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TAMPER EVIDENT SEAL AND TAPE

This application is a continuation-in-part of prior copending U.S. application Serial No. 08/388,136 entitled "Self Containing Tamper Evident Tape and Label" filed February 13, 1995, which is a
5 continuation-in-part of prior copending U.S. application Serial No. 08/285,639 entitled "Self Containing Tamper-Evident Seal" filed August 2, 1994.

Field of the Invention

This invention relates generally to
10 tamper-evident closures and, more particularly, a closure in the form of a tape or label that indicates a forced opening, cooling below a particular temperature, and/or heating above a particular temperature.

Background of the Invention

15 Tamper-evident closures for containers such as bags, envelopes, packages, etc. and tamper-evident tapes and labels for use with bags, envelopes, and other packages have been available for several years. Generally, if these existing closures are forced open,
20 the visual appearance of the closure changes so as to provide an indication that the contents of the container have been accessed. Containers fabricated having tamper-evident closures are commonly used in industries in which the contents of the containers must
25 be maintained in tight security, for example, in the

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banking industry. In certain instances package manufacturers employ prefabricated closures in the form of a tape or label to provide a tamper-evident closure on their packaging. Tamper-evident closures in the form of tapes or labels are also often used by everyday consumers who want to ensure that their packages are securely sealed and will evidence tampering if it occurs.

One form of container commonly used in banking and other industries is a bag, pouch or envelope (generally referred to herein as a bag) formed of a plastic material such as polyethylene. The opening in this type of bag is commonly closed with a pressure-sensitive adhesive located on one side of the bag. To close the bag, a peelback strip covering the free side of the adhesive is removed, and the exposed surface of the adhesive is then pressed against the opposite side of the bag. Generally, if a bag of this type is later forced open, the pressure-sensitive adhesive and/or other parts of the bag will distort and break apart, so as to provide an indication that the bag has been opened, possibly without authorization. Closures for a bag of this type have been formed with layers in addition to the pressure-sensitive adhesive to provide a clearer indication of when the closure is forced open. For example, U.S. Patent No. 5,060,848 to F.R. Ewan describes a tamper evident seal that uses a layer of nitrocellulose or acrylic ink that breaks apart in a selected pattern when the seal is forced open. The layer of ink is adhered to a polyester panel that is part of the seal. Before applying the ink the plastic panel is masked with a desired pattern of a silicon oil releasant material, which normally causes the ink to break apart in the masked pattern when the seal is forced open. Also, to ensure that the ink layer adheres to the silicon oil releasant material and polyester panel, a primer is applied over the silicon

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oil releasant, and the ink is then applied over the primer.

Unfortunately, bags of this type are generally expensive to manufacture, use hazardous materials, and are not easily recycled. For example, the polyester panel disclosed in U.S. Patent No. 5,060,848 to F.R Ewan is not easily recycled, and the primer required is hazardous. Furthermore, thieves have devised a scheme to gain access to the contents of bags of this type without detection. The scheme devised involves spraying a liquid refrigerant onto the adhesive to freeze the adhesive down to its glass transition temperature, generally at about -10°F. At this temperature, the adhesive becomes brittle and loses its adhesive qualities, i.e., tack. The thief is then able to open the bag and remove certain contents. The thief allows the adhesive to warm back to room temperature, at which point the adhesive regains its tack and then simply recloses the bag by applying pressure, all without any evidence of tampering.

Thieves have also devised a scheme to gain access to the contents of bags of this type without detection by heating the adhesive to a temperature at which the adhesive softens. The thief is then able to open the bag and remove certain contents. The thief can reseal the bag while the adhesive is still soft by applying pressure, all without any evidence of tampering.

Tamper-evident closures for plastic bags have been formed to combat the problem of refrigerant tampering. Such closures provide an indication that the bag was opened, whether or not a refrigerant is first applied. These closures include multiple adhesive and nonadhesive layers that have differing strengths so that when the closure is forced open, one or more of the layers is permanently altered, even if a refrigerant is first applied. For example, U.S. Patent

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No. 4,834,552 to K.R. Makowka describes a tamper-evident seal for a plastic envelope. The tamper-evident seal comprises two paper layers and an adhesive layer. One of the paper layers is bonded to a closure flap on the back wall of the envelope, the other paper layer is bonded to the front wall of the envelope, and the adhesive layer is applied to the free side of one of the paper layers. To close the envelope, the closure flap is folded over the envelope opening, and the adhesive layer is pressed onto the paper layer that has a free side. The adhesive seeps into the interstices of the paper layers to form a mechanical-type lock with the paper layers. The strength of this mechanical-type lock is apparently greater than the internal strength of the paper layers, even if a refrigerant is first applied, so that the paper layers break apart when the seal is forced open.

Unfortunately, closures such as the seal disclosed in the Makowka patent have several shortcomings. These closures do not provide any evidence of refrigerant tampering unless the closure is actually forced open. Thus, if a thief begins to attempt to open a bag by applying a refrigerant, but his efforts are somehow thwarted before he is able to force the bag open, the thief's tampering will go undetected. Even if these closures are forced open, they do not always satisfactorily provide evidence of such tampering. Any delamination of one of the paper layers can only be detected by close inspection; the delamination is not bold and distinct as would be desired. Once the closure is forced open, it is possible to use additional adhesive/glue to reclose the closure, without any readily visible evidence that the closure was ever opened. In addition, these closures generally have high production costs. For example, in addition to an adhesive layer as is commonly used to close plastic bags, the closure described in the

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Makowka patent requires two paper layers, which must both be bonded to the envelope during its production. Furthermore, the bag and closure taught by the Makowka patent is not readily recyclable.

5 To overcome these shortcomings in the existing technology, what is needed is a closure in the form of a tape or label that provides evidence of forced opening of a seal created by the tape or label regardless of whether a refrigerant is applied, and
10 additionally, provides evidence of refrigerant tampering, regardless of whether the closure is actually opened. Further, closures which provide evidence of heat tampering are also needed. The tape or label should be easy to close, and the evidence of
15 tampering provided should be readily visible, i.e., bold and distinct. Furthermore, the tape or label providing these features should also be relatively inexpensive and easy to recycle and include only nonhazardous materials. As explained in the following,
20 the present invention provides a tape and label that meets these criteria.

Summary of the Invention

In accordance with this invention, a bag closure that provides evidence of refrigerant tampering
25 is provided. The bag closure is sensitive to being cooled below a particular "breakdown temperature," so that if a refrigerant is applied, the visual appearance of the closure permanently changes, regardless of whether the closure is opened. In one preferred
30 embodiment of the invention, the closure includes an adhesive layer and a delaminating layer that visibly delaminates when the closure is cooled below the breakdown temperature. The bag includes a back and front wall that are joined at their peripheral side and
35 bottom edges. The opening of the bag is formed by the

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upper ends of the back and front walls, and the closure is located at this opening.

In accordance with further aspects of the invention, one surface of the delaminating layer is bonded to a closure flap formed at the upper end of the bag front wall. When the closure is closed, the opposite surface of the delaminating layer is adhered to one surface of the adhesive layer, and the opposite surface of the adhesive layer is adhered to the bag back wall. Further, in one preferred embodiment, the bag is formed so that one surface of the adhesive layer is adhered to the bag back wall and the opposite surface of the adhesive layer is covered with a peel-back strip. To close the closure, the peel-back strip is removed and the free surface of the adhesive layer is pressed against the delaminating layer.

In accordance with still further aspects of the invention, as the closure is cooled, e.g., with a refrigerant, the delaminating layer delaminates from the front wall prior to the adhesive layer losing its tack which occurs when the adhesive layer reaches its glass transition temperature. Thus, an indication of refrigerant tampering is provided before the refrigerant allows the closure to be easily opened. Furthermore, the delaminating layer delaminates regardless of whether the closure is actually opened, so that the closure provides evidence of the mere application of a refrigerant. Also, regardless of whether a refrigerant is first applied, the delaminating layer delaminates whenever the closure is opened, so as to provide an indication that the contents of the bag have been accessed.

