June 6, 1972 M. E. SLIVA ET AL 3,667,916

STERILIZATION INDICATOR

Filed Nov. 17, 1970

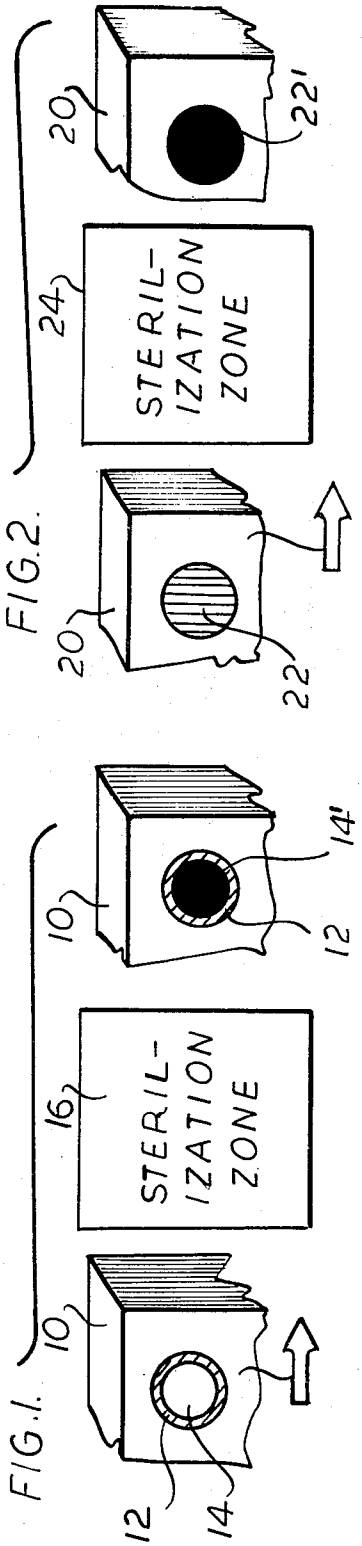

FIG. 1.

FIG. 2.

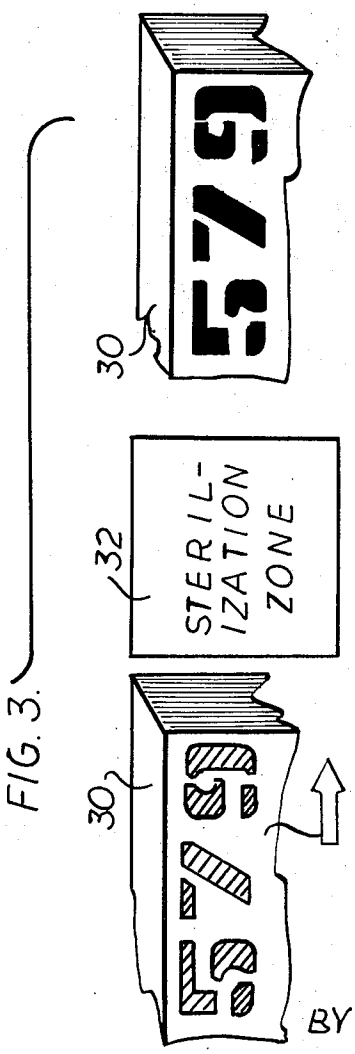

FIG. 3.

