

1

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DETECTION OF PACKAGE CONTAMINANTS
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10 Claims

ABSTRACT OF THE DISCLOSURE

The present disclosure relates to the clean room packaging of aerospace components in colored, preferably fluorescent, plastic film, in order to detect particle contamination resulting from abrasion between the packaged aerospace component and the packaging film.

The present invention relates to the detection of package contaminants, and more particularly, to a package (normally free of contaminants) which can be easily tested for the detection of contamination caused by the packaging material itself and to a method for determining the degree of contamination caused by such packaging material.

Certain industries, such as the aerospace industry, work with materials and components requiring very close tolerances. Because of these close tolerances, such as occur in missile components and highly volatile rocket fuels, extreme care must be taken in reducing contamination of all sorts to the lowest possible level. In order to reduce contamination or maintain it at a tolerable level, it is necessary to know both the size and number of contaminant particles and their composition so that such contaminants may be traced back to their source and eliminated or reduced in number and/or size. A great deal of work has been done in this field and the packaging and assembly of the clean and pure components and materials which must be protected from contamination are usually carried out in special rooms where the humidity and dust is carefully controlled, such as by carefully filtering the air.

Normally, such components and materials are manufactured in one locale, such as by a sub-contractor, and then transported to another locale where they are inserted into the system. Because such materials must be protected from contamination, they are generally carefully wrapped in suitable packages which prevent the entrance of contaminant particles to the cleaned and purified materials and components.

However, in a normal course of events, the packaged material is handled during either storage or transportation and such handling has a tendency to cause the packaged article to abrade the inside of the packaging film to produce particles of the packaging film which thereby cause contamination. Thus, one group of contaminants not previously identified are the packaging materials themselves which when abraded or mishandled generate such small particles which reduce the reliability of the packaged component in its intended environment.

Heretofore, the only methods available for identifying particles of the packaging material has been infrared spectro photometry, micro chemical analysis or microscopes equipped with hot stages for melting point determination. All of these methods are not only extremely time consuming, but they are also expensive because they require highly skilled personnel to make such determinations.

It is therefore an object of the present invention to alleviate the difficulties of the prior art, such as indicated above.

2

It is another object of the present invention to improve the reliability of the purity of articles which should be decontaminated.

It is another object of the present invention to determine the degree of contamination caused by particles of material in which the article has been packaged so that a particular article or component may be determined to have a higher degree of contamination than that which may be tolerated.

It is another object of the present invention to provide a new and improved package for clean and decontaminated articles, which package may be tested for contamination.

It is another object of the present invention to provide a new and improved method of testing for contaminants generated by the packaging material.

It is another object of the present invention to both reduce the cost of identifying package contaminants and increase the effectiveness and accuracy of such identifications.

It is another object of the present invention to provide for the simple daylight identification of a particular packaging material and/or a particular component packaged therein by color coding.

These and other objects as well as the nature and advantages of the present invention will be more apparent from the following detailed description.

A critical feature of the present invention is the incorporation in the packaging material of a small quantity of a fluorescent material. Various fluorescent materials may be used and the selection of such materials to be added to the particular plastic packaging material used can be easily determined by routine experimentation. In general, however, daylight fluorescent dyes should preferably be used, such as the various Rhodamine dyes. Other fluorescent dyes and pigments which may be used include those shown and described in the patents to Grossman No. 2,681,317, Thompson No. 2,956,027, Dann No. 2,980,697, Konig et al. No. 2,983,686, and McCafferty No. 3,162,642, among others. Additionally the plastic packaging material may also contain a daylight color which may or may not be the same color as the fluorescent material. Such additional daylight color is of assistance in color coding the packaging films and/or the packaged components.

The packaging materials themselves comprise self-supporting plastic film which is preferably relatively transparent so that the material packaged may be seen through. For the packaging of the highly sensitive materials here concerned with, it is highly desirable that only the highest quality of pure plastic film be used. Usually, polyolefins, such as polyethylene, and polyamides are the preferred plastic film forming materials used in the present invention although any plastic packaging material may be used if desired. High quality polyethylene and nylon resins are available for the formation of such plastic wrapping film and the resultant films have high purity, high strength and high abrasion resistance.

Because uniformity is highly essential, it is important that the fluorescent material be incorporated into the plastic prior to the formation of the plastic wrapping film; this insures that the fluorescent material is uniformly blended in the plastic. In many cases, the fluorescent material may be added during the actual resin formation and in such cases the fluorescent dye may become integral with the plastic molecules. In general, the quantity of fluorescent dye utilized will vary depending on the particular dye used, but it is not generally necessary to use greater than 5% by weight of the dye based on the total weight of the plastic film; often, much less than 5% is adequate. After blending of the resin and the fluorescent material, the plastic film may be formed in a conventional manner such as by melt extrusion into sheet or tube form.

After formation of the fluorescent material containing plastic packaging film, the film is moved into an environmentally controlled room in which the temperature, humidity, and maximum number of particles in the air is carefully regulated. The packaging material is then thoroughly cleaned and decontaminated. The resultant pure, clean and decontaminated self-supporting plastic wrapping film is then prepared for transportation to the packaging location, which could be in the same plant or in another plant.

