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(54) Title: PROCESS AND CHEMICAL FORMULATION FOR MAKING RIGID, BIODEGRADABLE ARTICLES

(57) Abstract

A rigidifying chemical solution and method of incorporating it into a cellulosic material to form a substantially rigid material is disclosed. The rigid material is dissolvable in water and biodegradable in conventional wastewater treatment systems. The chemical solution includes a rigidifying agent, such as sugar, dissolved in an aqueous solvent. When the rigidifying solution is applied to a cellulosic material such as paper, the solvent functions to incorporate the rigidifying agent into the cellulosic material. When the material dries, a rigidifying residue remains to form a substantially rigid structure with the cellulosic material. The rigidified material may be used to make a wide range of disposable articles.

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PROCESS AND CHEMICAL FORMULATION FOR MAKING RIGID, BIODEGRADABLE ARTICLES

Cross-Reference to Related Applications

This application is a continuation of U.S. Provisional Patent Application Serial No. 60/117,800 entitled "SYSTEM AND CHEMICAL FORMULATION FOR MAKING RIGID/READILY DISSOLVABLE MATERIAL" filed on January 29, 1999.

Field of the Invention

The present invention relates generally to biodegradable materials, and more particularly to a process for treating cellulosic materials, such as paper, to reversibly impart a substantial rigidity to the material without destroying the biodegradability of the material.

Background

It is well known that the escalating human population has placed a significant strain on the capacities of local, national, and global waste disposal and landfill resources. This situation is exacerbated by particular trends such as the reliance on pre-packaged, individual meals, single-use disposable items, and etc. As a result, there has been an increasing focus, in recent years, on reducing the amount of waste disposed of in landfills.

One important approach to waste reduction involves recycling used materials such as paper, cardboard, plastics, glass, etc. However, many materials cannot be recycled either due to their nature or the way in which the materials are used. Additionally, recycling may be inconvenient or unavailable in many communities so

that used materials, which are capable of recycling, are nevertheless disposed of in landfills.

An alternative approach to waste reduction involves manufacturing products from materials which are capable of disintegration or biodegradation. Such products either partially or fully decompose under the influence of natural environmental conditions or biological processes. As a result, the use of biodegradable products significantly reduces the volume of waste matter accumulated in landfills.

A common example of a biodegradable material is paper. As is well known in the art, paper is typically formed from cellulose fibers derived from trees and other plants. Certain cellulose-digesting bacteria are capable of consuming the fibers and converting them to naturally occurring compounds which are reincorporated into the environment. Indeed, wastewater treatment systems such as sewage plants and septic tanks typically employ such bacteria to decompose the cellulosic material found in wastewater streams including bathroom tissue, facial tissue, etc. Considering the enormous amount of tissue paper consumed each day, it is obvious that the ability of wastewater treatment systems to biodegrade tissue paper saves a substantial amount of landfill space. Thus, it would be desirable to make a variety of products from tissue paper since the used products could be disposed of without burdening overcrowded landfills.

Unfortunately, while paper, and especially tissue paper, is well suited for biodegradation in sewage lines, it has a limited number of uses given its naturally weak structural characteristics. Furthermore, techniques developed to increase the strength of paper typically also reduce its biodegradability.

Summary of the Invention

The present invention provides a chemical solution and a method of incorporating the solution into a cellulosic material to form a substantially rigid material that is dissolvable in water and biodegradable in conventional wastewater treatment systems. The chemical solution includes a rigidifying agent dissolved in an aqueous solvent that functions as a carrier to saturate the rigidifying agent into the cellulosic material. After the rigidifying solution is applied to the cellulosic material, the material is dried so that a residue remains to form a substantially rigid structure with the cellulosic material.

In one exemplary embodiment, a sugar such as sucrose is dissolved in a solvent including water and isopropyl alcohol to form the rigidifying solution. The sucrose solution is sprayed onto one or more layers of household tissue paper. The tissue paper is then heated to evaporate the solvent, leaving the sucrose incorporated into the tissue paper and imparting a substantial rigidity to the paper without destroying the inherent tendency of the paper to disintegrate in water. When disposed of in conventional sewage lines, the rigidified tissue paper loses its rigidity, disintegrates, and biodegrades.

The rigidified material may be used to make a wide range of disposable articles.

Brief Description of the Drawings

Fig. 1 is an isometric view of a roll of bathroom tissue having a core made in accordance with the present invention.

Fig. 2 is an isometric view showing the core of Fig. 1 partially immersed in water and beginning to lose its structural rigidity and to disintegrate.

