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USE OF FLUORESCENT DYES IN DENTAL DIAGNOSTIC METHODS

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This invention relates to means for making visible to the disease-causing foreign matter in the oral cavity. More particularly, it has reference to means for making readily visible such foreign matter as plaques, microcosms, tartar, materia alba and the like.

Various chemicals and drugs have long been used for delineating pathological conditions on external body surfaces, many of them containing dyes or other matter which serve to color an abnormal body portion so that it stands out with reference to the appearance of the normal areas adjacent thereto. In medical applications such tissue staining materials as iodine, tincture of benzoin, merthiolate and the like have been employed to contrast healthy and diseased body portions. In dental applications the use of iodine and, more recently, organic dyes have been employed in disclosing solutions to make visible dental caries, bacterial plaques or deposits of other foreign material on teeth. All of these diagnostic devices have met with vary degrees of success, but none has been universally adopted for the simple reason that neither the medical or dental practitioner, nor the patient, has found them very reliable.

Broadly stated, the object of the present invention is to provide reliable means for those concerned with the practice of the healing arts to outline in bold relief, for the naked eye to see, the various dental conditions described above.

A more specific object is to provide compositions, which, when applied to portions of the oral cavity having the described disease-causing foreign matter, are invisible until exposed to an appropriate light source whereupon those body portions are caused to glow and become readily visible.

Another object is to provide in chewing gums, crackers, and comparable otherwise edible foods similar means which are normally invisible when in contact with disease-causing foreign matter in the oral cavity, but which become visible when exposed to an appropriate light source.

Still another object is to provide in dental cement means which are normally invisible when in contact with decaying matter that may gain access behind dental inlays, crowns and the like, but which become visible when exposed to an appropriate light source.

One more object is to provide an appropriate light source in or usable with the physician's, dentist's, and patient's customary means for effecting needed therapy, for coaction with otherwise invisible means deposited on foreign matter contained on surfaces of the oral cavity so as to make them visible and distinguishable from neighboring body areas having no such foreign matter.

Other objects of the invention will be apparent from the following description.

All of these objects are accomplished by providing disclosing solutions, pastes or powders that are topically applied, or chewable foodstuffs, which contain a normally invisible constituent that fluoresces and becomes easily visible when activated by a proper light source. There are many such constituents available, almost all of them being either natural or synthetic food or drug and cosmetic colors which have been certified as safe for use on or consumption by humans by the U.S. Government's Food and Drug Administration. Other such materials are chemical substances known as "optical brighteners" which are nor-

mally colorless in a non-activated state, but which make such pathological disorders as dental cavities, gingival aberrations, etc. stand out by comparison with the adjoining teeth which are caused thereby to appear much whiter than ever before.

None of these colors or brighteners, when applied to diseased areas of the body, is readily visible to the unaided eye unless properly excited so as to cause them to fluoresce. Such excitation preferably is provided by a light source which is specific for the particular fluorescent material employed. When properly excited these colors or brighteners glow and are very easily discernible. Since those materials have an affinity for any soft, pulposus tissues such as decayed teeth, and for sticking in crevices such as develop around dental fillings and appliances, those areas will be caused to glow. Healthy tissues in the oral cavity and in many other regions of the body appear to rest deposition of these fluorescent materials, and are therefore not subjected to the same glowing appearance. Distinguishing the areas containing disease-causing foreign matter from the healthy regions thus becomes as simple as it is spectacular.

In some areas of the human body, when the fluorescent materials are applied in accordance with the present invention, skin lesions and the like are differentially diagnosed by virtue of the fact that the healthy tissues surrounding the diseased areas are caused to glow rather than vice versa. The reasons why the fluorescent materials will cling to or attack only diseased tissue in the one instance (such as the loose, absorptive, sponge-like, mucinous plaques, materia alba or other formations which collect around normal teeth) and only to healthy tissues in other cases are not known. But the fact remains that, as a result of either action, the diseased or adulterated areas are sharply delineated in accordance with the present invention. When applied to the teeth and gums any foreign substance, such as food particles, calculus or tartar whose non-removal can cause present and future dental health problems such as cervical or gum-like caries, is caused to glow vividly and can thus be readily delineated so as to facilitate correction of the condition. When applied to certain skin lesions and the immediate surrounding areas the adjacent healthy tissue will be caused to glow brightly while the lesions themselves are unchanged, and by this contrast the diseased portions are thus readily demarcated so as to simplify their diagnosis and treatment.