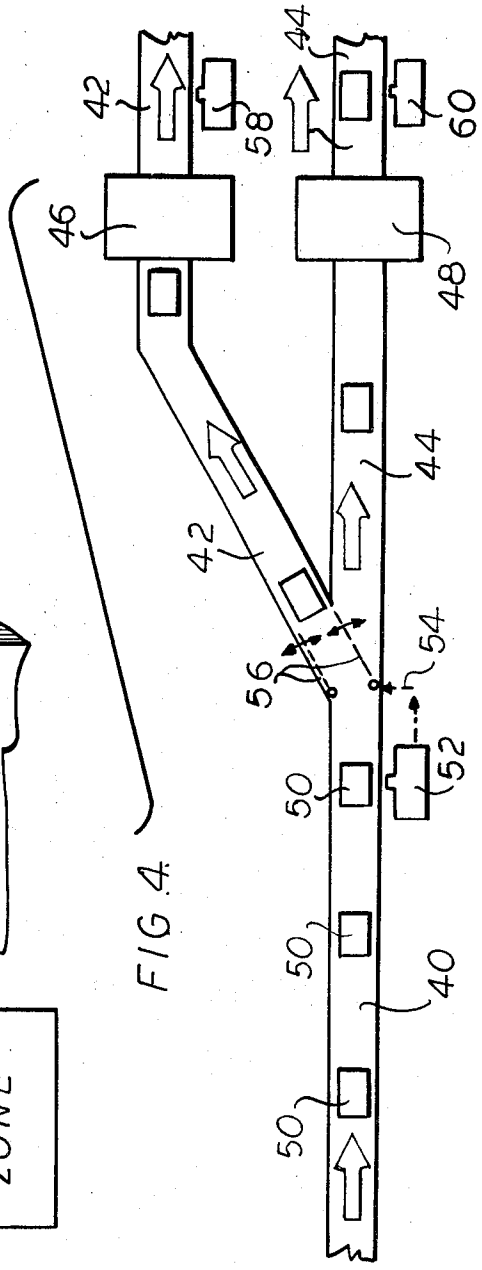

FIG. 4.

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STERILIZATION INDICATOR

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ABSTRACT OF THE DISCLOSURE

Low-cost telltale composition, which changes from a substantially light color to a substantially dark color under either steam or ethylene oxide sterilization conditions but is otherwise substantially insensitive to normal ambient environmental conditions including daylight, comprises a solution or dried solution of silver nitrate and a buffering quantity of a nitrate preservative selected from the group consisting of nitric acid, sodium nitrate or potassium nitrate. The telltale composition in aqueous alcoholic solution is printable on any substrate without imparting substantial color thereto, but is selectively colorable by the addition of desired pigments or dyes.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to an inexpensive composiition which changes color upon being subjected to either steam sterilization or ethylene oxide sterilization conditions. More specifically, it relates to a printable sterilization indicator responsive to both steam sterilization and ethylene oxide sterilization conditions, said indicator employing silver nitrate for color responsiveness and a preservative such as sodium nitrate to render the indicator substantially insensitve to ambient conditions, particularly light.

While the present invention is described with particular reference to its use as a sterilization telltale in the medical and sanitary products fields, it should be understood that the invention is not limited thereto. It may also be employed, for example, wherever its unique and selective indicating characteristics can be advantageously utilized.

Description of the prior art

One of the final steps in the manufacture of medical and and sanitary products such as bandages, pads, tapes, sponges, diapers, surgical kits, instruments and the like is to subject the products to sterilization conditions for obvious reasons. One technique for sterilizing such products is to subject the same, inter alia, to a moist atmosphere at a temperature of about 250° for at least about 30 minutes, superheated steam being employed for such purposes. Such steam sterilization technique is relatively inexpensive, convenient, and does not require complex equipment to carry out.

In those cases where the product cannot tolerate such high temperatures, e.g., heat-sensitive thermoplastic materials such as plastic instruments, composite products employing polyethylene films and the like, an alternative sterilization technique is to employ water vapor containing ethylene oxide gas as the sterilizing medium at a temperature up to about 150° F. Illustrative conditions for ethylene oxide sterilization include, inter alia, subatmospheric steam at about 145° F. and ethylene oxide gas in a concentration of 300 to 1000 mg. per liter, the sterilization period again being at least about 30 minutes. The resulting relative humidity may be in the range of about 30 to 80 percent, preferably about 40 to 60 percent. Thus even when employing ethylene oxide, water vapor is considered essential.

Sterilization of products is such an important and mandatory step that a positive and instantaneously-readable indication that it has in fact been carried out is highly desirable. Otherwise products may inadvertently bypass the sterilization step through carelessness or mistake. If the products do in fact pass through the sterilizer, the sterilizer may be inoperative, defective or improperly adjusted. To cope with such situations, indicators or telltales have been developed which can be imprinted on, or otherwise attached to, the product, or the container, or the pallet containing the same. These indicators or telltales change color or appearance in a known fashion when exposed to particular sterilization condition, thereby providing positive evidence of sterilization.