Fig. 3 is an isometric view of a sheet of corrugated material made in accordance with the present invention.

Fig. 4 is an isometric view of a container made in accordance with the present invention.

Fig. 5 is an isometric view of a tampon applicator made in accordance with the present invention.

Fig. 6 is a front elevation of disposable clothing made in accordance with the present invention.

Fig. 7 is a side elevation of a disposable shoe cover made in accordance with the present invention.

Detailed Description

One example of a substantially rigid, readily-dissolvable material in accordance with the present invention is depicted in the form of a bathroom tissue core, indicated generally at 10, in Figs. 1 and 2. The material is formed from a biodegradable, relatively pliant cellulosic substance that is strengthened and stiffened by applying a rigidifying solution to the substance and then drying it in a desired shape. However, the rigidifying residue that remains after drying is re-dissolvable upon exposure to water. As a result, the material can safely be disposed of in the sewage system. Thus, the material provides a new composition of matter having the structural rigidity necessary for a variety of applications, while retaining the inherent biodegradability of a cellulosic substance.

The invented process for treating the cellulosic material to reversibly impart a structural rigidity is surprisingly easy and inexpensive to implement in either single-unit construction or mass production. In essence, a non-toxic, rigidifying agent is dissolved in a solvent to form a rigidifying solution. The rigidifying solution is then applied to an accumulation of cellulosic fibers. When the solvent dries and/or evaporates from the fibers, at least a portion of the rigidifying agent remains as a residue that forms a substantially rigid material with the fibers. The material can easily be formed into any desired shape prior to drying so that the material will retain the desired shape until disposed of in water. It will be appreciated that the invention is susceptible to an almost unlimited number of uses, a few of which will be specifically mentioned below.

As is well known to those of skill in the art, there are many cellulosic substances which are suitable for making paper and paper-like products. A few of the most common of such substances include wood, hemp, and cotton. In addition, there are a wide variety of paper types and configurations well known in the art including tissue paper, writing paper, parchment, cardboard, corrugated paper, and etc. Variations in paper types are produced, for example, by changing one or more variables in the paper-making process such as pulping method, fiber size, degree of compression, additives, etc. For the sake of clarity, the invention is herein described in the context of only one such substance and configuration, i.e., household tissue paper. Nevertheless, it will be understood that the invention is in no way limited by such description as the invention may be effectively practiced with any of the known cellulosic materials, or combinations thereof, and in any desired configuration.

Household tissue paper, commonly used for facial tissue and bathroom tissue, is manufactured by a variety of sources and is available in virtually any retail store that sells food or sundries. This type of paper is typically formed from thin, relatively lightly compressed layers of wood pulp fiber according to conventional paper-making processes well known in the art. Upon immersion in water, household tissue paper loses virtually all structural rigidity and will begin to tear and/or disintegrate when exposed to even slight forces. Due to its pliant and fragile nature in water, tissue paper is well-suited for disposal in ordinary sewage systems because it is unlikely to form obstructions in waste lines. In addition, modern sewage treatment facilities and septic systems typically contain bacteria or other biological materials which readily breakdown or decompose the tissue paper, returning naturally occurring byproducts to the environment. Thus, its low cost, ready availability, and biodegradability make household tissue paper well suited for use as the source of cellulosic material.

In addition, tissue paper is relatively highly absorbent and, therefore, the rigidifying solution is easily incorporated into the cellulosic material. Some less absorbent cellulosic materials, while still being suitable for use in the rigidifying process, may be less efficient in incorporating the rigidifying solution. Consequently, the increase in rigidity for these materials may not be as dramatic as is the case with tissue paper.

As mentioned briefly above, the process of forming the substantially rigid, biodegradable material includes incorporating a rigidifying agent into the cellulosic materials to provide structural stiffness to the cellulose fibers. Any substance may be employed as the rigidifying agent, which is capable of combining with the cellulose

fibers to form a substantially rigid structure. For example, the group of substances commonly referred to as sugars have been found to provide an inexpensive, readily available rigidifying agent for use with cellulosic materials such as tissue paper. As used herein, the term sugar refers inclusively to all types of sugars including monosaccharides (e.g., fructose, glucose, dextrose, etc.), disaccharides (e.g., sucrose, etc.), and trisaccharides (e.g., raffinose, etc.), as well as sugar substitutes such as aspartame.