The characteristic glow is obtained by the selection of appropriate fluorescent material and a light exciting source therefor. Typical of the substances which can be employed are fluorescent FD&C (food, drug and cosmetic) color Red #3, fluorescent D&C (drug and cosmetic) colors Green #8, Red #19, Red #22, Red #28, Yellow #7, Yellow #8. These are all synthetic colors. In addition, certain natural colors will serve the same purpose although they do not fluoresce as well and they are subject to breakdown. Examples are chlorophyll which has a characteristic green color and carotene which has a yellow-orange appearance.

When any of these fluorescent dyes are applied to the gums, teeth, skin or other areas to be examined, and the part so treated is inspected under normal daylight or artificial light, the dye is substantially invisible. This is because the color is masked by the visible light. However, by using light of the proper wave length, and this can readily be accomplished by employing ordinary white light and a filter which will conceal the visible light on both sides of the absorption curve of the dye being used, the color will be readily visible. The degree of fluorescence will vary with the type of dye and the exciting light source.

Fluorescent dyes, as is well known, act radically dif-

ferent than ordinary non-fluorescent dyes. The latter are efficient as reflectors of visible light because the portion of the light spectrum they absorb serves no functional purpose. On the other hand, with fluorescent dyes the visible colors are also reflected but, in addition, most of the absorbed light activates the pigment molecule so as to be re-emitted as a color of a longer wavelength than the absorbed light. In other words, the fluorescent dyes are a source of light as well as a reflector of light. When properly excited or activated they give the appearance of a colored electric light bulb.

The minimum concentration of the dye is not critical to the successful operation of the invention, but there is a practical upper limitation. For example, a solution made up of as little as 0.00005% of most fluorescent dyes in water will work very satisfactorily. Preferably, of course, one should use the minimum amount of a given dye which will, when subjected to its maximum excitation by an appropriate light source, cause it to glow clearly. The upper limit is, however, restricted by the fact that almost all fluorescent dyes will lose their ability to fluoresce in concentrations over 5%. In addition, it won't be economical to use larger quantities; moreover, some may prove to be toxic in too great concentrations. As a rule, the preferred concentrations will range from about 0.01 to 2.0%.

The sources of light which may be employed are many, ranging from the common incandescent and fluorescent lamps to the quartz or mercury vapor type, or the hydrogen bulb which is filled with argon. All of these light sources must be used with an appropriate filter. Another source, known as "black light," may be employed; it has the additional advantage over the others in that it requires no filter. When optical brighteners, such as the "calco-fluor" brighteners manufactured by American Cyanamid Company or the Uvitex brighteners made by Ciba Corporation, are used, ultra-violet light is needed as the activator. It makes the brightener fluoresce a bluish-white. Ultra-violet may also be used with some of the fluorescent dyes. However, since the use of ultra-violet requires precautions against damage to the eyes, it is generally preferable to use normal white light in combination with appropriate filters as will be explained below.

Various color filters or diffraction type filters may be used to convert any of the different light sources to the proper wave length of light which will excite the specific dye of choice. Besides causing such excitation the only other requirement is that the wave length of light which is emitted by the filter be such as will not mask the dye's fluorescence with its own color. In other words the filter must be capable of (1) exciting a fluorescent material to cause it to glow, and (2) avoid masking that material's fluorescence by virtue of selective filtration of any unreacted wave lengths of light.

When selecting a color filter, i.e. a filter of a color which will emit only light that will excite a particular fluorescent dye, almost any transparent or translucent substance may be used. For example, among the plastic materials are the more or less flexible Mylar films made by E. I. du Pont de Nemours & Co., and the rigid Plexiglas acrylic sheets made by Rohm & Haas Co. Even colored glass may be employed.

