Title: METHOD OF SORTING AND VERIFYING TYPE OF PLASTIC CONTAINERS

This invention generally relates to a method of sorting a plurality of recyclable or reusable plastic containers in a recycling plant. In particular, the invention relates to the use of predetermined fluorescent markings on an external or internal surface of recyclable or reusable plastic containers to identify and sort the plastic containers according to their composition, contents, or use. Additionally, the present invention provides a method for determining whether the plastic container contains a coating material for purposes of recycling, reuse, or quality control.
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* Republic of Moldova
METHOD OF SORTING AND VERIFYING
TYPE OF PLASTIC CONTAINERS

FIELD OF THE INVENTION

This invention generally relates to the sorting of a plurality of recyclable or reusable plastic containers. In particular, the invention relates to the use of predetermined fluorescent markings on an external or internal surface of recyclable or reusable plastic containers to identify and sort the plastic containers according to their composition, contents, or use.

BACKGROUND OF THE INVENTION

Interest in the recycling of plastics has grown significantly due to the non-biodegradable nature of many plastics and the limited space available in landfills. In an effort to conserve natural resources, there is a demand for plastics to be recycled into new products or reused rather than merely being disposed of in a landfill.

A primary difficulty in recycling plastics is that, for a collection of recovered plastic items to be recyclable and therefore valuable, the plastic items must be sorted into smaller collections wherein all items of the fraction are made of the same generic material; only then can they be reground into a form useful in making new products. In addition, there is a need to separate plastic items based on their contents. Some plastic containers may have contained hazardous substances or may have been coated with foreign materials and need to be separated and processed in a special manner.
before recycling or reuse. In sum, it may be necessary or desirable to separate plastic items depending on their polymeric composition, optical color, original contents, and grade.

Generally, the resident or business that discards plastic items lacks the expertise to sort the items appropriately, nor can the waste collector be expected to be sufficiently knowledgeable to do so. As a result, this sorting is typically performed manually, but this process is extremely labor-intensive, expensive, and often inaccurate and may be hazardous to the persons responsible for sorting. Moreover, manual sorting may not be practical for large amounts of waste plastic.

Plastic containers are a prolific source of plastic waste, and thus are a primary target for recycling or reuse. Plastic containers come in many colors and shapes and are used for such products as carbonated beverages, household cleaning products, medicines, chemicals such as pesticides, and numerous other products. Generally, these containers are made of polyethylene terephthalate (PET), high density polyethylene (HDPE), polyvinyl chloride (PVC), polypropylene (PP), polycarbonate (PC) and polystyrene (PS). In addition, these containers may be coated with a particular chemical material such as an epoxy amine.

Various methods have been developed to sort plastic waste materials. Some methods separate plastic containers based on the container’s color (U.S. Pat. No. 5,314,072 and U.S. Pat. No. 5,432,545). Other methods separate plastic bottles of different materials into fractions wherein each fraction contains bottles of the same material (U.S. Pat. No. 5,344,026). This is accomplished by measuring the effect a plastic item has on light directed at a stream of items from a light source, then selectively removing items from the stream based on a comparison of the light measured and the light emitted from a detector. The method depends on the fact that each plastic material has an inherent characteristic effect on light that differs from other plastic materials. In addition, there is a method of sorting plastic waste material by incorporating therein a phosphor capable of phosphorescing when exposed to an appropriate light source (GB 2234347A). The resulting phosphorescence is used to trigger a signaling device to activate means capable of separating the waste into like
materials for recycling. The phosphors are used to identify different types of plastic material that correspond to a predetermined afterglow characteristics of the phosphor.

The prior art methods described above are limited in their ability to categorize plastic items for purposes of recycling or reuse, often relying on the overall color of the original plastic container or the characteristics of the particular polymer used to make the container. Moreover, there is no method for determining the presence of a coating material that may be applied to the plastic container and that must be removed before recycling or reuse. There exists a need to encode plastic containers with comprehensive information regarding composition, original contents, optical color, grade, or combinations thereof.

**SUMMARY OF THE INVENTION**

The present invention provides methods for sorting a plurality of recyclable or reusable plastic containers. According to the invention, a predetermined marking of fluorescent material is applied to an external or internal surface of the plastic container. This marking may be indicative of the container’s composition, contents, or previous use. The container is irradiated with ultraviolet light and an appropriate detector is used to identify the fluorescent marking. The container may then be sorted according to the fluorescent marking. In addition, the present invention relates to the recyclable or reusable plastic containers that have a fluorescent marking on an external or internal surface to identify the container when irradiated with ultraviolet light and viewed by an appropriate detector.