Sugars are typically commercially available in a crystallized form (e.g., table sugar, EQUAL sweetener, NUTRASWEET sweetener, etc.), but may also be available in other forms such as raw sugar starch, sugar beets, and liquids/syrups (e.g., KARO corn syrup, etc.). In any event, it is believed that the sugar, when introduced to cellulosic material, is incorporated in and/or around the cellulose fibers to impart a substantial rigidity to the fibrous web. Subsequently, upon exposure of the rigidified material to a solvent, the sugar is dissolved into the solvent and unincorporated from the cellulosic material, thereby returning the material to its pre-rigidified state. While any number or combination of sugars may be used as the rigidifying agent, for the sake of clarity, the description below will focus on an exemplary embodiment in which sucrose is used as the rigidifying agent.

Sucrose is commonly available in crystal form as ordinary table sugar. However, when dissolved in a suitable aqueous solvent, the sucrose loses its crystal structure and forms a homogenous rigidifying solution with the solvent. In accordance with one preferred embodiment of the invention, a sufficient quantity of the rigidifying solution is then applied to household tissue paper so as to saturate the

tissue with the solution. When allowed to dry, most or all of the solvent is evaporated, leaving a sucrose residue incorporated into the fibrous structure of the tissue. The sucrose does not re-crystallize when the solvent is evaporated, but forms a relatively uniform, continuous matrix with the tissue fibers.

It will be appreciated that the choice of solvent will vary depending on the rigidifying agent selected. Water has been found to be a preferred solvent for use with sugar. Preferably, a relatively small amount of an alcohol is added to the water. While many different alcohols can be used, a non-toxic alcohol such as isopropyl alcohol may be preferred for many applications. In addition to breaking down the crystallized structure of the sugar, the solvent acts as a carrier liquid to fully incorporate the sugar into the cellulosic material. Further, the solvent preferably does not adversely affect the cellulosic material, and may be easily removed by drying the material.

As will be understood by those of skill in the art, the volume ratios of the sugar and solvent will vary depending on the particular sugar and solvent used. Additionally, it may be desirable to heat the solvent when dissolving the sugar to reduce the time needed to dissolve the sugar and/or increase the amount of sugar dissolved in the solvent. In the exemplary preferred embodiment discussed above, in which the rigidifying solution includes table sugar dissolved in an aqueous solution of water and isopropyl alcohol, the following volume ratios have been found to be suitable: 6:1:12 (water:alcohol:sugar) (where sugar is measured by dry volume). The water/alcohol solvent is preferably heated to approximately 120°-200° Fahrenheit to ensure that the sugar is completely dissolved. However, other ratios and temperatures

may also be used depending on the application and desired characteristics of the resulting rigidified material.

Various techniques may be employed to apply the rigidifying solution to the tissue including, for example, spraying, brushing, or rolling the solution onto the tissue. Other techniques for applying a liquid to a material are also suitable. Typically, though not necessarily, the particular method used will be selected for compatibility with the manufacturing process and equipment of the particular rigid, biodegradable article in question. In any event, the application process is effective to introduce the rigidifying agent to the cellulosic material so that the agent combines with the cellulose fibers to form a substantially rigid structure. In general, it is usually desirable to saturate the cellulosic material with the rigidifying solution to ensure full incorporation of the rigidifying agent.

Once the rigidifying solution has been applied to the cellulosic material, the now saturated material may be formed into any desired shape prior to drying. Alternatively, the material may first be formed as desired, and then saturated with the rigidifying solution. In any event, depending on the characteristics of the cellulosic material used, it may be necessary to support the saturated material in the desired shape until the drying process has at least partially been completed. For example, in the exemplary embodiment in which tissue paper is used, physical support is usually necessary due to the relative pliability of wet tissue paper. However, once dry, the sucrose rigidifying agent provides sufficient stiffness to the cellulosic material so that further support is typically unnecessary. Indeed, the rigidified material is usually sufficiently rigid to successfully resist moderate deforming forces. Further, the

sugar/cellulose structure is at least somewhat elastic and, therefore, capable of deforming under relatively heavier forces without cracking, tearing, etc.

The rigidifying process is completed by drying the saturated cellulosic material. It will be appreciated that the drying process may vary depending on the rigidifying agent and aqueous solvent solution being used. In the sucrose/water/isopropyl alcohol formulation described above, the water/alcohol solvent is capable of drying "naturally" under ordinary room conditions. Alternatively, the drying process may be assisted or shortened by heating the material, decreasing the ambient pressure, and/or moving air across the material. Heat may be applied through any conventional means including microwave energy. Care should be taken, however, to avoid igniting any components of the rigidifying solution that may be flammable, such as isopropyl alcohol. As will be expected, the necessary drying time will generally decrease with increasing temperature, decreasing pressure, increased air flow, etc.