In accordance with still further aspects of the invention, the delaminating layer comprises a layer of ink that is applied to the closure flap on the bag front wall. Furthermore, the adhesive layer comprises a pressure-sensitive adhesive and the closure flap

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comprises a plastic material. The closure flap, ink and pressure-sensitive adhesive are chosen so that when the temperature of the closure is above the glass transition temperature of the adhesive, the bond (i.e., affinity) between the ink layer and the adhesive layer is at least as strong as (and preferably stronger than) the bond between the ink layer and the closure flap. As a result, the ink layer delaminates when the closure is forced open. Also, the adhesive layer and the closure flap are chosen such that, when cooled, the closure flap and the adhesive layer shrink at different rates. As a result, the ink layer - which is sandwiched between the adhesive layer and closure flap - delaminates as the closure is cooled below the breakdown temperature. Preferably, both the ink and closure flap have contrasting colors so that delamination of the ink can be easily seen. Further, in one preferred embodiment, the closure flap comprises a polyethylene plastic and the ink is water based. In one preferred embodiment, the ink is in direct contact with the closure flap without any intervening primer or releasant, and the closure flap is not pretreated (e.g., by corona discharge). A process for manufacturing this bag closure is also provided by the invention.

In a second preferred embodiment of the invention, the previously described delaminating layer of the bag closure includes two layers of ink. A patterned layer of clear ink is applied directly to the closure flap without any intervening primer or releasant, or pretreating of the closure flap. For example, the clear ink can be applied in a pattern to form a series of "stop signs." After the pattern of clear ink is applied, the closure flap is treated, e.g., with a corona discharge process, so that the ink more readily adheres to the closure flap. Then a uniform layer of colored ink is applied over the

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patterned layer of clear ink and ink-free portions of the closure flap. When the closure flap is closed, the two ink layers are sandwiched between the adhesive and the closure flap, which is preferably a polyethylene plastic. If the closure flap is quickly "frozen" or forced open, the clear ink, and the colored ink positioned over the clear ink delaminates from the closure flap. The colored ink in between the clear ink pattern remains on the closure flap, so that the pattern of the clear ink appears.

In accordance with another aspect of the present invention, a tamper evident tape or label formed similarly to the tamper-evident closure described above is provided. In one preferred embodiment of this aspect of the present invention, a polyethylene plastic layer is used to form the tape or label backing. A layer of ink is applied to the plastic layer, and a layer of pressure-sensitive adhesive is then applied over the ink. The tape or label is secured by pressing the adhesive layer onto the desired surface. As with the closures described above, if a thief or other unauthorized person applies a refrigerant to the tape and/or forces the tape open, the tape provides permanent evidence of such tampering by visible delamination of the ink layer.

In accordance with yet another embodiment of this invention, a bag closure that provides evidence of heat tampering is also provided. The bag closure is sensitive to being heated above a particular activation temperature, so that if heat is applied, the visual appearance of the closure permanently changes, regardless of whether the closure is opened.

In one preferred embodiment of the invention, the closure includes a thermally activatable or thermochromic ink layer that visibly changes when the closure is heated at or above the activation temperature of the ink. The thermally activatable ink

layer can be applied uniformly or in a pattern, for example, so that upon activation, the ink forms a series of "stop signs." Alternatively, a uniform coating of a standard ink can be used to provide a background contrast, and a layer of the thermally activatable ink can be applied in a pattern, such as the above-referenced series of "stop signs" over the layer of standard ink. In this embodiment of the invention, when dry, the standard ink and the thermally activatable ink are the same color. However, if the closure is heated to a temperature at or above the activation temperature of the thermally activatable ink layer, the thermally activatable ink visibly changes so as to form a series of contrasting "stop signs" against the standard ink layer. In a particularly advantageous embodiment of the invention, the thermally activatable ink layer is used in combination with any of the tamper evident closures described above.

As will be appreciated from the foregoing brief summary, this invention provides a tape or label that can be used as a bag closure that provides evidence of the mere application of a refrigerant, and/or the mere application of heat, regardless of whether the closure is actually forced open. Furthermore, if the closure is forced open, whether or not a refrigerant and/or heat is first applied, the tape or label provides a permanent indication that the closure was opened. As will be further appreciated from the foregoing brief summary, the tapes and labels and corresponding manufacturing process provided by this invention present a cost savings over existing tapes and labels since they include a minimal number of layers which are inexpensive to form. The materials used are inexpensive and nonhazardous. Furthermore, because the tape and labels are preferably formed of a polyethylene plastic, they are easily recycled.

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Brief Description of the Drawings

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURES 1A and 1B are pictorial views of a bag including a tamper-evident seal formed in accordance with the invention;

FIGURE 2A is a side cross-sectional view of the bag shown in FIGURES 1A and 1B, and FIGURE 2B is a side cross-sectional view of the bag with the seal closed;

FIGURE 3 is a front view of the bag illustrating the visual appearance of the seal when closed;

FIGURE 4A is a pictorial view of the seal illustrating how the seal visually distorts if the seal is forced open, and FIGURE 4B is a pictorial view illustrating how the visual distortion remains, even if the seal is reclosed;

FIGURE 5 is a front view of the bag illustrating the visual distortion of the seal that occurs when the seal is cooled below a particular temperature;

FIGURES 6A-6D are top views of a plastic strip formed in accordance with a further embodiment of the present invention, and FIGURE 6E is a side cross-sectional view of the plastic strip shown in FIGURES 6A-6D;

FIGURE 7 is a side cross-sectional view of a bag with a tamper-evident seal including the plastic strip shown in FIGURES 6A-6E in accordance with the invention;

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FIGURE 8A is a front view of the bag shown in FIGURE 7, illustrating the visual appearance of the seal when a portion of the seal is forced open;

FIGURE 8B is an end cross-sectional view of the seal in FIGURE 8A, illustrating the delamination of the portion of the seal that is forced open; and

FIGURE 9A is a side cross-sectional view of a bag including a tamper-evident tape formed in accordance with a further aspect of the present invention, and FIGURE 9B is a side cross-sectional view of a bag with the tamper-evident tape sealing the bag closed;

FIGURE 10 is a pictorial view of a roll of tamper-evident tape formed in accordance with the present invention; and

FIGURE 11 is a side view of a section of a roll of tamper-evident tape formed in accordance with the present invention.

Detailed Description of the Preferred Embodiment

FIGURES 1A and 1B illustrate a bag 10 that incorporates a seal 12 formed at the opening 14 of bag 10. The bag includes a front wall 16 and a back wall 18 that are joined together at the bottom and side edges to form an enclosure having opening 14 at the upper ends of front wall 16 and back wall 18. Seal 12 is included to close opening 14 and to provide visual evidence of any forced opening of seal 12. Furthermore, seal 12 will visually distort if the opening of the bag is cooled below a particular "breakdown temperature," e.g., by the application of a refrigerant.

Seal 12 includes a plastic strip 20, a layer of ink 22, and a layer of adhesive 24. The bottom end of plastic strip 20 is attached to the inner surface of the upper end of front wall 16. Ink layer 22 is printed on the inner surface of plastic strip 20.

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While ink layer 22 is represented by a grid of lines in the figures, ink layer 22 is preferably a uniform layer of ink. As shown in FIGURES 1A and 1B, adhesive layer 24 is preferably applied to the inner surface of the upper end of back wall 18. The free surface of adhesive layer 24 is covered with a peel-back strip 26. To seal the opening of the bag closed, peel-back strip 26 is removed from adhesive layer 24, and plastic strip 20 is pressed onto adhesive layer 24, which is a pressure sensitive adhesive. Thus, when seal 12 is closed, ink layer 22 is sandwiched between adhesive layer 24 and plastic strip 20.

The location of the various layers of seal 12 can be seen more definitely in the side cross-sectional views in FIGURES 2A and 2B. Plastic strip 20 is attached at its lower end 28 to the inner surface of the upper end of front wall 16, and ink layer 22 is printed on the inner surface of plastic strip 20. Adhesive layer 24 is applied to the inner surface of the upper end of back wall 18, and the free surface of adhesive layer 24 is covered with peel-back strip 26. FIGURE 2B illustrates the alignment of seal 12 after peel-back strip 26 is removed and the seal is pressed closed. Plastic strip 20 is pressed onto adhesive layer 24 so that ink layer 22 adheres to adhesive layer 24.

As shown in FIGURES 2A and 2B, adhesive layer 24 preferably extends approximately an eighth of an inch below the bottom edge of plastic strip 20, so that when seal 12 is closed, a portion of adhesive layer 24 adheres directly to front wall 16. This helps prevent loose contents within the bag from partially opening seal 12 as the contents bump against the seal. Without a portion of adhesive layer 24 adhering to front wall 16, contents within the bag could falsely activate the tamper evidencing means of seal 12.

Preferably, back wall 18 includes a detachable identification tab 30 formed by perforating

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the upper end of back wall 18. As shown in FIGURES 1A and 1B, the perforations allow identification tab 30 to be easily removed. Preferably, identifying text or numbers are printed on identification tab 30 and

5 matching identifying text or numbers are printed on either front wall 16 or back wall 18 of the bag. When the bag is sealed closed, identification tab 30 can be removed and used as a receipt.