In the case of steam sterilization, various inks have been developed which will change color when exposed to such sterilization conditions. For example, U.S. Pat. 3,360,337 discloses an indicator ink for forming white markings which turn black upon steam sterilization. Similarly, U.S. Pat. 3,360,338 discloses an indicator ink for forming yellow markings which become red-brown in color upon steam sterilization. Similar indicator inks and tapes are also disclosed in U.S. Pats. Nos. 3,360,339 and 3,386,807.

In the case of ethylene oxide sterilization, printing inks have likewise been developed which can be utilized as sterilization indicators. For example, U.S. Pat. 3,098,751 discloses compositions for printing telltale insignia which are formulated to change from acid pH to alkaline pH upon exposure to ethylene oxide in the presence of water vapor. The change is rendered visual by incorporating an acid-alkali dye indicator.

Still other indicators are available to show or visually record temperature, temperature changes and/or temperature time relationships. These include, for example, U.S. Pats. 3,344,670, 3,352,794 and 3,460,964.

But such prior art indicators suffer from one or more shortcomings. None of them is fully effective for indicating both steam sterilization conditions and ethylene oxide sterilization conditions. Some react to dry heat regardless of the presence of essential moisture, thus giving a misleading sterilization indication. Some are unduly photosensitive and deteriorate excessively in the presence of strong light. Some give only transient or reversible indications or are dependent on the particular substrate on which they are printed. Some are relatively costly, are not readily printable or impart, prior to sterilization, an undesired color to the substrate.

OBJECTS OF THE INVENTION

It is therefore an object of the present invention to cope with these and other problems associated with prior art sterilization indicators. It is a more specific object of the present invention to provide an inexpensive sterilization indicator which is effective for irreversibly indicating either steam sterilization or ethylene oxide sterilization conditions and will discriminate from dry heat.

It is another object of the present invention to provide a printable, multipurpose sterilization indicator which is substantially colorless, and yet colorable if desired. It is still another specific object to provide a multipurpose sterilization indicator which is substantially non-photosensitive and does not depend for operability on the particular substrate to which it is applied. These and other objects of the present invention will become apparent as the detailed description proceeds.

SUMMARY OF THE INVENTION

These objects are achieved by a telltale composition which comprises a blend of silver nitrate and a buffering quantity of a nitrate preservative selected from the group

consisting of nitric acid, sodium nitrate, potassium nitrate, or mixtures thereof, preferably sodium nitrate. The telltale composition is typically applied in the form of a printable aqueous solution. Advantageously, it may be applied to any substrate. After drying, the dried solution is substantially colorless until subjected to steam sterilization or ethylene oxide sterilization conditions, which change the indicator to a substantially dark color, usually solid black, depending upon the substrate. The indicator is selective in that dry heat or dry ethylene oxide will not bring about the same degree of color change.

The relative proportion of the nitrate preservative in the indicator depends upon the extent of buffering required, keeping in mind that silver nitrate is normally characterized by photosensitiveness. Too little preservative renders the indicator susceptible to changes by ambient conditions, e.g., daylight, particularly when stored for prolonged periods of time. This may be coped with to a limited extent by storing the indicator, if in liquid form, in an opaque or amber glass container. Too much preservative may render the indicator substantially insensitive to even sterilization conditions, or necessitate unduly long sterilization cycles to effect change.

In practice, when applied to cardboard containers for medical products such as bandages and the like, at least about 0.2 mol of preservative per mol of silver nitrate should be present to assure stability under ambient conditions. Concentrations substantially in excess of about 1 mol of preservative per mole of silver nitrate may render the indicator unduly insensitive. The preferred range is about 0.3 to 0.8 mol of preservative per mol of the silver nitrate.

Manifestly, as will be apparent to those skilled in the art, varying the proportion of preservative may be a means of obtaining a time-sterilization integrator. Proportions are best determined empirically for the particular type of sterilization and the particular intensity thereof.

As a printable ink, the telltale composition is preferably in the form of an aqueous solution containing about 0.3 to 3 parts by weight of water per part of silver nitrate and preservative. When applying the ink to a porous substrate such as paper or cardboard, a penetration agent such as isopropyl alcohol, ethanol or methanol, preferably isopropyl alcohol, may be added to the aqueous solution. When employing the preferred isopropyl alcohol, an amount in the range of about 10 to 50 percent by volume, based on the total solution, should be satisfactory.

