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