In the process just described, a dramatically increased rigidity is imparted to household tissue paper by incorporating sucrose in and/or around the cellulose fibers of the paper. Depending on the number of layers of tissue paper used and the quantity of sucrose which is incorporated, the resulting material is amazingly strong, having a rigidity equal to a much greater thickness of cardboard. However, the rigidity is completely reversible by simply immersing the material in a sucrose solvent such as water. Thus, unlike prior paper rigidifying processes, the invented process does not destroy the inherent tendency of the tissue to disintegrate in water, or the biodegradability of the tissue in standard wastewater treatment systems.

In addition to a dramatically increased rigidity, other characteristics may be imparted to the tissue paper by adding optional substances to the rigidifying solution. For example, the rigidified tissue may be formed with a desired color by adding selected coloring agents to the rigidifying solution. Preferably, the coloring agent is selected so as not to interfere with the rigidifying process. While a number of coloring agents are suitable and therefore within the scope of the invention, one preferred coloring agent is conventional food color because it is inexpensive, readily available in a variety of colors, and is non-toxic. Other coloring agents may also be used.

It will be appreciated that the intensity of color imparted to the rigidified material will be at least somewhat proportional to the concentration of coloring agent in the solution. Thus, the amount of coloring agent added to the rigidifying solution can be varied to adjust the color of the material. In the embodiment where food coloring is used in the sugar/water/isopropyl alcohol solution, it has been found that adding approximately 16-drops of food coloring to approximately 187-milliliters of rigidifying solution results in a rigidified material with a moderately intense color. Other factors potentially effecting the final color of the rigidified material will include the absorbency and initial color of the cellulosic material.

Additionally, or alternatively, a scenting agent may be added to the rigidifying solution to impart a desired scent to the rigidified tissue paper. For example, potpourri or any other scented material may be added which will leave a scented residue when the material is dried. While various concentrations of scenting agent may be used, in the embodiment where potpourri is added to the sugar/water/isopropyl alcohol

rigidifying solution, it has been found that approximately 10-milliliters of potpourri added to approximately 187-milliliters of solution results in a rigidified material with a moderate scent. As a further option, selected enzymes, which are capable of disintegrating other materials in holding tanks, septic tanks, etc., may be incorporated into the rigidifying solution to enhance the utility of the rigidified material.

While the coloring and scenting agents have been described as being added to the rigidifying solution, it will be appreciated that the various constituents of the rigidifying solution may typically be added in any order. Thus, reference herein to adding a coloring or scenting agent to the rigidifying solution will be understood to include adding such agent to the solvent either before or after the sugar is added. Alternatively, the coloring or scenting agent may be added to the sugar, and the combination dissolved in the solvent. As a further alternative, one or more of the various rigidifying, coloring, and/or scenting agents may be added to either the water or the alcohol before the other solvent component is added. In short, there is generally no required sequence for mixing the rigidifying solution.

As another option, the rigidified material may be further processed after drying to impart other characteristics desirable for a particular application. For example, a particular coating such as wax (or wax paper), plastic, or etc., may be applied to selected regions of the rigidified material to provide a water-insoluble surface. This may be desirable, for example in food containers, etc. Additionally, the rigidified material may be ornamented with indicia or decoration using ink, paint, etc. Exemplary indicia include trademarks, use or disposal instructions, and etc.

Although the invented process imparts a substantial rigidity to the cellulosic material, additional post-process shaping remains possible. For example, the rigidified material may be cut to a desired shape, punctured, folded, bent, or otherwise reshaped. In some cases, it may be desirable to slightly moisten the material to increase its pliability.

While it is impractical to describe with any detail the myriad uses to which the present invention may be applied, it is possible to at least illustrate a few of such uses. For example, the rigidified material is obviously well suited to replace ordinary cardboard in virtually any application in which cardboard is currently used. Not only is the material much easier to dispose of than cardboard, it also requires much less cellulosic material than cardboard to produce a structure having a given degree of strength and rigidity.

This latter point illustrates a further advantage of the present invention. Specifically, articles formed of paper and other cellulosic material may be made using less cellulosic material without sacrificing rigidity. Indeed, the rigidifying solution may be applied to the cellulose fibers during the paper-making process. For example, the solution may be added to the cellulosic material before it is formed into a pulp, or alternatively, before the pulp is formed into a continuous sheet, or alternatively, before the sheet is finally dried. In any event, the rigidifying agent provides a structural stiffness that otherwise must be supplied by a greater thickness of cellulose fibers. Thus, in addition to producing materials and articles which are easily biodegradable, the invention also reduces the consumption of natural resources such as trees.