After being closed, if seal 12 is forced

10 open, the seal visually distorts. Plastic strip 20 is partially transparent so that ink layer 22 can be seen from the outer side of plastic strip 20 before seal 12 is closed, as shown in FIGURE 1A, and after seal 12 is closed, as shown in FIGURE 3, which is a front view of

15 the bag with seal 12 closed. In particular, objects that are in direct contact with the inner surface of plastic strip 20 can be seen from the outer side of plastic strip 20. In contrast, if an object is positioned near the inner surface side of plastic strip

20 20, but not in direct contact with the inner surface of plastic strip 20, the object can barely be seen, if at all, from the outer side of plastic strip 20.

Accordingly, when ink layer 22 is printed on the inner surface of plastic strip 20, the ink can be seen from

25 the outer surface of plastic strip 20, as shown in FIGURE 1A and FIGURE 3. However, as illustrated in FIGURE 4A, if seal 12 is forced open, a substantial portion of the ink remains adhered to adhesive layer 24 and accordingly delaminates from plastic strip 20.

30 When this occurs, the ink is no longer visible from the outer side of plastic strip 20.

If an attempt is made to re-close seal 12, the visual distortion of the ink is still visibly apparent, as illustrated in FIGURE 4B, because the ink

35 does not re-adhere to plastic strip 20. The ink is printed onto plastic strip 20 while wet, i.e., in a liquid state. The ink then dries. Once dried, if the

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ink is delaminated from plastic strip 20, the ink no longer adheres to the inner surface of plastic strip 20. As a result, even when plastic strip 20 is re-pressed against adhesive layer 24, the ink remains sufficiently separated from plastic strip 20 so that the ink cannot be clearly seen through the outer side of plastic strip 20. In the illustration shown in FIGURES 4A and 4B, a portion 32 of seal 12 is forced open and then re-closed. As illustrated in FIGURE 4B, portion 32 that was forced open is visibly distorted, in sharp contrast to the portion 34 of seal 12 that was not opened.

In order for ink layer 22 to delaminate from plastic strip 20 when the seal is forced open, it is necessary that the bond between the ink and plastic strip 20 be relatively weak i.e., weak relative to the bond between adhesive layer 24 and ink layer 22. Because the bond between the ink and plastic strip 20 is relatively weak, if adhesive layer 24 merely adhered to ink layer 22, the overall strength of seal 12 would be relatively weak. Adhesive layer 24 would simply release from plastic strip 20 whenever ink layer 22 delaminated from plastic strip 20. This could cause the seal to inadvertently open during handling and shipping of the bag, which would be highly undesirable. To avoid this potential problem, ink layer 22 is sufficiently thin so that there are voids in ink layer 22. As a result, when seal 12 is pressed closed, portions of adhesive layer 24 adhere to the inner surface of plastic strip 20 through the voids in the ink. The affinity between the adhesive and the plastic strip is sufficiently high so that the strength of seal 12 is acceptably strong. Thus, seal 12 generally does not open unless it is intentionally forced open by pulling plastic strip 20 away from back wall 18.

In addition to distorting when forced open, seal 12 is sensitive to cooling so that if the seal is

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cooled below a particular "breakdown temperature," e.g., -10°F , the seal visibly distorts in a manner similar to when the seal is forced open. In particular, as illustrated in FIGURE 5, when the seal is cooled below a breakdown temperature, ink layer 22 delaminates from plastic strip 20 so that the ink can no longer be clearly seen when viewing the outer side of plastic strip 20. The mechanism for the delamination of the ink is differential rates of shrinking of adhesive layer 24 and plastic strip 20. In particular, plastic strip 20 and adhesive layer 24 are chosen so that they shrink at different rates when cooled. In a preferred embodiment, the adhesive shrinks more and at a greater rate than plastic strip 20. Because the ink has a strong affinity to the adhesive, as the adhesive and the plastic strip shrink at different rates, ink layer 22, which is sandwiched between the plastic strip and the adhesive, is pulled away from the plastic strip. As a result, the ink is no longer clearly visible through the outer side of plastic strip 20.

The ability of seal 12 to provide visual evidence of cooling is important because a common technique used by thieves to gain access to plastic bags sealed with a pressure sensitive adhesive is to "freeze" the bag with a refrigerant, as previously described herein. Seals that combat this form of tampering have been introduced. However, as previously described herein, these prior art seals do not provide evidence of mere "freezing." Rather, the prior art seals simply provide evidence of a forced opening of the bag, whether or not the bag is first "frozen." In sharp contrast, seal 12 provided by the present invention provides a permanent visual indication if the seal is cooled below the breakdown temperature, regardless of whether or not the seal is actually forced open.

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Furthermore, seal 12 provided by the present invention cannot be opened without ink layer 22 visibly delaminating, whether or not the seal is first "frozen." This is ensured by choosing a pressure sensitive adhesive for adhesive layer 24 that has a relatively low glass transition temperature. When a pressure sensitive adhesive is cooled to its glass transition temperature, the adhesive loses its adhesive properties, i.e., its adhesive tack. The adhesive is chosen so that its glass transition temperature is lower than the breakdown temperature of seal 12, at which temperature ink layer 22 delaminates from plastic strip 20. As a result, as the seal is progressively cooled, ink layer 22 at least partially delaminates from plastic strip 20 before the glass transition temperature of the pressure sensitive adhesive is reached. Thus, the ink delaminates before the seal is sufficiently "frozen" to allow the seal to be opened without any significant force.

It is important that the breakdown temperature of seal 12 be greater, i.e., at a higher temperature, than the glass transition temperature of the pressure sensitive adhesive, to ensure that the seal cannot be opened without detection. If, in contrast, the glass transition temperature is above the seal's breakdown temperature, a refrigerant could be used to cool the seal to the adhesive's glass transition temperature, at which point the adhesive would lose its adhesive tack and release from the upper end of back wall 18 and/or ink layer 22 and plastic strip 20. The bag could then be opened, and then after warming to room temperature be reclosed. As long as the temperature of the bag is kept above the breakdown temperature, no visual indication of tampering would exist.

Adhesive layer 24 and plastic strip 20 are also preferably chosen so that they expand at different

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relative rates when warmed, i.e., the plastic strip and adhesive layer have different thermal coefficients of expansion. In one preferred embodiment, the adhesive expands more and at a greater rate than plastic strip

5 20. As a result, if, after the seal is "frozen" below the breakdown temperature, a portion of ink layer 22 has not delaminated from plastic strip 20, the ink will further delaminate upon warming of seal 12. This further ensures that the delamination is sufficient to

10 provide a significant visual indication of "freezing."

The embodiment of seal 12 shown in FIGURES 1 and 2 is one preferred embodiment of the invention. FIGURES 9A and 9B illustrate a second embodiment. The second embodiment includes many of the same component

15 parts as the first preferred embodiment; accordingly, like components are referred to with the same reference numerals, except that the reference numerals are double primed. In the second embodiment, adhesive layer 24" is applied to the inner surface of ink layer 22"

20 instead of to the inner surface of the back wall 18". The free surface of adhesive layer 24" is covered with peel-back strip 26". The other structural aspects of seal 12" are the same as seal 12 in FIGURES 1 and 2. To close the seal, peel-back strip 26" is removed and

25 the free surface of adhesive layer 24" is pressed against the inner surface of back wall 18". If the seal is forced open or "frozen," ink layer 22" visually delaminates, as described with respect to the first embodiment shown in FIGURES 1 and 2. While the second

30 embodiment shown in FIGURES 9A and 9B is an alternative embodiment, the first embodiment shown in FIGURES 1 and 2 is preferred because adhesive 24 adheres more strongly to back wall 18 when applied hot, as described in more detail below, as opposed to adhesive layer 24"

35 of the second embodiment that is pressed against back wall 18" to close seal 12".

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While one preferred embodiment of a bag incorporating a seal formed in accordance with the present invention has been shown so far, various other bag structures can be formed. For example, with respect to FIGURE 2A, if front wall 16 is formed of the same material as plastic strip 30, front wall 16 can be extended to the same height as back wall 18. Plastic strip 30 would then be eliminated and ink layer 22 would be printed on the inner surface of the upper end of front wall 16. As a further alternative, front wall 16 could be extended beyond the height of back wall 18, so that a fold-over closure flap is formed by the upper end of front wall 16. Adhesive layer 26 would then be applied to the outer surface of back wall 18, and the closure flap would be folded over the opening of the bag onto the adhesive on the outer surface of back wall 18.