The printability characteristics of the telltale composition are further improved by addition of "body" enhancing substances such as methylcellulose (e.g., "Methocel HG25," sold by Dow Chemical Company), carboxymethylcellulose, or the like, preferably methylcellulose. These substances tend to increase viscosity and otherwise render the composition more readily "stampable." When employing the preferred Methocel HG25, amounts in the range of about 0.8 to 1.8 percent by weight, based on total solution, have been found satisfactory.

While the indicator in the form of a dried solution is substantially colorless, it may be colored, if desired, to render it highly visible even before exposure to sterilization conditions. Thus, color imparting pigments may be added to render the composition visually detectable. Manifestly the pigments or dyes should be safe and non-irritating and otherwise conform to standards for materials which are to come in contact with the human body.

Suitable coloring agents are commercially available. For example, McCormick & Co., Inc., Baltimore, Maryland, sells various "Food Colors," e.g., "FD&C Green #1," which may be employed. Another commercial source is Day-Glo Color Corp., which sells a series of "Day-Glo" Fluorescent Pigments, e.g., "Aurora Pink," "Neon Red" and the like.

The ability to selectively color the indicator permits it to be used for multipurposes. For example, the color of the indicator prior to sterilization may provide the code as to what type of sterilization is to be employed. The indicator may also be imprinted as numbers or letters or combinations thereof or the like to correspond to the usual production coding systems which are in use. The color can be detected visually by the production line worker or automatically by color sensors. Output signals from such sensors could direct the product to the correct sterilization zone or activate an alarm in the event a product is being charged to the wrong zone. Thus, for example, a container of temperature sensitive products which should be sterilized using low temperature ethylene oxide sterilization conditions will not inadvertently be destroyed by subjecting it to the high temperatures associated with steam sterilization conditions.

The change in the color of the indicator as the result of exposure to sterilization conditions serves the essential function of providing positive evidence that the product has in fact been sterilized. This prevents the inadvertent shipping of unsterilized products which either fail to pass through the sterilizer or pass through an inoperative, maladjusted or otherwise defective sterilizer. If the indicator has been imprinted in the form of a production coding, the color change thereof doesn't affect the coding.

When using nitric acid as the preservative in the formulation, the indicator should not be used where it may result in skin contact. To avoid the possibility of such irritation problems, sodium nitrate or potassium nitrate should be employed, preferably sodium nitrate. An indicator formulated with sodium or potassium nitrate can also cause some irritation if it were to get in an open wound. If colored, it will stain the skin and clothing like most other inks. Appropriate precautions should be taken.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more clearly understood from the following description of specific embodiments, read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a schematic illustration of one mode of applying the telltale composition of the present invention to a container for medical or sanitary products, both before and after passing through a sterilization zone;

FIG. 2 is similar to FIG. 1 and illustrates another mode of application, including color precoding to indicate the type of sterilization;

FIG. 3 is also similar to FIGS. 1 and 2 and illustrates still another mode of application wherein the composition is imprinted in the form of a number code; and

FIG. 4 is a diagrammatic plan view schematically illustrating one of a number of ways in which the color-coded composition of the present invention may be used to monitor and direct products to the proper sterilization zone.

It should be understood that the subject matter is illustrated in the drawings by graphic symbols and the like and that the drawings are not necessarily to scale. Thus the representations may depart from the actual appearances when visually observed. It should also be understood that the invention is not limited in any sense to the particular embodiments illustrated.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIG. 1, container **10**, which may be a cardboard carton containing packages of sterilizable medical supplies, such as plastic instruments, is precoded by means of green-colored printed annulus **12**. The ink used to print the annulus is a permanent ink which is not affected by sterilization conditions. In this illustrative embodiment, it indicates that the container is to be subjected to chemical sterilization conditions, i.e., water vapor-containing ethylene oxide gas.

The circular area **14** delimited by annulus **12** is imprinted with a sterilization indicator of the present invention comprising an aqueous alcoholic solution of silver nitrate and sodium nitrate and a body enhancing quantity of methylcellulose, illustrative formulations therefor being set forth in the specific examples hereinafter. The solution may or may not be colored with a suitable dye, as desired.

Container **10** is sterilized in sterilization zone **16**, thereby changing the indicator, now indicated by encircled area **14'**, to a substantially solid black color. The green-colored area of annulus **12** remains unchanged, thus preserving the code as to the type of sterilization conditions.