Focusing now more closely on the drawings, Figs. 1 and 2 show one application in which the rigidified material is used to replace the cardboard ordinarily found in a consumer article. Specifically, in place of a cardboard inner core for a roll of paper such as bathroom tissue paper, inner core 10 may be constructed from the same bathroom tissue 12 which is wound around the core. Alternatively, core 10 may be formed of a different cellulosic material than tissue 12. In any event, when bathroom tissue 12 is exhausted, core 10 may be disposed of in the toilet. In view of the large number of bathroom tissue rolls consumed by the average household, the elimination of the non-biodegradable cardboard core achieves an enormous reduction of landfill waste.

As depicted in Figs. 1 and 2, inner core 10 is substantially cylindrical in shape with a hollow center bore adapted to fit over standard bathroom tissue dispensers. Inner core 10 may be formed in any size and shape but is typically formed to the dimensions of a standard cardboard inner core for a bathroom tissue roll. Accordingly, the length of inner core 10 is approximately $4^{7}/_{16}$ inches, the outer diameter is approximately 1¾ inches, and the inner diameter is approximately $1\ ^{45}/_{64}$ inches. In alternative embodiments, such as a paper towel core, the dimensions of the core will preferably be compatible with standard paper towel cores made of cardboard.

Inner core 10 is usually formed from one or more sheets of bathroom tissue. It will be understood that the number of tissue layers used will depend on whether the tissue employed is a multi-ply material or a single-ply material. In accordance with the present invention, the rigidifying solution is applied to the sheets such as by

spraying. A suitable rigidifying solution is the sugar/water/isopropyl alcohol solution described above. Optionally, the solution may contain a coloring and/or scenting agent. Once saturated with rigidifying solution, the sheets are then formed into a roll of the desired size. Alternatively, the sheets may be placed over a form of the desired size and shape. The form is usually constructed of glass, metal, or some other material adapted for easy release of the sheets after drying.

In a typical mass production application, the rigidifying process is incorporated into the existing tissue manufacturing process. Thus, once the tissue is formed into large, core-less rolls, the first several sheets of the outer edge of the tissue is sprayed with rigidifying solution. The tissue is then rewound onto heated mandrels. The mandrels are heated to ensure that the inner layers of tissue, which have been saturated with rigidifying solution, are dried quickly. Typical mandrel temperatures may be in the range of approximately 250° to 300° Fahrenheit. It has been found that these temperatures achieve sufficient drying within approximately 25-30 seconds. A slight amount of force may be applied to the wetted layers of tissue (e.g., by rollers, etc.) to adhere the adhere the solution and layers together.

There are a variety of ways in which a mandrel may be configured for heating. In tests involving a non-rotated section of a standard stainless steel 316 industrial roll paper mandrel, it has been found that the mandrel may be heated to a desired temperature by placing a resistive electrical heating element (approximately 1/4" diam.) in the inside diameter (approximately 1" diam.) of the mandrel. The heating element may be powered by 120 VAC wall current using either manual or automatic control to achieve the desired temperature. Various devices may be used for detecting

the mandrel temperature including one or more thermocouples mounted to the mandrel. Alternatively, the mandrel temperature may be measured using a non-contact infra-red thermometer focused on a portion of the mandrel which is free of tissue paper and painted black. It is calculated that a full-size heated mandrel such as described above would require approximately two kilowatts of power to initially heat the mandrel to approximately 300° Fahrenheit, and approximately 0.6 kilowatts/hour to maintain the mandrel at the target temperature.

When the tissue has been completely wound onto the mandrels, the tissue forms a long roll which can be cut into individual rolls of standard size as shown in Fig. 1. The inner layers of tissue, although integral with the outer layers, have been rigidified and thus provide a structurally sound core to replace the standard cardboard core. Nevertheless, upon immersion in water 14, the inner layers lose their rigidity and become essentially indistinguishable from the non-rigidified layers. Thus, the core can be safely disposed of in standard sewage systems.

Fig. 3 shows another example of a biodegradable, environmentally-friendly article formed according to the present invention. Indicated generally at 16 is a sheet of corrugated material, at least a portion of which is formed from substantially rigid, biodegradable material. In the embodiment depicted in Fig. 3, corrugated sheet 16 includes a relatively flat first outer layer 18, a ribbed inner layer 20, and a relatively flat second outer layer 22. Ribbed inner layer 20 is sandwiched between outer layers 18 and 22 to form an extremely strong composite structure. While sheet 16 is depicted as consisting of three layers, it will be appreciated that additional flat and/or ribbed layers may be added for increased strength, thickness, etc.