The seal provided by the present invention can be formed as a tape or label 40, as shown in FIGURES 10 and 11. The structure of tape 40 is essentially the same as the structure of seal 12" of the second embodiment shown in FIGURES 9A and 9B. Tape 40 includes a flexible, plastic backing 42, a layer of ink 44 printed on plastic backing 42, and a layer of adhesive 46 applied to the free surface of ink layer 44. Plastic backing 42 is analogous to plastic strip 20" in FIGURES 9A and 9B, and ink layer 44 is sandwiched between plastic backing 42 and adhesive layer 46. The free surface of adhesive layer 46 is covered with a peel-back strip 48. To apply tape 40 to an object, peel-back strip 48 is removed from a section of the tape then adhesive layer 48 is pressed onto the object to form a seal. As described with respect to bag 10 and 10", if tape 40 is forced off the object or if the tape is frozen below its breakdown temperature, ink layer 44 delaminates from plastic backing 42, to provide a visual indication of tampering.

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Roll of tape 40 can be used in various applications to form seals on surfaces of containers such as bags and envelopes. For example, tape 40 could be used to seal an envelope. The tape could also be
5 used to seal closed the opening of a bag as previously described herein. For example, bag 10 shown in FIGURE 2A could be formed without seal 12, so that the bag simply consists of back wall 18 and front wall 16. Front wall 16 could be extended up beyond back wall 18,
10 so that the upper end of front wall 16 forms a closure flap that can be folded over opening 14 onto the outer surface of back wall 18. The closure flap could then be secured onto back wall 18 with tape 40 by overlapping the tape over the closure flap and back
15 wall 18. Alternatively, bag 10 shown in FIGURE 2A could be formed without seal 12 and then the upper portion of back wall 18 could be folded over the upper end of front wall 16 to contact the outer surface of front wall 16. The closure flap could then be secured
20 onto front wall 16 with tape 40 by overlapping the tape over the closure flap and front wall 16.

In addition to providing a tape for forming seals on containers, tape 40 can be printed on, for example, on plastic backing 42 to provide a label or
25 other type of indicating means.

The seal provided by the present invention is preferably constructed of relatively simple, inexpensive, and nonhazardous materials. The seal is preferably manufactured on a continuous line system,
30 using conventional equipment including printers and handling machines. With respect to seal 12 shown in FIGURE 2A, plastic strip 20 is preferably formed of a high density polyethylene or other polyolefin such as polypropylene. Plastic strips 20 are preferably formed
35 of polyethylene, as opposed to some other plastic such as polyester, so that the strips can be easily recycled. Preferably, plastic strip 20 is colored so

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as to contrast with the color of the ink of ink layer 22. For example, if the ink is blue, the plastic strip could be yellow. The plastic strip can be formed using an extrusion process as is commonly done in the plastics industry. Typically, to extrude polyethylene sheets, polyethylene pellets are melted and then extruded. To form colored plastic strips, color pigment, e.g., yellow pigment, is preferably added to the melted polyethylene, e.g., at a ratio of ten percent (10%) of the total mixture. In one preferred embodiment, the polyethylene sheets are formed of a thickness of approximately 2.3 mils. The polyethylene sheets are cut into approximately 1.125 inch strips, and then cut to length, to form plastic strips 20.

The ink of ink layer 22 is preferably a water-based ink that has a Ph of 7.5 to 8.2, such as Universal Reflex Blue sold by CPI Inks, Inc. However, other inks such as a solvent-based ink could be used. The ink is printed on the inner surface of plastic strip 20. Actually, the ink is preferably printed on the polyethylene sheets before the sheets are cut to form plastic strips 20. The pattern of ink does not have to be very exact; in fact, in one preferred embodiment the ink is printed as a uniform layer.

Thus, inexpensive printing techniques can be used. For example, a flexographic press that includes a photo polymer print roller can be used to print the ink even if a particular pattern is desired. The advantage of using a flexographic press is that the photo polymer roller for creating the print pattern is relatively inexpensive to manufacture. In contrast, a rotogravure printer, which includes steel printing plates and is much more expensive, has generally been used to hold more exact registration and produce more precise characters on the walls of plastic bags.

As previously described herein, while the precision of the pattern of ink is not critical, the

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thickness of the ink layer is important. Ink layer 22 must be sufficiently thin so that there are microscopic voids in the ink through which adhesive layer 24 can migrate and therefore adhere to plastic strip 20. If
5 ink layer 22 is too thick, adhesive layer 24 will not migrate through the ink layer and adhere to the inner surface of plastic strip 20. Instead, the adhesive layer will only adhere to ink layer 22, which would result in a seal that is too weak. It is also
10 important that the ink have a relatively weak bond or adhesion to the inner surface of plastic strip 20, so that ink layer 22 delaminates from plastic strip 20 if the seal is forced open or "frozen."

The structure and manufacturing process of
15 the seal embodiment shown in FIGURES 1 and 2 do not involve any pretreating, such as with a corona discharge or a silicon releasant, of the inner surface of plastic strip 20. That is, the ink is applied without any intervening adhesion promoting material or
20 pretreating, and without any intervening adhesion suppression material. Accordingly, this embodiment of the seal is very inexpensive to manufacture. For example, with respect to FIGURE 2A, the inner surface of plastic strip 20 is not pretreated with a corona
25 discharge process, because a relatively weak adhesion between the ink and plastic strip is desired. Furthermore, because a water-based ink is preferably used, which has a relatively weak adhesion with polyethylene, no releasants such as silicone are
30 required.

With respect to FIGURE 2A, ink layer 22 is preferably printed onto the inner surface of plastic strip 20 in a single coat, which involves printing wet ink onto plastic strip 20. The single coat of ink is
35 uniform, i.e., a flood coat. While it is important that ink layer 22 is sufficiently thin so that there are voids in ink layer 22, there is a lower limit on

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how thin the ink should be. If ink layer 22 is extremely thin, there will not be a sufficient visual color contrast in the seal when ink layer 22 delaminates from plastic strip 20. In one preferred embodiment, an appropriate ink thickness is obtained by using a water-based ink that has a viscosity reading of 20 to 30 seconds with a # 3 Zahn cup, and printing the ink on plastic strip 20 with a flexographic printer. After the wet ink is printed on plastic strip 20, the ink is thoroughly dried, for example, by using heat guns.

It is also possible to print a particular pattern of ink e.g., a grid pattern, onto plastic strip 20. For example, using a flexographic press, two coats of ink could be printed onto plastic strip 20. The first coat of ink would be a flood coat that is uniform, and the second coat of ink would be applied in a grid pattern over the flood coat.

Regardless of the ink pattern used, the bottom end of plastic strip 20 is preferably secured to the inner surface of front wall 16 by a heat seal, e.g., a running heat sealer, as is commonly done to seal together plastic materials such as polyethylene. However, plastic strip 20 can also be attached in other ways, e.g., using an adhesive or glue. Plastic strip 20 is preferably secured to the inner surface, as opposed to the outer surface, of front wall 16 so that it is relatively easy to visually detect any slits or cuts made near plastic strip 20. While it is certainly possible to adhere plastic strip 20 to the outer surface of front wall 16, if this done, a slit, e.g., made using a razor blade, could be made under plastic strip 20 where plastic strip 20 is sealed to front wall 16. It would be difficult to visually detect such slits as the slits would be underneath the substantially opaque plastic strip 20.

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As previously described, front wall 16 and back wall 18 are preferably formed of a plastic material, such as polyethylene. Common extrusion techniques can be used to form the back and front walls. The side edges of the back and front walls are preferably joined together by a heat seal. The bottom ends of the back and front walls are preferably formed of a single sheet of plastic that is folded to form the bottom end, as shown in FIGURE 2A. Alternatively, two separate sheets of plastic could be used to form the back and front walls, in which case, the bottom ends of the walls would be joined together with a heat seal. Because the walls of the bag and plastic strip 20 are all preferably formed of polyethylene, the bag is recyclable.

As previously described, adhesive layer 24 is applied to the inner surface of back wall 18, as shown in FIGURE 2A. The free surface of adhesive layer 24 is covered with peel-back strip 26. To close the seal 12, peel-back strip 26 is removed and the free surface of adhesive layer 24 is pressed against ink layer 22 as shown in FIGURES 2A and 2B. Preferably, no intervening materials are applied to the inner surface of back wall 18 or the inner surface of ink layer 22. As a result, when the seal is closed, adhesive layer 24 is in direct contact with the inner surface of back wall 18 and the inner surface of ink layer 22, as shown in FIGURES 2B.