Alternatively, the present invention provides a method for determining whether the plastic container contains a coating material for purposes of recycling, reuse, or for quality control purposes. The coating material contains a fluorescent material which may be identified by an appropriate detector upon irradiation with ultraviolet light to determine the presence or absence of the coating material.

The methods of the present invention do not merely sort plastic containers by the container’s original color or composition. Nor is the invention limited to sorting plastic containers by bulk color by incorporating a substance on the container that emits a predetermined color when irradiated with appropriate light, the color
corresponding to a particular characteristic of the plastic container. Through the use of discrete fluorescent markings and appropriate detectors, the present invention enables the plastic container to be encoded with discrete comprehensive information about the plastic container’s composition, contents, or use. As a result, a recycling process involving the methods of the present invention has the ability to sort plastic containers based on numerous and varied criteria.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1 and 2 include an illustration of a marked container which may be used in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides methods for sorting a plurality of recyclable or reusable plastic containers. The methods of the present invention include the step of applying at least one predetermined marking of fluorescent material to an external or internal surface of the container. The container is irradiated with ultraviolet irradiation and the marking is detected and identified by an appropriate detector. The plastic container is then sorted according to the fluorescent marking which is indicative of the container’s composition, contents, or use. The invention also relates to the plastic containers encoded with the predetermined marking of fluorescent material.

Alternatively, the present invention provides a method for determining whether the plastic container contains a coating material for purposes of recycling, reuse, or quality control. A fluorescent material is incorporated into the coating material prior to applying the coating to the plastic container. An appropriate detector is used to identify the presence or absence of the fluorescent material by irradiating the container with ultraviolet irradiation. The plastic container is then sorted according to the presence or absence of the fluorescent material, which is indicative of the presence or absence of the coating material. This method may also be used to indicate if the coating material has been applied evenly or completely or applied in an appropriate or desirable thickness.
The plastic containers of the present invention include, for example, bottles, packages, tubs, trays, pails, or other plastic articles used to store or hold various substances. The plastic containers are formed by methods well known in the art and are molded from any number of polymer resins in accordance with their intended use. The container may be molded of a specific resin in a single layer or multiple layers, with or without color, or comprise a mixture of more than one material. The container may also be laminated or coated with one or more materials.

The resins include, but are not limited to, polyethylene terephthalate (PET), high density polyethylene (HDPE), polyvinyl chloride (PVC), polypropylene (PP), polycarbonate (PC), polystyrene (PS), polyamide, amorphous PET, and polyacrylonitrile (PAN). The coating materials may include, but are not limited to, epoxy amines and/or other materials which may enhance the barrier resistance of the container to oxygen and/or carbon dioxide, or other gases.

According to the present invention, each of the plastic containers may be marked with at least one predetermined marking of fluorescent material. The fluorescent materials may be an ink, dye, spray, paint, stain, or combination thereof. The fluorescent materials are commercially available and well known in the art. Preferably, the fluorescent material is a fluorescent ink. In addition, the fluorescent material is preferably invisible to the naked eye so as to not detract from the appearance of the container, but it is to be understood that the ink may also be visible to the naked eye.

The fluorescent markings preferably comprise discrete patterns or codes. The pattern or code may comprise numbers, letters, geometric shapes, bar codes, or combinations thereof. The characteristic color of the fluorescent material may also comprise the particular pattern or code. Additionally, the marking may itself be a color or mixture of colors. According to the present invention, the marking may be as simple or complex as necessary to encode the desired information.

The predetermined fluorescent marking is indicative of the plastic containers composition, contents, or use. For example, a blue triangle may indicate a blue PET container that was used to hold pesticides. A green triangle may indicate a clear PET container used to hold a beverage. It is to be understood that the fluorescent
marking can be indicative of a wide range of information particular to the container and can incorporate any desired criteria useful in the recycling or reuse of the container.

The fluorescent marking can be applied to the container in any conventional manner by processes well known in the art. For example, the fluorescent marking may be applied by ink jet printing, offset printing, roll-coating, spray-coating or otherwise incorporated during the manufacture of the plastic container. Preferably, the marking is applied by ink jet printing.