As an example of the use of the present invention and its simplicity, one may consider its application in the field of dentistry. The dentist applies a disclosing solution, which consists of water plus a few drops of the fluorescent dye, to the gums and teeth by means of cotton swabs. He then directs light from his dental operating lamp upon the patient's oral cavity. The lamp could be permanently equipped with an appropriate filter, although optionally it could be a simple attachment to his normal operating lamp which supplies white light. To illustrate, if he used the popular dental lamp described in U.S. Patent No.

2,437,516, he could have associated therewith the proper filter material in sheet or roll form (the latter preferably in a roll-up type cartridge). The filter could be made to intercept the light when needed to supply light of the color required to act as the fluorescence exciting source, and yet be readily withdrawn so that the normal light which the lamp supplies can be produced when it is desired.

When the appropriately filtered light strikes the fluorescent dye any tartar, calculus, decay, etc. will immediately stand out in bold relief by virtue of the brilliant red, yellow or green dyes which have clung thereto. The patient can be made to see without any difficulty where and to what extent his pathological problem exists. The dentist, moreover, can apply his therapy to the affected part while it is bathed under this characteristic, tell-tale glow, and be assured that he will not miss any area that needs treatment.

As another example of the use of the invention, the same diagnostic advantages are put in the hands of the patients so that they can avail themselves of them in their home. By incorporating the fluorescent dye or optical brightener in toothpaste or in a mouthwash, and by making available a convenient source of light for exciting the dye, all persons can visibly and positively attack their teeth and mouth hygiene problem. No longer will they have to blindly brush their teeth or rinse their mouths, and merely hope that they are contacting the bacterial or other deposits which they are aiming to separate from gums, teeth or mucosa. As a convenient light source there is provided a toothbrush which has a small bulb, battery operated, located in its handle. The bulb in the brush handle is selected so as to provide an emitted light whose color will excite the fluorescent dye being used. The patient can reverse the handle of the brush so as to direct the light in the mouth before, during and after brushing to make certain no area which needs cleaning has been missed. Of course, inclusion of the light source in the toothbrush is optional. It can be in a separate light holder fashioned like a small pen-light. Then again, a filter arrangement may be set up in the bathroom or other suitable location so as to convert the normal source of light in the home to light usable in accordance with this invention in very much the way it has been proposed to adapt the dentist's operating lamp for this purpose.

All of the fluorescent materials which are useful in this invention will glow effectively when the light which strikes them has a frequency of between 3000 and 5200 Angstrom units, and preferably between 3200 and 3900 Angstrom units. Many diffraction gratings can break up white light and permit only light in these frequencies to be emitted. Various single or multiple color filter arrangements, preferably those which appear to be a deep blue or purple in white light, will emit light in the indicated ranges of wave lengths.

A number of ways in which the present invention may be employed in dental diagnosis and therapy have been suggested above, and still others will become more or less obvious once the novel method is understood. Following is a summary of the principal modes of its application:

(1) A fluorescent mouthwash, furnished in liquid form or in readily soluble pellets, for disclosing plaques, microcosins, tartar, leaky fillings, dental decay, etc.

(2) A fluorescent disclosing solution for the same purposes.

(3) A fluorescent test cracker or other chewable food such as candy or gum which will aid in diagnosing food impaction areas, gum disease, etc.

(4) A fluorescent dental cement for use in diagnosing leaking inlays, crowns, etc.

(5) A fluorescent solution which will aid in diagnosis of lesions in the oral cavity.

(6) A fluorescent solution for use by the dentist in describing the need for oral prophylaxis to the patient.

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(7) A fluorescent solution which will aid the dentist in teaching the patient how adequately to take care of his teeth and gums at home.

(8) A fluorescent solution or toothpaste which will enable the patient to observe the care with which he is attending to his oral health needs.

(9) A fluorescent solution for enabling the dentist to see whether the margins of fillings have been properly adapted to the tooth structure.