In accordance with the invention, at least one of layers 18, 20, and 22 is formed from rigidified cellulosic material as described above. The other layer(s) may be formed from conventional material such as paperboard, cardboard, etc. However, preferably more than one of the layers, and most preferably all of the layers, are formed of rigidified material. In the latter case, all of sheet 16 will be biodegradable. In any event, at least a portion of sheet 16 will disintegrate upon immersion in water, and will biodegrade when exposed to cellulose-consuming micro-organisms.

A further example of an article formed from rigidified cellulosic material is the container 24 illustrated in Fig. 4. Container 24 may be formed from corrugated material, such as illustrated in Fig. 3, or it may be formed of non-corrugated material. The elasticity of the rigidified material allows the creation of a living hinge 26 to connect a lid 28 to the container. The container walls are preferably made from continuous sheets of tissue paper which are formed into a box and then rigidified as described above. Alternatively, the walls may be formed by gluing separate pieces of rigidified material together. As with the other articles, container 24 may optionally be formed of colored or scented rigidified material as described above. In addition, the interior of the container may be lined, for example, by wax paper or plastic, for storage of food, liquid, or etc.

As an additional example, a sewer-disposable tampon applicator is indicated generally at 30 in Fig. 5. As is well known in the art, conventional tampon applicators are formed from plastic and/or cardboard coated with plastic. Unfortunately, these materials are often disposed of in sewer lines where they cause blockages because they retain their rigidity after immersion in water. In contrast, applicator 30 is formed

from rigidified material coated with a perforated layer of plastic, wax, or etc. Consequently, when applicator 30 is disposed of in the sewer lines, the rigidified material quickly loses its rigidity and begins to disintegrate, thus preventing any blockages of the sewer lines. While the plastic coating may or may not fully biodegrade, the main bulk of applicator 30 will biodegrade, thereby substantially reducing the solid wastes processed by wastewater treatment systems.

Fig. 6 shows a biodegradable garment 32 made in accordance with the invention. While garment 32 is depicted as a pair of coveralls, it will be appreciated that garment 32 may be made in any suitable shape or style of clothing including a gown, poncho, shirt, shorts, pants, hood, etc. In addition, although garment 32 may include conventional non-biodegradable items such as zippers, buttons, etc., at least a portion, and preferably most of the garment is made of rigidified material so that the garment is substantially biodegradable. Garment 32 may be useful for any activity where it is desired to protect underlying clothing or to prevent transmission of bodily fluids. A few exemplary applications include medical or surgical garments, garments for handling hazardous wastes or asbestos removal, garments or tarpaulins for painting, and etc.

Fig. 7 shows a disposable shoe cover 34 which can be worn over a shoe 36 to protect the shoe from a dirty environment and/or to protect a clean or delicate flooring from foot traffic. As with conventional shoe covers, disposable shoe cover 34 may be made in any size or shape as desired, and may include optional elements such as an elastic opening 38 or a non-skid sole (not shown).

It will be understood that the examples described above and illustrated in the drawings are just a few of the virtually unlimited uses to which the present invention may be applied. Those of skill in the art will appreciate that any application or article requiring a structurally rigid, disposable material may be suitable for employing the rigidified material described above. Thus, the invention is not limited to the specific examples illustrated herein, but includes all such applications and articles.

Experimental results on the degradability of the rigidified material are summarized below:

EXPERIMENTAL RESULTS

Rigidified material samples were dimensioned as: 1 ½ inch diameter x 4 ¼ inches long, i.e., an inner core 10. For testing purposes, a ½ x ½ inch sample was removed from the outer edge of one end of the core. The measured values of ambient air temperature and relative humidity during the experiment were 72° Fahrenheit, and 57%. The measured value of the sample water was 70° Fahrenheit. Water volume for the experiment was measured at 100 ml in a glass beaker.

Physical Properties

Wall thickness of rigidified material sample - .016 inch

Color - pink

Procedures:

Using the measured water sample, the standing pH value, iron level, and water grain hardness values were tested (see Table 1). Following the initial measurements of baseline data for iron, pH, and grain hardness a ½ x ½ inch square sample of the

rigidified was placed in the 100 ml water solution. A timer stop watch was activated when the sample square was placed in the water.