Referring to FIG. 2, container **20** of medical supplies is imprinted with red-colored indicator **22** in a circular pattern, the red color being the code, in this exemplar, for steam sterilization. After being subjected to such sterilization in zone **24**, the indicator, now indicated by reference numeral **22'**, is solid black, thereby providing positive and instantaneously-readable evidence of sterilization. Unlike the embodiment of FIG. 1, however, the type of sterilization is no longer indicated.

FIG. 3 illustrates how the composition of the present invention may be employed to serve a threefold purpose. Container **30** is imprinted with a production code illustrated by the numbers "579," the indicia being imprinted using the composition of the present invention colored to indicate the type of sterilization to be employed. After passing through sterilization zone **32**, the production code "579" remains as before but is substantially black, thereby providing positive evidence of sterilization.

Thus, the colored composition of the present invention serves its first function as the printing ink for the production code, its second function by indicating the type of sterilization to be used, and its third function by providing positive evidence that sterilization has in fact taken place. Manifestly, the borders of the numbers "579" could include a color coding which doesn't change upon sterilization, similar to annulus **12** of FIG. 1. Thus, even after sterilization, the type of sterilization could still be indicated. Alternatively, the numbers or letters of the imprinted indicia could include a code to indicate the type of sterilization.

FIG. 4 illustrates a production line such as conveyor system **40** having bifurcated legs **42** and **44** leading to steam sterilization zone **46** and ethylene oxide sterilization zone **48**, respectively. As containers **50** proceed down line **40** they pass by sensor **52** which senses the color of the indicator, e.g., red or green. Corresponding control signals **54** are sent to the controller for parallel gates **56** which direct the containers to leg **42** or **44**, depending upon the color sensed by sensor **52**.

After passing through the respective sterilization zones **46** and **48**, the containers are again sensed by sensors **58** and **60**, respectively, which are designed to "read" whether the sterilization indicator has changed to a substantially black color. If not, visual or audio warning signals could be actuated to alert the operators of a malfunction. Alternatively, the conveyor system could be controlled thereby, for example, by shutting it down until the cause of the malfunction is ascertained.

The two legs **42** and **44** of the production line could again be combined after the sterilization zones whereby only one sensor would be required to monitor the sterilization indicator. This schematic production line assumes that sterilization takes place intermittently-continuously. Other variations in the production scheme, e.g., continuous, batch-type, and the like, will be apparent in the light of this disclosure and those skilled in such arts can readily provide the necessary adaptations and instrumentation to implement the same.

EXAMPLES

The present invention will be more clearly understood from the following specific examples of certain embodiments which have already been generally described and illustrated above.

EXAMPLE 1—Nitric acid as preservative

Three indicator solutions were prepared using varying proportions of silver nitrate and concentrated nitric acid. The first solution, identified as the 1:1 solution, was prepared by dissolving 10 grams of silver nitrate in 50 milliliters of deionized water, adding 10 milliliters of concentrated nitric acid and then further diluting the solution to 100 milliliters with deionized water. The second solution, identified as the 2:3 solution, was prepared by dissolving 20 grams of silver nitrate in 50 milliliters of deionized water, adding 30 milliliters of concentrated nitric acid and then further diluting the solution to 100 milliliters with deionized water. The third solution, identified as the 1:5 solution, was prepared by dissolving 10 grams of silver nitrate in 50 milliliters of deionized water and adding 50 milliliters of concentrated nitric acid thereto, resulting in precipitation of some silver nitrate therefrom.

Indicator strips were prepared from each of the three solutions by painting the solution on conventional adhesive tape and on filter paper and air drying the same. The strips were mounted on cardboard plaques and exposed to various conditions, namely, daylight for a period of over three weeks, ethylene oxide sterilization conditions and steam sterilization conditions. The appearances after exposore were compared, the following changes being observed:

	Observed change		
Indicator	Daylight	Ethylene oxide sterilization	Steam sterilization
1:1 solution	Light coloration	Light brown	Black.
2:3 solution	do	Dark brown	Do.
1:5 solution	do	Brown	Do.

The 2:3 solution has the preferred properties. It is relatively immune to daylight and turns very dark on exposure to either oxide or steam sterilization conditions.