In the preferred embodiment, adhesive layer 24 is formed of a pressure sensitive adhesive that is rubber-based, has a relatively high liquid tactifier content, and is applied as a hot melt using an extrusion process. The adhesive must have a low glass transition temperature and simultaneously a relatively high internal cohesive strength. As previously described, it is important that the adhesive have a glass transition temperature that is below the breakdown temperature of the seal. Preferably, the

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adhesive has a glass transition temperature that is below -10°F . In addition to the requirement that the glass transition temperature be below -10°F , the adhesive preferably has the following characteristics:

- 5 180° peel strength of 7.9 lbs. (± 0.4 lbs.) on steel; viscosity of 10,500 cps at 300°F , 3,900 cps at 325°F , 2,000 cps at 350°F ; a melting point of 181°F ; a SAFT reading of 500gm/sq. in. at 143°F ; and an application temperature of $300-325^{\circ}\text{F}$. In one preferred embodiment,
- 10 the adhesive is clear so that ink layer 22 can be seen through back wall 18 and adhesive layer 24 when seal 12 is closed. Various adhesive compositions exist in the prior art. Based upon the preceding characteristics, an appropriate pressure-sensitive adhesive can be
- 15 readily composed. Most likely, the basic ingredients of the adhesive include a rubber base of synthetic block polymers with a liquid tactifier added to provide the specified viscosity. An adhesive having the preceding characteristics can be manufactured by
- 20 various adhesive producers, including Swift Adhesives Co. and Ecomelt, Inc.

- To apply the adhesive, the adhesive is melted and extruded onto the inner surface of back wall 18. Peel-back strip 26 is then placed over the free surface
- 25 of the adhesive. In one preferred embodiment, the peel-back strip is formed of high density polyethylene, and the surface of the peel-back strip that is in contact with the adhesive is coated with silicon so that the peel-back strip easily releases from the
- 30 adhesive. When the adhesive cools, a pressure sensitive adhesive is formed.

- While the materials and manufacturing process were described in the context of a bag incorporating a seal as provided by the present invention, it will be
- 35 readily appreciated that the materials and manufacturing process of tape 40 shown in FIGURES 10 and 11 are basically the same. In particular, tape 40

is formed of the same materials as in the same process as seal 12" shown in FIGURES 9A and 9B.

FIGURES 6A-E illustrate an alternative ink composition/pattern and manufacturing process for plastic strips 20 and 20" shown in FIGURES 2A and 9A. A seal incorporating the plastic strip 20' shown in FIGURES 6A-E has the benefits of being more difficult to force open and providing a more visible indication of a forced opening than the previously described embodiments. The drawback of the embodiment shown in FIGURES 6A-E is that the resulting seal does not evidence refrigerant tampering as effectively as the previously described embodiments. The ink/plastic strip embodiment shown in the top views in FIGURES 6A-D and the side cross-sectional view in FIGURE 6E includes a plastic strip 20', a patterned layer of clear ink 60 (e.g., ink extender), and a uniform layer of colored ink 62. Plastic strip 20' is preferably formed of a high density polyethylene, as previously described plastic strip 20. Preferably, plastic strip 20' is colored, e.g., yellow.

Patterned layer of clear ink 60 is printed, e.g., using a flexographic press, onto an untreated surface of plastic strip 20'. Clear ink 60 should have a weak affinity to untreated polyethylene and should be able to withstand a corona discharge process as described in the following. Preferably, ink 60 is a water-based ink as previously described, except that ink 60 contains no pigment so that the ink is clear. For example, colorless, water-based ink extender manufactured by CPI Inks, Inc. sold under the name Universal Flex Extender can be used. However, a solvent-based ink extender could also be used. Ink 60 is printed in a selected pattern, so that the majority of the surface of plastic strip 20' is free of clear ink 60. As shown in FIGURE 6B, in one preferred

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embodiment, clear ink 60 is printed as a series of "stop signs."

After clear ink 60 is applied and dried, e.g., using a heat gun, the surface of plastic strip 20' on which clear ink 60 is applied is treated with a corona discharge process to roughen and increase the surface energy of plastic strip 20', as illustrated pictorially by line dashes 64. In one preferred embodiment, a corona discharge treater set to a strength of approximately 43 to 50 dynes is used. The corona discharge process is used so that colored ink 62 adheres well to plastic strip 20'. In particular, after plastic strip 20' is subjected to a corona discharge, colored ink 62 is printed as a uniform layer over plastic strip 20', so as to cover the entire surface of plastic strip 20'. In place of using a corona discharge process, the plastic strip 20' could be subjected to plasma treatment, chemical treatment, or flame treatment.

FIGURE 7 is a side cross-sectional view of a bag 10' incorporating plastic strip 20' to form a seal 12'. When seal 12' is closed, colored ink layer 62 is sandwiched between adhesive layer 24 and plastic strip 20'. Because plastic strip 20' is subjected to a corona discharge process before the application of colored ink 62, colored ink 62 forms a strong adhesion with those portions of plastic strip 20' not covered with clear ink 60. As a result, if an attempt is made to force open seal 12', colored ink 62 will not delaminate from plastic strip 20', except along the pattern where clear ink 60 was applied, as shown in FIGURE 8B. Colored ink 62 does not delaminate from plastic strip 20' because colored ink 62 adheres more strongly to the treated portions of plastic strip 20' than to adhesive 24. However, because clear ink 60 was applied to the untreated surface of plastic strip 20', clear ink 60 does not adhere very well to plastic strip

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20'. As a result, colored ink 62 and clear ink 60 delaminate from plastic strip 20' along the pattern of clear ink 60 when an attempt is made to force the seal open.

5 Colored ink 62 is chosen to have a color that contrasts with the color of plastic strip 20'. In one preferred embodiment, plastic strip 20' is yellow and colored ink 62 is blue. Preferably, colored ink 62 is water-based, as is the case for previously described
10 ink layer 22. Because the color of colored ink 62 contrasts with the color of plastic strip 20', the pattern in which clear ink 60 was applied boldly appears when an attempt is made to force open the seal. For example, as indicated in FIGURE 8A, when a portion
15 66 of seal 12' is forced open, the "stop sign" pattern appears, whereas an untampered portion 68 of seal 12' appears uniformly opaque. The delamination of colored ink 62 and clear ink 60 in portion 66 of seal 12' is shown in FIGURE 8B, which is an end cross-sectional
20 view of portion 66 shown in FIGURE 8A.

 Because colored ink 62 adheres much more strongly to treated plastic strip 20' than ink layer 22 previously described with reference to FIGURE 2A, seal 12' illustrated in FIGURE 8 is much more difficult to
25 open. After being closed, if seal 12' is quickly "frozen" with a refrigerant, some "stop signs" will appear as a result of clear ink 60 delaminating from plastic strip 20' due to the differential shrink rates between plastic strip 20' and adhesive 24'. However,
30 because colored ink 62 adheres strongly to the majority of the surface of plastic strip 20', colored ink 62 provides structural support that prevents the differential shrink rates from delaminating clear ink 60 as readily as ink layer 22 in the previously
35 described embodiments.

 Other than the differences specifically described hereinabove, the manufacturing process and

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materials of seal 12' are the same as for previously described seal 12 and 12" shown in FIGURES 2A and 9A. For example, both clear ink 60 and colored ink 62 are preferably water-based with a viscosity reading of 20 to 30 seconds with a #3 Zahn cup, and the inks are preferably applied using a flexographic printer.

In accordance with yet another embodiment of this invention, a bag closure that provides evidence of heat tampering is also provided. The bag closure is sensitive to being heated above a particular activation temperature, so that if heat is applied, the visual appearance of the closure permanently changes, regardless of whether the closure is opened.

As discussed above, in addition to the use of refrigerant cooling, thieves also use heating to tamper with bag closures. Typically, the adhesive layer of a bag closure can be heated using, for example, a hair dryer or other heating device. The adhesive is softened and the bag can then be opened.

To indicate tampering by heat, a "heat activatable," or "thermochromic," ink layer is used in the closure of the invention. As used herein, the term "heat activatable" or "thermochromic" ink refers to inks which, upon the application of heat, exhibit a visible, permanent color change.

Any of the types of thermochromic inks known in the art can be used. In the present invention, it is particularly advantageous to use a thermochromic ink which permanently visually changes when heated to a temperature of at least about 140°F, more preferably at least about 150°F, or higher. This activation temperature range is desirable because typically the adhesives described above for use with the closures of the invention soften sufficiently at a temperature between about 140°F and about 180°F to enable a person to open the closure. A particularly preferred ink is

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available from Midwest Coatings Inc. of St. Louis, Missouri, and is described in more detail below.