The fluorescent markings may be applied on part of the plastic container, including the label, or on the entire outside surface of the container. In one embodiment, fluorescent material may be applied to the entire outside surface of a container through conventional spray-coating methods as well known to those skilled in the art. Additionally, the fluorescent markings may be applied to internal surfaces of the container where the container is made of several different layers. Also, it is possible that the markings be preprinted and adhesively bonded to the plastic container. Preferably, the fluorescent markings are applied to substantially the entire outside surface of the container. In this case, even if the container is broken down or cut prior to recycling, every piece of the container would contain the necessary information required for recycling, reuse, or other processing.

Figures 1 and 2 illustrate a marked container 10, which for the sake of example is in the form of a bottle, in accordance with the present invention. The container 10 has an open end 12, a shoulder 14, a label panel 16, and a base 18. In Figure 1 geometric symbols, i.e. triangles, may be applied over substantially the entire outside surface of the container. In Figure 2, letters may be applied in a circumferential band across the top and bottom portions of the label panel 16.

Preferably, the plastic containers are marked shortly after manufacture with a predetermined marking that is indicative of the container's composition, contents, or use. However, the containers may be marked as an integral part of the manufacturing process. In any event, it is preferable that the fluorescent markings are applied before the container is ground up, shredded, or washed in preparation for recycling or reuse. It is to be understood that the fluorescent markings may be applied on the plastic containers at any convenient time, when the containers are stationary or moving.
The fluorescent markings may be detected and identified by methods well known in the art. Typically, the plastic containers may be formed randomly into a stream at a processing plant after domestic or commercial use and subsequent collection. In order to detect the fluorescent markings, the plastic containers may be irradiated by an ultraviolet light source under which circumstances the markings will emit light of a unique frequency in the visible range. A source of ultraviolet radiation may include equipment such as the Blak-Ray by Ultra-Violet Products, of San Gabriel, California, and other sources of ultraviolet radiation are well known in the art.

Detection of this emitted light, and therefore identification of the discrete markings, may be effected in a number of conventional manners, and the recycling process may comprise a means to orient the container to a position in which the markings can be more easily detected. The fluorescent markings may be detected by a detector or combination of detectors capable of identifying a discrete pattern or code. These are well known by those of ordinary skill in the art and can be selected without undue experimentation. For example, the detectors may comprise a photodiode, photomultiplier, photodiode array or imaging system which utilizes either a dispersion device to restrict or select wavelength or a non dispersive optical filter. These devices can detect a specific optical color by an increase in voltage, current or charge relative to a color which is not within the bandpass of the dispersive element or filter. In addition, the detector may be a charged coupled device (CCD), charged induced device, or other optical character recognition device that can detect alphanumeric characters or symbols. For example, a CCD stores and transfers information in the form of packets of electrical charge. When light from an image or scene is focused on a CCD, a pattern of electrical charges is created. The charges vary in proportion to the amount of light and thus serve as an accurate electrical representation of picture elements. The choice of detector and/or detectors will depend on the form and complexity of the fluorescent marking that requires identification.

Typically, the detection device produces an electronic signal and cooperates with a microprocessor or other recognition device programmed to interpret the wavelengths of light emitted. Based on the data from the detector, the recognition device identifies the predetermined fluorescent marking and in turn cooperates with an
electromechanical device that separates the containers based on the information encoded with the fluorescent markings.

For example, containers marked with blue triangles which may indicate a pesticide container may be sorted into a washing system, whereas containers marked with green triangles which may indicate beverage bottles, may be directed to a shredder. Moreover, unmarked bottles may be separated into a stream requiring further evaluation or manual evaluation.

It is to be understood that any desirable sorting procedure may be developed based on the predetermined information indicated by the fluorescent marking. The electromechanical or sorting device may be any device responsive to the detector and recognition device and suitable for removing containers from a stream of containers. Typically, the sorting device directs each container to an appropriate stream or bin based on the container’s fluorescent marking and may incorporate, for example, mechanical paddles, hydraulic jets, or air jets. Also, it is to be understood that the method of the present invention may incorporate sorting devices currently being used in recycling plants.

Another aspect of the invention relates to a method for determining the presence or absence of a coating material on a plastic container. Examples of coating materials include, but are not limited to, epoxy amines and/or other materials applied to the external surface of a container which will enhance the barrier resistance of the container to oxygen and/or carbon dioxide, or other gases.