EXAMPLE 2—Nitric acid as preservative

The 2:3 solution prepared as described in Example 1 was applied in a circular pattern directly to three sterilizable cardboard plaques. After air drying, the indicator circles were substantially colorless. One plaque was then exposed to daylight for more than three weeks; another plaque was exposed to ethylene oxide sterilization conditions; and the third plaque was exposed to steam sterilization conditions.

Substantially no change occurred to the indicator circle on the plaque exposed to daylight. In contrast, the indicator circles on the plaques exposed to either type of sterilization conditions changed to a substantially solid black color.

EXAMPLE 3—Nitric acid as preservative; variable studies

A series of tests were conducted to ascertain the effects on the indicator of such variables as temperature, temperature combined with high humidity, exposure to light and the addition of coloring dyes. In each case the 2:3 solution prepared as described in Example 1 was coated on a cardboard substrate in a circular pattern and air dried in the absence of daylight.

In the temperature-effect studies, the coated substrates were exposed to various temperatures for varying exposure periods. At about ordinary room temperature and at about 122° F. no change occurred even after six hours expousre. At temperature of about 212–225° F. a slight yellowing was observed after two hours exposure. At about 265° F. which approximates temperatures associated with steam sterilization, the indicator turned yellow after one hour exposure. At still higher temperatures, e.g., about 300° F. and about 350° F., the indicator turned brown after ½ hour exposure but in no case did

it result in the dark brown or black colors associated with chemical or steam sterilization conditions. Thus, the indicator can be considered to discriminate between mere high temperature and sterilization conditions.

To ascertain whether the indicator would react to elevated temperature combined with high humidity, an indicator sample was placed in an oven at about 212° F. and saturated with water vapor. After three hours only a slight yellow tinge was observed. This evidences that as a practical matter the indicator would be quite stable at the much-less-severe ambient conditions encountered in industrial plants and the like.

In the light-effect studies, an indicator sample was exposed to both sunlight for four hours and then to artificial light for over three weeks. No change in color occurred, again evidencing the stability of the indicator.

In the color-effect study, the 2:3 solution prepared as described in Example 1 was colored with sufficient methyl orange and methyl red to impart a light pink color to the solution. The solution was then coated on a cardboard substrate and exposed to sterilization conditions. The presence of the pre-sterilization color had no effect on the black after-sterilization color.

EXAMPLE 4—Sodium nitrate as preservative

Sterilization indicators were prepared as hereinafter described and color coded to indicate the type of sterilization subsequently to be employed. For ethylene oxide sterilization, the indicator solution was colored green; for steam sterilization, the indicator was colored red. The formulations employed are as follows:

	Green indicator	Red indicator
Silver nitrate, gms	70.0	70.0
Sodium nitrate, gms	20.0	20.0
Methocel AG25, gms	3.5	3.5
Water, ml	100.0	100.0
Isopropyl alcohol, ml	30.0	30.0
Guinea Green pigment, gm	0.2	
Dayglo Fluorescent pigment AX-15-5, gm		8.33

In each case, the silver nitrate and sodium nitrate are dissolved in the water with continuous stirring and a mixture of the Methocel HG25 and isopropyl alcohol added thereto. The solution is stirred for 15 minutes and the coloring pigment then added thereto, followed by continuous stirring for another 15 minutes. The resulting indicator inks are stored in a dark bottle until used.

The inks can be printed on cartons, bags and any other porous sterilizable package. The inks will also function if it is printed or otherwise applied to the product itself, whether porous or not.

EXAMPLE 5—Sodium nitrate as preservative

Sterilization indicators were prepared as hereinafter described and color coded to indicate the type of sterilization conditions to be subsequently employed. As in Example 4, for ethylene oxide sterilization, the indicator solution was colored green; for steam sterilization, the indicator solution was colored red. The formulation employed are as follows:

	Green indicator	Red indicator
Silver nitrate, gms	70.0	70.0
Sodium nitrate, gms	15.0	15.0
Methocel HG25, gms	2.5	3.0
Water, ml	100.0	160.0
Isopropyl alcohol, ml	30.0	30.0
FD & C Green B, gm	.113	
Dayglo Fluorescent pigment (Neon Red), gm		8.33

In each case the silver nitrate and sodium nitrate were added to the water and mixed for at least about 10 minutes. The Methocel HG25 was then mixed in the isopropyl alcohol for about 3 minutes and the resulting solution added to the solution of sodium nitrate and silver nitrate. After again mixing for about 15 minutes, the colorant was added to each of the respective indicator solutions, followed by mixing for an additional 5 minutes. The resulting indicator inks were coated on cardboard substrates in a circular pattern and air dried.