Timed interval observations were completed as follows:

(Note: a gentle swirling action kept the sample in motion)

1 minute - color changes began to appear at all four edges of the sample

2 minutes - ply separation began

3 minutes - ply separation section began to go clear. Remained opaque.

5 minutes - wall thickness of ply section are noticeably thinner

10 minutes - breakup of ply sections- wall thickness measured at .006 inch

13 minutes - suspension of ply sections in water sample

15 minutes - continued degradation of ply section samples

Post Testing Readings:

Water Sampling

A repeated test series for measurements of iron, pH, and grain hardness were conducted on the water sample taken from the 100 ml volume used to observe/test the rigidified material sample. The following table includes data summarizing the results of the iron, pH, and grain hardness before and after the test series.

Table 1: Summary Findings – Before & After – iron, pH, grains hardness

Iron		pH		Water Grain Hardness	
Before	After	Before	After	Before	After
.5	.5	7.4	7.1	15	15

Comparison Testing of Standard Household Tissue Core (Cardboard)

Using a standard cardboard inner core of similar diameter and length with a measured wall thickness of .021 inch, a ½ x ½ section was placed into a 100 ml water volume sample of comparable temperature under exact conditions of ambient air and relative humidity values. For the purposes of the test, the primary consideration was the ability of the core sample to dissolve into the water volume sample. Using a timer stop watch, the sample was observed over a 30 minute period and the only observable result was ply separation after approximately 15 minutes with no further degradation of wall thickness through the entire observation period. At the end of the 30 minute observation period the wall thickness measured .021 inch, the thickness measured at the beginning of the test.

Conclusion

The timed observations demonstrate that the rigidified material sample is able to reduce its mass beginning within the first minute of contact with water. Further, with turbulent conditions associated with conventional water disposal systems, the entire rigidified material mass would degrade as a solute into the water.

While the invention has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a

limiting sense as numerous variations are possible. Applicant regards the subject matter of the invention to include all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. No single feature, function, element or property of the disclosed embodiments is essential. The following claims define certain combinations and subcombinations which are regarded as novel and non-obvious. Other combinations and subcombinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such claims, whether they are broader, narrower or equal in scope to the original claims, are also regarded as included within the subject matter of applicant's invention.

I CLAIM:

1. A process for imparting a substantial rigidity to a cellulosic material without destroying an inherent tendency of the material to at least partially disintegrate in water, the process comprising:

dissolving one or more sugars in an aqueous solvent to form a rigidifying solution;

applying the rigidifying solution to the material; and

drying the material.

2. The process of claim 1, wherein the aqueous solution includes water.

3. The process of claim 2, wherein the aqueous solution includes an alcohol.

4. The process of claim 3, wherein the material includes tissue paper.

5. The process of claim 1, wherein the material includes paper.

6. The process of claim 2, wherein the material includes tissue paper.

7. The process of claim 1, further comprising the step of adding a coloring agent to the rigidifying solution to impart a selected color to the material.

8. The process of claim 1, further comprising the step of adding a scenting agent to the rigidifying solution to impart a selected scent to the material.

9. The process of claim 1, wherein the step of drying includes heating the material.

10. The process of claim 1, further comprising the step of forming the material into a desired shape.

11. The process of claim 10, wherein the step of forming is carried out before the step of drying.

12. A process for reversibly imparting a substantial rigidity to a material formed from cellulosic fibers, comprising:

dissolving a rigidifying agent in a carrier liquid, where the rigidifying agent is in the form of a plurality of crystals; and

incorporating the rigidifying agent into the material by

applying the carrier liquid to the material, and

evaporating the carrier liquid such that at least a portion of the rigidifying agent remains as a non-crystal residue to form a substantially rigid structure with the cellulosic fibers;

where the non-crystal residue is dissolvable upon exposure of the rigid structure to water.

13. The process of claim 12, wherein the rigidifying agent includes a sugar.

14. The process of claim 12, wherein the carrier liquid includes water and an alcohol.

15. The process of claim 12, wherein the step of evaporating includes heating the material.

16. The process of claim 12, wherein the cellulosic fibers include wood pulp.

17. An aqueous chemical solution combinable with cellulosic fibers and effective to reversibly form a substantially rigid material with the fibers upon drying, the chemical solution comprising:

an aqueous solvent; and

a selected amount of one or more sugars dissolved in the aqueous solvent.

18. The chemical solution of claim 17, wherein the aqueous solvent includes water and an alcohol.

19. The chemical solution of claim 17, further comprising a coloring agent.

20. The chemical solution of claim 17, further comprising a scenting agent.

21. The chemical solution of claim 17, wherein the one or more sugars includes sucrose in the form of food-grade table sugar.