The packaging material is then transported to the packaging area or room, which is also environmentally controlled with respect to temperature, humidity and number of particles in the air, and the specially cleaned and decontaminated articles, such as electronic or aerospace components, are then packaged in the plastic film in such a manner as to seal the package so that no dirt or other contaminants may enter the package through the plastic film. These so packaged components are then generally stored or are shipped to their situs of use. During the shipping and/or storage, the articles undergo inevitable handling. The more such packages are handled, the more the articles abrade against the packaging film thereby inherently releasing contaminating particles.

Upon reaching the situs of use, the packaged articles are then removed from the plastic film and are inserted in the particular system of which they are to form a part. As with the packaging room and the plastic film cleaning room, the assembly room is also environmentally controlled to reduce any chance of outside contamination.

Due to the above mentioned handling of the packaged components and the resultant generation of tiny plastic contaminating particles, it is necessary to test the components to see if they have been contaminated to such a degree by the plastic particles that they are no longer suitable for their intended use. In accordance with the present invention this may be accomplished very simply by merely washing the inner surfaces of the plastic film to collect the contaminating particles which adhere thereto. Such washing is preferably carried out by utilizing an organic liquid, but any method could be used which accurately collects all the particles, even the use of a suitable vacuum cleaner. It may also be desirable to wash the packaged component with an organic liquid to collect the contaminant particles which have adhered thereto; this practice is useful where only "spot" checks are made and the tested component may then be discarded.

When the particles are collected, they are then subjected to ultra-violet light which causes the fluorescent material in the plastic particles to fluoresce, thereby permitting an accurate determination or "count" of the particles which have adhered to the inside of the plastic package. Since the ratio of the particles adhering to the component and the particles adhering to the inside of the plastic film can be statistically determined in a simple manner, the amount of contamination of the components is therefore determined and this can be compared to the degree of permissible contamination so that the component can be either accepted for use or rejected.

The invention will be further understood by the following examples which are illustrative and are not to be taken as limitative of the present invention, although such examples include the preferred embodiments.

Example I

High pressure polyethylene, formed in a polymerization reactor at pressures of 15,000–45,000 p.s.i. at temperatures of 100–300° C. in the presence of a free radical catalyst, such as oxygen or peroxide, is obtained in pellet form. A sulfonamide-amine-aldehyde resin containing 2.9% fluorescein (lead free) in a quantity of 10% by weight is mixed with 90% by weight of the polyethylene in molten form and the composition is thoroughly pelletized. The pelletized, fluorescent material containing polyethylene is then extruded in the form of a blown tubular film. When

fluorescein is used as the fluorescent material, 0.5–3% may be used in the sulfonamide-amine-aldehyde resin and 1–20% of the sulfonamide-amine-aldehyde resin blend with the fluorescein therein may be then used with the polyethylene. The sulfonamide-amine-aldehyde resin is not essential but is helpful for blending purposes; other resins may also be used for blending if desired. In place of fluorescein, fluorescent dyes such as disclosed in the patent to D'Alelio et al. Reissue #25,845 may be used.

After its formation, the blown tubular plastic film is then moved into an environmentally controlled area where the temperature, humidity and maximum number of particles in the air is rigorously controlled. In this environment, the plastic film is then thoroughly cleaned and decontaminated. It is then passed into a packaging room, in which the environment is also rigorously controlled, where aerospace components are individually placed within a leading section of the plastic tube and the tube is heat sealed about the component and severed from the remainder of the tube to provide a completely sealed package.

A plurality of so-formed packages are then collected and transported to a storage room. When the storage room has become sufficiently filled with a quantity of packages which may be shipped, the packages are transported to a truck and are then shipped to another plant where the components are intended to be assembled in their proper location in the desired system. Upon reaching the second plant, the packages are removed from the truck and are transported to another storage room from which they are ultimately removed and transported to another environmentally controlled room. In this environmentally controlled room, the packages are opened and the components are removed. Several of the plastic packaging films with the components removed are then tested in the following manner to determine the degree of contamination caused by abraded plastic particles (all the plastic films could be tested if desired, but in this case only several "spot" checks are made).

Samples are chosen at random. The interior of each plastic bag is separately washed with isopropanol by merely sloshing the washing material gently in the plastic bag. If desired, other materials such as trichlorotrifluoroethane (Freon) may be used as the washing liquid. The washing material is then poured from the bag into a filter funnel and onto a filter disc utilizing vacuum to impinge the contained contaminant particle into the surface of the filter. The filtered disc is then examined microscopically using oblique ultra-violet light at 3700 angstroms and 100 watts intensity to effect fluorescence of the plastic particles. In this case a monocular microscope with mechanical stage magnifications of approximately 100 power and 40 power equipped with ocular or stage micrometer in 0.1 to 0.01 millimeter divisions is used to examine the particles. The particles may additionally be examined under such microscope using 5000–6000 candle power light as a daylight light source. The testing is carried out in a clean room in which the environment is controlled. Based on a predetermined amount of contamination which may be tolerated, the packaged components may be rejected or accepted depending on the amount of contaminant particles found on the filter.