At room temperatures, substantially no change in the respective indicators occurs, except for a slight darkening around the edges after several weeks. Such slight darkening is not misleading because it is readily apparent that the indicators have not been exposed to sterilization conditions. Upon exposure to sterilization conditions, however, the indicators change to a substantially black appearance throughout.

EXAMPLE 6—Sodium nitrate as preservative

Colored indicator solutions prepared as described in Example 5 were coated on glass, rather than on a cardboard substrate. Upon exposure to steam sterilization or ethylene oxide sterilization conditions, the indicators turn to a burnt red or dark brown, in contrast to the black color when the indicator is coated on a cardboard substrate. Notwithstanding, the color changes are very pronounced and readily observed. Thus the indicators of the present invention can be used on various substrates, porous or non-porous, organic or inorganic.

EXAMPLE 7—Potassium nitrate as preservative

Green and red indicator solutions were prepared as described in Example 5, except that potassium nitrate was substituted for sodium nitrate, the weight proportions being the same. When "printed" on cardboard substrates and air dried, the resulting indicators are stable in daylight but turn a deep black when subjected to ethylene oxide or steam sterilization conditions.

From the above description, drawings and examples it is apparent that the objects of the present invention have been achieved. While only certain embodiments have been described or illustrated, many alternative modification and equivalents will be apparent from the above description to those skilled in the art. These and other alternatives and equivalents are considered within the spirit and scope of the present invention and coverage thereof is intended by the claims of any patents based on this application and any continuations or divisions thereof, even though not necessarily encompassed by the strict verbiage thereof.

Having described the invention, what is claimed is:

1. A telltale composition which changes from a substantially-light color to a substantially-dark color under the conditions of either steam or ethylene oxide sterilization but is substantially insensitive to normal ambient environmental conditions including daylight, said composition comprising a blend of silver nitrate and a buffering quantity of a nitrate preservative selected from a group consisting of nitric acid, sodium nitrate, potassium nitrate or mixtures thereof.

2. The telltale composition of claim 1 wherein said nitrate preservative is sodium nitrate.

3. The telltale composition of claim 1 including a color-imparting pigment to render the composition visually detectable prior to exposure to sterilization conditions.

4. The telltale composition of claim 1 wherein said nitrate preservative is present in the amount of at least about 0.2 mol of preservative per mol of silver nitrate.

5. The telltale composition of claim 1 in the form of a dried solution of said silver nitrate and said nitrate preservative.

6. The telltale composition of claim 1 in the form of an aqueous solution containing about 0.3 to 3 parts by weight of water per part of silver nitrate and preservative.

7. The telltale composition of claim 6 including a body-enhancing quantity of methylcellulose whereby to improve the printability and stampability characteristics thereof.

8. The telltale composition of claim 6 in an aqueous solution, including about 10 to 50 percent by volume, based on total solution, of isopropyl alcohol to enhance

the penetrability of the composition into porous substrates.

9. A telltale composition which changes to a substantially darker color upon exposure to either steam or ethylene oxide sterilization conditions but is substantially insensitive to normal ambient environmental conditions including daylight, said composition comprising silver nitrate and about 0.3 to 0.8 mol of sodium nitrate per mol of silver nitrate.

10. The telltale composition of claim **9** including a color-imparting pigment to render the composition visually detectable prior to exposure to sterilization conditions.

11. The telltale composition of claim **9** in aqueous solution containing about 0.5 to 1.5 parts by weight of water per part of silver nitrate and sodium nitrate, said

aqueous solution including 10 to 50 percent by volume, based on total solution, of isopropyl alcohol and about 0.8 to 1.8 percent by weight, based on total solution, of methylcellulose.

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MORRIS O. WOLK, Primary Examiner

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U.S. Cl. X.R.

23—253 TP; 73—356; 116—114; 252—408