(10) A fluorescent solution which will enable the dentist to see whether the plastic facings on prosthetic appliances are closely enough adapted to the metal (gold or platinum) surfaces so as to create an adequate mechanical seal which is free from leakage.

In making any preparation suitable for the above and kindred uses one may include, if desired, one or more additives which are useful for other purposes. For example, antibiotics, antiseptics, brightening agents, solvents, spreading or wetting agents, etc., may be utilized for various purposes. Almost any known mouthwash, toothpaste, tooth powder, or other formulations useful for diagnostic or therapeutic treatment of external body surfaces, and of some internal surfaces such as the oral cavity, may be modified with a suitable fluorescent dye so as to be applicable in accordance with the present invention. As an illustration, the following examples are given of time-tried and tested formulations which have been so adapted, and it should be understood that they are merely illustrative and far from all-encompassing of the variety of compositions which can be made for similar purposes. In each case, when the composition was applied to the teeth and gums, the treated portions of the mouth glowed when exposed to black light or to light in the frequency range of about 3000 to 5200 Angstrom units.

Example 1

An alkaline mouthwash is made by mixing together the following ingredients, in the indicated proportions, in sufficient quantity to make up 1 liter:

	Percent
Sodium bicarbonate -----	2.00
Sodium chloride -----	0.50
Sucaryl sodium -----	0.30
Eucalyptol -----	0.03
Thymol -----	0.02
Safrole -----	0.05
Ethyl alcohol -----	25.00
Water -----	71.10
Fluorescent FD&C Red #3 dye -----	1.00
	100.00

A patient's mouth is rinsed with this solution and then exposed to first black and then to other light in the frequency range of 3000-5200 Angstrom units. In each instance the areas of the teeth and gums which bear decayed matter or dental caries glow vividly while the adjacent, healthy areas remain unaffected by the light cast thereon.

Example 2

A toothpaste is made by mixing together the following ingredients, in the indicated proportions, sufficient to make up 500 ml.:

	Percent
Insoluble sodium metaphosphate -----	26.60
Dicalcium phosphate -----	26.60
Gum -----	1.40
Flavoring matter -----	1.60
Purified sodium lauryl sulfate -----	1.10
Glycerol (40.7%) and water (1.0%) -----	41.70
Fluorescent D&C Green #8 dye -----	1.00
	100.00

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A patient's teeth are brushed with this paste and then exposed to black light and to other light sources in the frequency range of 3000-5200 Angstrom units. As in Example 1, the decayed area and the dental caries stand out in bold relief in comparison with the adjacent clean and healthy areas.

Example 3

A toothpowder is made by mixing together the following ingredients, in the indicated proportions, sufficient to make up 500 ml.

	Percent
Microcrystalline aluminum hydroxide -----	91.25
Aluminum hydroxide (325 mesh) -----	5.00
Flavoring matter -----	0.60
Saccharin, soluble -----	0.25
Sodium fluoride -----	0.10
Sodium lauryl sulfoacetate -----	2.20
Fluorescent D&C Red #19 dye -----	0.60
	100.00

A patient's teeth are brushed and exposed to light as in Example 2 with comparable results.

Example 4

A liquid dentrifice is made by mixing together the following ingredients, in the indicated proportions, sufficient to make up 250 ml.:

	Percent
Sodium N-lauryl sarcosinate -----	2.0
Sodium carboxymethylcellulose -----	4.0
Flavoring matter -----	0.5
Water -----	92.5
Fluorescent D&C Red #22 dye -----	1.0
	100.0

A patient's teeth are brushed and exposed to light as in Example 2 with comparable results.

Example 5

Two mouthwashes are made as follows, by mixing together the components in the indicated proportions, sufficient to make up 1 liter in each case:

(a)

	Percent
Zinc chloride -----	0.150
Saccharin sodium -----	0.100
Cinnamon oil -----	0.040
Menthol -----	0.050
Color -----	0.002
Ethyl alcohol -----	25.000
Water -----	73.658
Fluorescent D&C #28 Red dye -----	1.000
	100.000

(b)

	Percent
Gramicidin -----	0.006
Pluronic F-68 -----	0.500
Spearmint oil -----	0.050
Menthol -----	0.050
Cinnamon oil -----	0.010
Saccharin, sodium -----	0.150
Ethyl alcohol -----	25.000
Water -----	73.234
Fluorescent D&C Yellow #7 dye -----	1.000
	100.000

Two different patients' mouths are rinsed with these two mouthwashes and exposed to light as in Example 1 with comparable results in both cases.