Example II

A high purity ϵ -caprolactan polyamide resin is reduced to a melt and the fluorescent material is added thereto. In this case, the fluorescent material comprises two components, i.e. Saturn-Yellow, a co-condensation product of naphthalimide, and Tinopia SFG, 7-(2-fluoro-6-diethylamino-1,3,5-triazin-4-yl)-amino-3-phenyl-coumarin, disclosed in U.S. Patent No. 2,945,033. The Saturn-Yellow is used in a quantity of 1% by weight, although it may be used in quantities of 0.1%, and the Tinopia in a quantity of 0.05% by volume, although it may be used in quanti-

ties of 0.01–5% by volume. In place of the Saturn-Yellow, fluorescent materials such as shown in the patents of Switzer et al. No. 2,864,771 and Kazenas No. 2,938,873 may be used, if desired.

The molten nylon, having the fluorescent material incorporated therein, is thoroughly mixed to provide a uniform composition and the melt is then extruded through a flat die onto a quench drum as a film in accordance with known procedure. The nylon film is then heat sealed into a series of pouches. The packaging pouches are then cleaned and the packaging is carried out as described above in Example I. In this case, however, the plastic pouches are cleaned and hermetically sealed against contamination in one location and are then shipped to another plant where the actual packaging of electronic components takes place. After packaging, the sealed packages are stored and shipped as described in Example I to the assembly plant where the electronic components are depackaged. As in Example I, the plastic pouches are spot checked after depackaging by washing the interior thereof with a solvent in this case Dow Clene-W R, the washing solution is filtered to collect the particles and the particles are tested for quantity and size as described in Example I.

Based on the spot testing, it can be determined whether due to unusual handling or other causes, the particular shipment caused undue abrasion between the packaged articles and the plastic film so as to render the packaged components unsuitable for their particular use.

The present packaging system and testing procedure greatly reduces the time and effort required to determine whether the components have been contaminated by particles of the packaging material due to abrasion or mishandling of the packages. At the same time it improves the effectiveness and accuracy of such determinations.

It will be obvious to those skilled in the art that various changes may be made without departing from the scope of the invention and therefore the invention is not intended to be limited to what is shown in the drawings and described in the specification, but only as set forth in the appended claims.

What is claimed is:

1. A package comprising a clean and decontaminated article highly sensitive to particle contamination and a plastic packaging material surrounding said article in sealing relationship, said plastic packaging material comprising a pure, particle-free and decontaminated plastic covering layer containing, dispersed throughout, a small quantity of a coloring material, said colored plastic comprising means for permitting the detection of abraded plastic particles, so that contaminant plastic particles of said film resulting from abrasion with said article are visible under light to thereby permit detection of said contaminant plastic particles.

2. A package in accordance with claim 1 wherein said plastic covering layer comprises a self-supporting plastic film.

3. A package in accordance with claim 2 wherein the plastic comprising said plastic film is selected from the group consisting of polyolefins and polyamides.

4. A package in accordance with claim 1 wherein said

coloring material comprises a fluorescent material, so that contaminant particles from said film fluoresce under ultra-violet light to thereby permit detection of said particles.

5. A package in accordance with claim 1 wherein said coloring material has both daylight and fluorescent coloring.

6. A package in accordance with claim 4 wherein the plastic comprising said plastic film is polyethylene and said fluorescent material comprises 1–20% by weight of said film of a composition consisting essentially of up to 3% by weight of fluorescein and about 97% by weight of a sulfonamide-amine-aldehyde resin.

7. A package in accordance with claim 4 wherein the plastic comprising said plastic film is polycaprolactam and said fluorescent material comprises 0.1–5% by weight of said film of a co-condensation product of naphthalimide and 0.01–5% by volume of said film of 7-(2-chloro-6-diethyl - amino - 1,3,5 - triazin - 4 - yl) - amino - 3 - phenylcoumarin.

8. The method of determining whether a packaged article has become contaminated with particles of the packaging material, comprising:

providing a pure, clean and decontaminated plastic packaging film having incorporated therein a small quantity of coloring material;

packaging a clean and decontaminated article in said plastic packaging film under conditions preventing said article from becoming contaminated with foreign particles, said film providing a barrier to the entrance of foreign particles therethrough to said article;

transporting said packaged article to its situs of use; removing said article from said packaging film;

and optically determining the degree of contamination effected by particles of said packaging film, the coloring material in said film permitting said determination in a simple manner.

9. A method in accordance with claim 8 wherein said coloring material comprises a fluorescent material.

10. A method in accordance with claim 9 wherein said packaged article is transported to a decontaminated zone; and further comprising:

removing said packaging film from said article in said decontaminated zone;

washing the inner surfaces of said plastic film to collect contaminating particles in said wash; and

wherein said determination comprises collecting said contaminating particles and subjecting said particles to ultra-violet light.

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