As will be appreciated by the skilled artisan, the time required to effect the color change can vary as heating conditions vary, i.e., the activation temperature of the ink system used, the temperature applied to the seal, how long heat is applied, and the like. For example, when the seal is heated to a temperature at the lower end of a range of thermochromic ink activation temperatures, the visible color change can take place more slowly than when higher activating temperatures are used.

The thermochromic ink can be used in the tamper-evident closures of the invention in various ways. For example, in one preferred embodiment, the thermochromic ink is applied to an outer surface of plastic strip 20, on a surface opposite ink layer 22. The plastic layer 20 is printed using standard techniques, as described above, for example, using a flexographic press including a photo polymer roller printed. The thermochromic ink can be printed onto the outer surface of plastic strip 20 before or after the ink layer 22 is printed thereon. Further, the thermochromic ink layer can be applied as a substantially uniform coating on a surface of the plastic strip 20, or applied in a pattern, for example, so that upon activation, the ink forms a series of "stop signs." The thermochromic ink is then dried using conventional equipment, such as heat guns. Of course, the thermochromic ink is dried at a temperature below its activation temperature.

When dry, the thermochromic ink is a specific color. However, when heated to its activation temperature, dye compounds in the thermochromic ink can undergo a chemical reaction. As the dye compounds react, the color of the dye compounds changes, which results in a change in the color of the ink. In the

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example given below, the thermochromic ink initially appears white, similar to a standard white ink which is not thermally activatable. Once activated, the thermochromic ink turns from white to a reddish-purple color. The present invention is not, however, limited to this particular color format. The thermochromic ink can provide a permanent visual indication if the seal is heated at or above the activation temperature, regardless of whether or not the seal is actually forced open.

Alternatively, a standard, non-thermochromic ink, such as a conventional alcohol based ink, can be applied in a uniform coating to the outer surface of plastic strip 20 to provide a background contrast against which the color change is clearly visible. A layer of thermochromic ink is then applied in a pattern, such as the above-referenced series of "stop signs" over the layer of standard ink. Preferably, the standard, non-thermochromic ink and the thermochromic ink are the same color initially, such as white. If the closure is subsequently heated, the thermochromic ink visibly changes so as to form a series of contrasting reddish "stop signs" against the standard ink layer. Preferably, an industry standard water based clear overcoat layer is applied over at least a portion of the strip to protect the thermochromic ink from scuffing.

Preferably, as described above, the thermochromic ink layer is used in combination with seal 12, i.e., which includes an ink layer 22, and in which the plastic strip 20 and the adhesive layer 24 exhibit differential shrinking and expansion rates. It will be apparent, however, that the thermochromic ink layer can be used for security purposes with various other seals which include an adhesive bonding layer and a plastic strip as a support for the thermochromic ink layer which do not include ink layer 22. In this

embodiment of the invention, the thermochromic ink layer can be printed on either the inner or outer surface of a plastic strip. The free surface of the adhesive layer can be covered with a peel-back strip.

- 5 As described above, to seal the closure, the peel-back strip is removed from the adhesive layer, and the plastic strip is pressed onto adhesive layer. Further, the thermochromic ink layer can be used without regard to specific differential shrinking rates of the plastic
10 support strip and the adhesive layer upon cooling, or differential expansion rates thereof upon warming.

Further, the thermochromic ink layer can also be provided as a component of a seal in the form of a tape or label 40, as shown in FIGURES 10 and 11. The
15 structure of tape 40 which includes the thermochromic ink layer is essentially the same as described above.

An exemplary thermochromic ink formulation is as follows. First, Solution "A" is prepared as follows. A carrier for the dye compounds is prepared
20 by mixing 85% water and 15% polyvinyl alcohol (PVOH). This mixture can be strained, for example, using a 25 micron filter. A mixture is then prepared with the following: 60% PVOH; 39.6% of a conventional leuco dye (well known in the industry); 0.1% Nopko-W dispersing
25 agent (industry standard); 0.1% Surfonol TG wetting agent (industry standard); and 0.2% defoamer (industry standard).

Solution "B" is then prepared by first formulating a carrier as described above including 85%
30 water and 15% PVOH. A mixture is then prepared comprising: 60% PVOH; 39.6% bisphenol-A activator; 0.1% Nopko-W dispersing agent (industry standard); 0.1% Surfonol TG wetting agent (industry standard); and 0.2% defoamer (industry standard).

35 The final formulation is prepared by mixing 1 part Solution "A" to 4 parts Solution "B". Although not wishing to be bound by any explanation of the

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invention, it is believed that when the ink is heated, the bisphenol A activator can initiate a chemical reaction within the structure of the leuco dye compound, thus altering its structure and producing a color change.

This particular formulation has an activation temperature of about 155°F. The ink is initially white when dry and changes color to a bright red or reddish purple when heated to its activation temperature or higher to provide a permanent visible color change. This, as noted above, is particularly advantageous for use with adhesives having a softening point between about 140°F and 180°F.

However, this formulation is subject to various modifications. For example, higher or lower percentages of each of the formulation components can be used, and/or higher or lower "A" to "B" ratios, and the like. Further, thermochromic dye compounds and thermochromic dye compound activators, other than leuco dyes and bisphenol A, respectively, can also be used in accordance with this aspect of the invention. In addition, polyvinyl alcohol is a preferred carrier because its use can provide a desired degree of flexibility to the ink layer, which is particularly advantageous in continuous in-line application to plastic substrates. However, other carriers can also be used.

As will be appreciated by the skilled artisan, preferably the particle size of the ink formulation is sufficiently small to provide smooth consistent application of the ink to a substrate surface. Further, it is preferred that the thermochromic ink formulation not be cut or mixed with other inks or solutions, and that the equipment used to produce the seals of the invention is clean.

While the preferred embodiments of the invention have been illustrated and described, it will

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be appreciated that various changes can be made therein without departing from the spirit and scope of the invention. Accordingly, the scope of the invention is not to be limited by the description of the preferred
5 embodiments, but instead should be determined by reference to the claims that follow.

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

1. A tamper evident seal, including:
 - 5 (a) an adhering layer means for adhering to a surface of an object when said seal is applied to the object;
 - (b) a support layer means for supporting said adhering layer means; and
 - 10 (c) a delaminating layer means, adhered to said adhering layer means and said support layer means when said seal is applied to the object, said delaminating layer means for providing a permanent indication of tampering with said seal by cooling said
 - 15 seal below a breakdown temperature when said seal is applied to the object, whereby if a refrigerant is applied to said seal to cool said seal below said breakdown temperature in an attempt to open said seal without detection, an indication of the mere
 - 20 application of the refrigerant is provided regardless of whether said seal is opened.

2. The tamper-evident seal of Claim 1, wherein said adhering layer means has adhesive tack and a glass transition temperature at which said adhering
- 25 layer means loses said adhesive tack, and wherein said adhering layer means and said delaminating layer means are selected so that said breakdown temperature is above said glass transition temperature.

3. The tamper-evident seal of Claims 1-2,
- 30 wherein when said seal is applied to the object, said delaminating layer means is further for visibly distorting when said seal is forced open, so as to provide a permanent indication of a forced opening of



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said seal regardless of whether said seal is cooled below said breakdown temperature.

4. The tamper-evident seal of any of Claims 1-3, wherein said adhering layer means and said support layer means are selected to have different relative rates of shrinking when cooled, so that when said seal is cooled, said adhering layer means and said support layer means shrink at different rates causing said delaminating layer means to visibly distort.

10 5. The tamper-evident seal of any of Claims 1-4, wherein said adhering layer means and said support layer means are selected to have different relative rates of expansion when warmed, so that upon warming after being cooled below said breakdown temperature,
15 said adhering layer means and said support layer means expand at different rates causing said delaminating layer means to visibly distort.

6. The tamper-evident seal of any of Claims 1-5, wherein:
20 said support layer means is a plastic strip;
said adhering layer means is an adhesive layer carried on the plastic strip, the adhesive layer having an adhesive tack and a glass transition temperature at which said adhesive layer loses said
25 adhesive tack; and
said delaminating layer means is an ink layer between the plastic strip and the adhesive layer.

7. The tamper-evident seal of Claim 6 above, wherein said ink layer has first and second
30 surfaces, and said first surface of said ink layer is in direct contact with and adhered to one surface of said plastic strip without any intervening adhesion promoting material, without any adhesion promoting



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pretreating of said one surface of said plastic strip, and without any intervening adhesion suppression material; and

5 said adhesive layer has first and second surfaces, said first surface of said adhesive layer in direct contact with and adhered to said second surface of said ink layer.