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Example 6

Three toothpastes are made by mixing together the components listed in the following formulations, in the indicated proportions, sufficient to make up 500 ml. each:

	Percent
(a)	
Tricalcium phosphate -----	26.67
Glycerol -----	45.40
Water -----	14.40
Peppermint flavoring -----	0.58
Gum tragacanth -----	0.96
Saccharin -----	0.10
Surface active agent (Nacconol LAL) -----	2.89
Diammonium phosphate -----	5.00
Urea (100 mesh) -----	3.00
Fluorescent D&C Yellow #8 dye -----	1.00
	100.00
(b)	
Calcium carbonate -----	12.10
Dicalcium phosphate dihydrate -----	36.20
Sodium N-lauryl sarcosinate -----	2.00
Glycerol -----	30.60
Water -----	14.30
Irish moss -----	1.00
Sweetening agent, flavor and preservative -----	2.80
Fluorescent chlorophyll dye -----	1.00
	100.00
(c)	
Tricalcium phosphate -----	38.66
Urea -----	13.00
Dibasic ammonium phosphate -----	3.00
Sorbitol -----	14.50
Glycerol -----	10.00
Water -----	15.64
2,2 dihydroxy-5,5-dichlorodiphenyl methane ---	0.25
Sodium lauryl sulfoacetate -----	2.00
Aminoacetic acid -----	0.34
Carboxymethylcellulose -----	0.28
Flavoring oil -----	1.10
Saccharin -----	0.23
Fluorescent carotene -----	1.00
	100.00

Three different patient's teeth are brushed with these three toothpastes and exposed to light as in Example 2 with comparable results in all three cases.

Examples 7-12

Examples 1-6 are repeated, in each case using as little as 0.00005% of the fluorescent dye instead of the 1% concentration. In each instance, the distinctive glow is obtained, but with somewhat less sharp delineation of the healthy or clean areas from the diseased or unclean areas.

Similar results are obtained by adding the appropriate fluorescent dyes to disclosing solutions, dermatological medicaments and "paints," etc. It is, therefore, obvious that the scope of the invention is broad and is not to be limited to the examples hereinabove provided merely by way of illustration. Nor are the sources of light, the filters, the devices for furnishing light to be used by the dentist or by the patient in his own house, some of which were herein disclosed by way of exemplification, to be considered in any way limiting. In fact, the only restrictions are believed to be those encompassed by the metes and bounds of the following claims.

I claim:

1. A method of making visible to the naked eye the presence of disease-causing foreign matter in the oral cavity of a living human being, comprising, applying a composition containing a non-toxic, pharmaceutically acceptable fluorescent dye to the areas suspected of having

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disease-causing foreign matter and to the areas adjacent thereto having relatively no such foreign matter, and bathing both areas in light whose wave length has a frequency within the range of between about 3000 and 5200 Angstrom units, whereby the two areas are sharply delineated as the one of said areas which contains the foreign matter is caused to glow with the color of the fluorescent dye while the other remains substantially unilluminated.

2. The method of claim 1 in which the composition containing the dye is applied to gums and teeth, whereby any disease-causing foreign matter deposited on those portions of the oral cavity are caused to stand out in bold relief while the adjacent areas having no such foreign matter are substantially unilluminated.

3. The method of claim 1 in which the source of light is diffused through a filter that transmits light having a wave length in the range of 3000 to 5200 Angstrom units.

4. The method of claim 3 in which the filter is a colored, light transmitting material which will permit only the transmission of light that will excite the particular fluorescent dye which is used.

5. The method of claim 1 in which the concentration of the dye is between about 0.00005% and about 5.00%, the remainder essentially consisting of water.

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