According to the present invention, the coating material would contain a fluorescent material. The fluorescent material may be any fluorescent material described earlier in this description, and is preferably a fluorescent ink. Preferably, the fluorescent material would be mixed thoroughly in any conventional manner with the coating material prior to the coating material being applied to the container.

The plastic container may be irradiated with ultraviolet light and an appropriate detector may be used to identify the presence of the fluorescent material. The detector may be a detector described earlier in this description, and is preferably a photodiode array. The detection of the fluorescent material may be indicative of the presence or absence of the coating material. Typically, the particular coating material
will be identified by the color emitted by the fluorescent material incorporated within
the coating material upon irradiation with ultraviolet light. For example, the color red
may be designated to indicate the presence of a water based epoxy amine coating
whereas the color green may be designated to indicate the presence of a coating
containing an ultraviolet cured material. Moreover, the detection of the fluorescent
material may be indicative of the uniformity or completeness of the coating material on
the container. Additionally, the intensity of the light emitted by the fluorescent material
within the coating material may be a function of the thickness of the coating material.
For example, if the container requires a 75 μm thick coating, such a thickness can be
correlated to a specific intensity representative of the fluorescent material within the
coating. Therefore, the methods of the present invention may be used to sort coated
materials that may require special processing to remove the coating prior to recycling or
reuse, or provide a quality control function by determining if the coating material has
been appropriately applied to the container.

Although the invention has been described in detail and with reference to
specific embodiments thereof, it will be apparent to one skilled in the art that various
changes and modifications can be made therein without departing from the scope and
spirit of the present invention. For example, the present method may be applicable to
any material capable of being recycled or reused including paper, cloth, glass, metal, and
ceramics.
CLAIMS:

1. A method of sorting a plurality of recyclable or reusable plastic containers, said method comprising the steps of:

   applying at least one predetermined marking of fluorescent material to an external or internal surface of said plastic container;

   using a detector to identify said fluorescent marking by irradiating said container with ultraviolet irradiation;

   and

   sorting the plastic container according to said fluorescent marking;

   whereby said marking is indicative of said container's composition, contents, or use.

2. The method of claim 1 wherein said fluorescent marking is visible or invisible to the naked eye.

3. The method of claim 1 wherein said containers are marked by ink jet printing.

4. The method of claim 1 wherein a plurality of discrete fluorescent markings are applied over the surface of the plastic container.

5. The method of claim 4 wherein said plurality of markings are uniformly applied over said surface.

6. The method of claim 4 wherein said plurality of markings are applied in a predetermined pattern.

7. The method of claim 1 wherein said markings comprise numerical, alphanumerical, or geometric indicia.
8. The method of claim 1 wherein said marking is a bar code.

9. The method of claim 1 wherein said marking is a colored marking.

10. The method of claim 1 wherein said marking is applied as plastic containers pass in line relative to a processing step.

11. A method for determining the presence of a coating material on a plastic container, said method comprising the steps of:
   - applying a coating to an external surface of said plastic container, said coating containing fluorescent material;
   - using a detector to identify the presence or absence of said fluorescent material by irradiating said container with ultraviolet irradiation;
   and
   - sorting the plastic container according to the presence or absence of said fluorescent material;

   whereby said fluorescent material is indicative of the presence of said coating on said container.

12. The method of claim 11 wherein said coating enhances the barrier resistance of said container to oxygen and carbon dioxide.

13. The method of claim 11 wherein said fluorescent material is indicative of the uniformity of the coating on the container.

14. The method of claim 11 wherein said fluorescent material is indicative of the thickness of the coating.

15. A plastic container suitable for recycling or reuse having at least one predetermined fluorescent marking on an external or internal surface of said
container to identify the composition, contents, or use of said container when irradiated by ultraviolet irradiation and viewed by a detector.

16. The plastic container according to claim 15 wherein said marking is a colored marking.

17. The plastic container according to claim 15 wherein a plurality of discrete fluorescent markings are applied over the surface of said container.

18. The plastic container according to claim 17 wherein said plurality of markings are applied in a predetermined pattern.

19. The plastic container according to claim 15 wherein said marking is a bar code.

20. The plastic container according to claim 15 wherein said markings comprise numerical, alphanumerical, or geometric indicia.