8. The tamper-evident seal of Claim 6, wherein:

10 said plastic strip is a polyolefin strip having a surface treated with an adhesion promoting process except at selected untreated areas defining a selected pattern on said surface of said polyolefin strip, so that said surface of said polyolefin strip,
15 has treated areas and said untreated areas;

said ink layer is over said treated areas and said untreated areas of said polyolefin strip, said ink layer being in direct contact with said treated areas and having an adhesion to said treated
20 areas that is strong relative to an adhesion of said ink layer to said untreated areas; and

wherein if said tape is forced off the object, said ink layer delaminates from said polyolefin strip at said untreated regions, so that
25 said selected pattern is visible, thereby providing evidence of tampering.

9. The tamper-evident seal of Claim 8, wherein said adhesion promoting process comprises a corona discharge process.

30 10. The tamper-evident seal of Claims 8-9, further including a masking layer adhered directly to said surface of said polyolefin strip in said selected pattern so as to define said untreated areas; wherein:



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said masking layer has an adhesion with said untreated areas that is weak relative to the adhesion of said ink layer to said treated areas; and said ink layer is over said masking layer and in direct contact therewith, so that said masking layer is sandwiched between said ink layer and said untreated areas of said polyolefin strip.

11. The tamper-evident seal of Claim 10, wherein said masking layer is a water-based ink extender.

12. The tamper-evident seal of any of Claims 8-11, wherein said polyolefin strip is colored to have a color that contrasts with the color of said ink layer, thereby increasing the ease with which said delamination of said ink layer can be seen.

13. The tamper-evident seal of any of Claims 1-12, wherein said delaminating layer means is a water-based ink layer.

14. The tamper-evident seal of any of Claims 1-13, wherein said support layer means comprises polyethylene.

15. The tamper-evident seal of any of Claims 1-14, wherein said support layer means includes printing.

16. The tamper-evident seal of any of Claims 1-15, further comprising a thermally activatable layer means adjacent a surface of said support layer means opposite said delaminating layer means for providing a permanent indication of tampering with said seal by heating said seal at or above an activation temperature of said thermally activatable layer means, wherein if



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heat is applied to said seal to heat said seal at or above said activation temperature in an attempt to open said seal without detection, an indication of the application of heat is provided regardless of whether
5 said seal is opened.

17. The tamper-evident seal of Claim 16, wherein said thermally activatable layer means comprises a thermally activatable ink layer which provides a permanent indication of tampering with said
10 seal when said seal is heated at or above an activation temperature of said thermally activatable ink layer by changing color at said activation temperature.

18. The tamper-evident seal of Claim 16, wherein said thermally activatable layer means
15 comprises:
a masking ink layer adhered directly to said outer surface of said support layer means; and
a thermally activatable ink layer substantially the same color as said masking ink layer
20 adjacent said masking ink layer so that said masking ink layer is sandwiched between said support layer means and said thermally activatable ink layer, wherein said thermally activatable ink layer provides a permanent indication of tampering with said seal when
25 said seal is heated at or above an activation temperature of said thermally activatable ink layer by changing color at said activation temperature to provide a thermally activatable ink layer which has a color that contrasts with the color of said masking ink
30 layer, thereby increasing the ease with which said heating of said ink layer can be detected.

19. A tamper-evident bag including the tamper-evident seal of Claim 6 and further including:



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a back wall having an upper end, a bottom end, and two sides, wherein said back wall is said object to which said seal is applied; and

- a front wall having an upper end, a bottom end, and two sides, said front wall including said support layer means, wherein the bottom ends and the sides of said back and front walls are joined together to form an enclosure having an opening at the upper ends of said back and front walls, and wherein said seal is included as part of said bag for sealing said opening closed.

20. The tamper-evident bag of Claim 19, wherein:

- said back wall is formed of polyethylene; said second surface of said adhesive layer is in direct contact with and adhered to the upper end of said back wall; said first surface of said adhesive layer is covered with a peel-back strip; and to seal said opening of the bag closed, said peel-back strip is removed, and said first surface of said adhesive layer is pressed directly onto said second surface of said ink layer.

21. The tamper-evident bag of Claim 20, further comprising a thermally activatable layer means adjacent a surface of said support layer means opposite said delaminating layer means for providing a permanent indication of tampering with said seal by heating said seal at or above an activation temperature of said thermally activatable layer means, wherein if heat is applied to said seal to heat said seal at or above said activation temperature in an attempt to open said seal without detection, an indication of the application of



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heat is provided regardless of whether said seal is opened.

22. A method of forming a tamper-evident seal for a bag that includes (a) a back wall having an upper end, a bottom end, and two sides, and (b) a front wall having a bottom end, two sides, and an upper end that includes an untreated plastic strip, wherein the bottom ends and the sides of the back and front walls are joined together to form an enclosure having an opening at the upper ends of the back and front walls, the method comprising the steps of:

- (a) applying a layer of wet ink directly onto the untreated plastic strip;
- (b) drying said layer of wet ink;
- (c) applying a layer of hot melt adhesive onto the upper end of the back wall; and
- (d) applying a peel-back strip over said layer of adhesive.

23. The method of Claim 22, wherein:
said layer of wet ink is a flood coat of ink that is uniform; and
said flood coat of ink is applied sufficiently thin so that there are voids in said layer of ink, so that when said layer of adhesive is pressed onto said layer of ink, a portion of said layer of adhesive adheres through said voids to said untreated plastic strip.

24. The method of Claims 22-23, wherein:
the front wall of the bag is plastic;

and

said plastic strip, having said layer of ink applied thereto, is attached to the bag by heat sealing said plastic strip onto the upper end of said front wall.



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25. The method of Claim 22, further comprising the step of exposing first areas of a surface of the plastic strip to an adhesion promoting process, second areas of said surface of said plastic strip not being exposed to said adhesion promoting process, said second areas defining a selected pattern prior to said wet ink applying step; and wherein during said wet ink applying step, said ink layer is in direct contact with said first areas of said plastic strip.

10 26. The method of Claim 25, further comprising the step of applying a masking layer onto said surface of said plastic strip in said selected pattern prior to said step of exposing said plastic strip to an adhesion promoting process, so as to
15 prevent said second areas of said plastic strip from being exposed to said adhesion promoting process.

27. The method of Claims 25-26, wherein said adhesion promoting process comprises a corona discharge process.

20 28. The method of any of Claims 25-27, wherein said ink layer is in direct contact with said masking layer at second areas of said plastic strip, so that said masking layer is sandwiched between said plastic strip and said ink layer.

25 29. The method of any of Claims 25-28, wherein said masking layer is a water-based ink extender.

30. The method of any of Claims 22-29, wherein said ink layer is a water-based ink.

30 31. The method of any of Claims 22-30, wherein said plastic strip comprises polyethylene.



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32. The method of any of Claims 22-31, further comprising the steps of:

- (a) applying a layer of wet thermally activatable ink directly onto the untreated plastic strip on a surface opposite said first ink layer; and
- (b) drying said layer of wet thermally activatable ink.

33. The method according to Claim 32, further comprising the step of applying a layer of wet masking ink directly onto the untreated plastic strip on a surface opposite said first ink layer and drying said layer of wet masking ink prior to applying said wet thermally activatable ink so that said masking ink layer is sandwiched between said plastic strip and said thermally activatable ink layer, wherein said masking ink layer and said thermally activatable ink layer have substantially the same color when dry.

34. A tamper-evident tape, including:

- (a) an adhering layer means for adhering to a surface of an object when said tape is applied to the object;
- (b) a support layer means for supporting said adhering layer means; and
- (c) a delaminating layer means, adhered to said adhering layer means and said support layer means, said delaminating layer means providing a permanent indication of tampering with said tape by cooling said tape below a breakdown temperature when said tape is applied to the object, whereby if a refrigerant is applied to said tape to cool said tape below said breakdown temperature, an indication of the mere application of the refrigerant is provided regardless of whether said tape is removed from the object.



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35. The tamper-evident tape of Claim 34, wherein said adhering layer means has adhesive tack and a glass transition temperature at which said adhering layer means loses said adhesive tack and wherein said
5 adhering layer means and said delaminating layer means are selected so that said breakdown temperature is above said glass transition temperature.

36. The tamper-evident tape of Claims 34-35, wherein when said tape is applied to the object, said
10 delaminating layer means is further for visibly distorting when said tape is forced from the object, so as to provide a permanent indication of a forced removal of the tape seal regardless of whether said tape is cooled below said breakdown temperature.

37. The tamper-evident tape of any of Claims 34-36, wherein said adhering layer means and said support layer means are selected to have different relative rates of shrinking when cooled, so that when
15 said tape is cooled, said adhering layer means and said support layer means shrink at different rates causing
20 said delaminating layer means to visibly distort.

38. The tamper-evident tape of any of Claims 34-37, wherein said adhering layer means and said support layer means are selected to have different
25 relative rates of expansion when warmed, so that upon warming after being cooled below said breakdown temperature, said adhering layer means and said support layer means expand at different rates causing said delaminating layer means to visibly distort.

39. The tamper-evident tape of any of Claims 34-38, wherein:
30 said support layer means is a plastic strip;



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said adhering layer means is an adhesive layer carried on the plastic strip, the adhesive layer having an adhesive tack and a glass transition temperature at which said adhesive layer loses said
5 adhesive tack; and

said delaminating layer means is an ink layer between the plastic strip and the adhesive layer.

40. The tamper-evident tape of Claim 39, wherein said ink layer has first and second surfaces,
10 and said first surface of said ink layer is in direct contact with and adhered to one surface of said plastic strip without any intervening adhesion promoting material, without any adhesion promoting pretreating of said one surface of said plastic strip, and without any
15 intervening adhesion suppression material; and

said adhesive layer has first and second surfaces, said first surface of said adhesive layer in direct contact with and adhered to said second surface of said ink layer.

20 41. The tamper-evident tape of Claim 39, wherein:

said plastic strip is a polyolefin strip having a surface treated with an adhesion promoting process except at selected untreated areas defining a
25 selected pattern on said surface of said polyolefin strip, so that said surface of said polyolefin strip has treated areas and said untreated areas;

said ink layer is over said treated areas and said untreated areas of said polyolefin
30 strip, said ink layer being in direct contact with said treated areas and having an adhesion to said treated areas that is strong relative to an adhesion of said ink layer to said untreated areas; and

wherein if said tape is forced off
35 the object, said ink layer delaminates from said



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polyolefin strip at said untreated regions, so that said selected pattern is visible, thereby providing evidence of tampering.

42. The tamper-evident tape of Claim 41,
5 wherein said adhesion promoting process comprises a corona discharge process.

43. The tamper-evident tape of Claims 41-42,
further including a masking layer adhered directly to
said surface of said polyolefin strip in said selected
10 pattern so as to define said untreated areas; wherein:
said masking layer has an adhesion with
said untreated areas that is weak relative to the
adhesion of said ink layer to said treated areas; and
said ink layer is over said masking
15 layer and in direct contact therewith, so that said
masking layer is sandwiched between said ink layer and
said untreated areas of said polyolefin strip.

44. The tamper-evident tape of Claim 43,
wherein said masking layer is a water-based ink
20 extender.

45. The tamper-evident tape of any of Claims
41-44, wherein said polyolefin strip is colored to have
a color that contrasts with the color of said ink
layer, thereby increasing the ease with which said
25 delamination of said ink layer can be seen.

46. The tamper-evident tape of any of Claims
34-45, further comprising printing on the support layer
means.

47. The tamper-evident tape of any of Claims
30 34-46, wherein said delaminating layer means is a
water-based ink layer.



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48. The tamper-evident tape of any of Claims 34-47, wherein said support layer means comprises polyethylene.

49. The tamper-evident tape of any of Claims 34-48, further comprising a thermally activatable layer means adjacent a surface of said support layer means opposite said delaminating layer means for providing a permanent indication of tampering with said seal by heating said seal at or above an activation temperature of said thermally activatable layer means, wherein if heat is applied to said seal to heat said seal at or above said activation temperature in an attempt to open said seal without detection, an indication of the application of heat is provided regardless of whether said seal is opened.

50. The tamper-evident seal of Claim 49, wherein said thermally activatable layer means comprises a thermally activatable ink layer which provides a permanent indication of tampering with said seal when said seal is heated at or above an activation temperature of said thermally activatable ink layer by changing color at said activation temperature.

51. The tamper-evident seal of Claim 49, wherein said thermally activatable layer means comprises:
a masking ink layer adhered directly to said outer surface of said support layer means; and
a thermally activatable ink layer substantially the same color as said masking ink layer adjacent said masking ink layer so that said masking ink layer is sandwiched between said support layer means and said thermally activatable ink layer, wherein said thermally activatable ink layer provides a permanent indication of tampering with said seal when



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said seal is heated at or above an activation temperature of said thermally activatable ink layer by changing color at said activation temperature to provide a thermally activatable ink layer which has a color that contrasts with the color of said masking ink layer, thereby increasing the ease with which said heating of said ink layer can be detected.

52. A method of forming a tamper-evident tape for attachment to an object, comprising the steps:
- 10 (a) providing an untreated plastic strip;
 - (b) applying a layer of wet ink directly onto the untreated plastic;
 - (c) drying said layer of wet ink;
 - 15 (d) applying a layer of hot melt adhesive onto the layer of dried ink.

53. The method of Claim 52, wherein:
- said layer of wet ink is a flood coat of ink that is uniform; and
- 20 said flood coat of ink is applied sufficiently thin so that there are voids in said layer of ink so that when said layer of adhesive is applied onto said layer of ink a portion of said layer of adhesive adheres through said voids to said untreated
- 25 plastic strip.

54. The method of Claim 52, wherein said plastic strip is a polyolefin strip; and further comprising the step of exposing first areas of a surface of the polyolefin strip to an adhesion promoting process, second areas of said surface of said polyolefin strip not being exposed to said adhesion promoting process, said second areas defining a selected pattern prior to said wet ink applying step; and wherein during said wet ink applying step, said ink
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layer is in direct contact with said first areas of said polyolefin strip.

55. The method of Claim 54, further comprising the step of applying a masking layer onto
5 said surface of said polyolefin strip in said selected pattern prior to said step of exposing said polyolefin strip to an adhesion promoting process, so as to prevent said second areas of said polyolefin strip from being exposed to said adhesion promoting process.

10 56. The method of Claims 54-55, wherein said adhesion promoting process comprises a corona discharge process.

57. The method of Claims 55-56, wherein said
15 ink layer is in direct contact with said masking layer at second areas of said polyolefin strip, so that said masking layer is sandwiched between said polyolefin strip and said ink layer.

58. The method of any of Claims 55-57,
20 wherein said masking layer is a water-based ink extender.

59. The method of any of Claims 52-58,
wherein said ink layer is a water-based ink.

60. The method of any of Claims 52-59,
wherein said plastic strip comprises polyethylene.

25 61. The method of any of Claims 52-60,
further comprising the steps of:

(a) applying a layer of wet thermally activatable ink directly onto the untreated plastic strip on a surface opposite said first ink layer; and



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(b) drying said layer of wet thermally activatable ink.

62. The method according to Claim 61, further comprising the step of applying a layer of wet masking ink directly onto the untreated plastic strip on a surface opposite said first ink layer and drying said layer of wet masking ink prior to applying said wet thermally activatable ink so that said masking ink layer is sandwiched between said plastic strip and said thermally activatable ink layer, wherein said masking ink layer and said thermally activatable ink layer have substantially the same color when dry.

63. A tamper-evident seal, including:

(a) an adhering layer for adhering to a surface of an object when said seal is applied to the object;

(b) a support layer for supporting said adhering layer; and

(c) a thermally activatable layer disposed on a surface of said support layer for providing a permanent indication of tampering with said seal by heating said seal at or above an activation temperature when said seal is applied to the object, wherein if heat is applied to said seal to heat said seal at or above said activation temperature in an attempt to open said seal without detection, an indication of the application of heat is provided regardless of whether said seal is opened.

64. The tamper-evident seal of Claim 63, wherein said thermally activatable layer comprises a thermally activatable ink layer which provides a permanent indication of tampering with said seal when said seal is heated at or above an activation



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temperature of said thermally activatable ink layer by changing color at said activation temperature.

65. The tamper-evident seal of Claim 63, wherein said thermally activatable layer comprises:
- 5 a masking ink layer adhered directly to a surface of said support layer means; and
- a thermally activatable ink layer substantially the same color as said masking ink layer adjacent said masking ink layer so that said masking
- 10 ink layer is sandwiched between said support layer and said thermally activatable ink layer,
- wherein said thermally activatable ink layer provides a permanent indication of tampering with said seal when said seal is heated at or above an activation
- 15 temperature of said thermally activatable ink layer by changing color at said activation temperature to provide a thermally activatable ink layer which has a color that contrasts with the color of said masking ink layer, thereby increasing the ease with which said
- 20 heating of said ink layer can be detected.