22. A roll of bathroom tissue, comprising:

a substantially rigid inner core; and

a selected quantity of bathroom tissue wound around the inner core;

where the inner core is formed from one or more layers of cellulosic material and a rigidifying residue that remains after applying a solution including a sugar and water to the cellulosic material, and then drying the cellulosic material.

23. The claim of 22, wherein the cellulosic material includes paper.

24. The claim of 23, wherein the paper includes tissue paper.

25. The claim of 22, wherein the solution further includes an alcohol.

26. A composition of matter comprising cellulose fibers and one or more sugars, the composition being formed by dissolving the one or more sugars in a solvent to form a solution, applying the solution to the fibers, and drying the fibers.

27. The composition of claim 26, wherein the solvent includes water and an alcohol.

28. The composition of claim 26, wherein the cellulose fibers include wood pulp.

29. The composition of claim 26, wherein the cellulose fibers are in the form of paper.

30. An environmentally-friendly article, comprising:

at least one substantially rigid, biodegradable portion formed from

one or more layers of tissue paper, and

a rigidifying residue remaining after a solution including a sugar, water, and an alcohol is applied to the tissue paper and then dried.

31. The article of claim 30, wherein the biodegradable portion is in the form of a core for a paper roll.

32. The article of claim 30, wherein the biodegradable portion forms at least a part of an applicator for a tampon.

33. The article of claim 30, wherein the biodegradable portion forms at least a part of a garment.

34. The article of claim 30, wherein the biodegradable portion forms at least a part of a container.

35. The article of claim 30, wherein the biodegradable portion forms at least a part of a corrugated material.

36. The article of claim 30, wherein the biodegradable portion forms at least a part of a shoe cover.

37. In a process for making paper, where a cellulosic material is formed into a pulp and then dried as a substantially continuous sheet, the improvement comprising:

adding a sugar to the cellulosic material to stiffen the paper.

38. The process of claim 37, wherein the sugar is added to the cellulosic material before it is dried.

Fig. 1

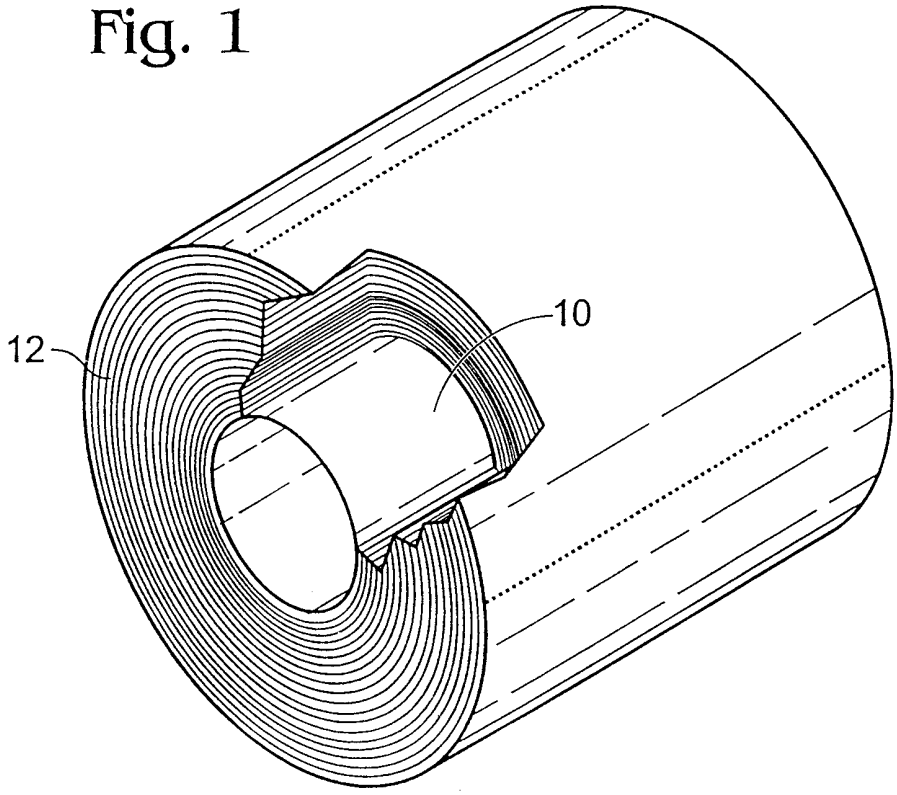


Fig. 2

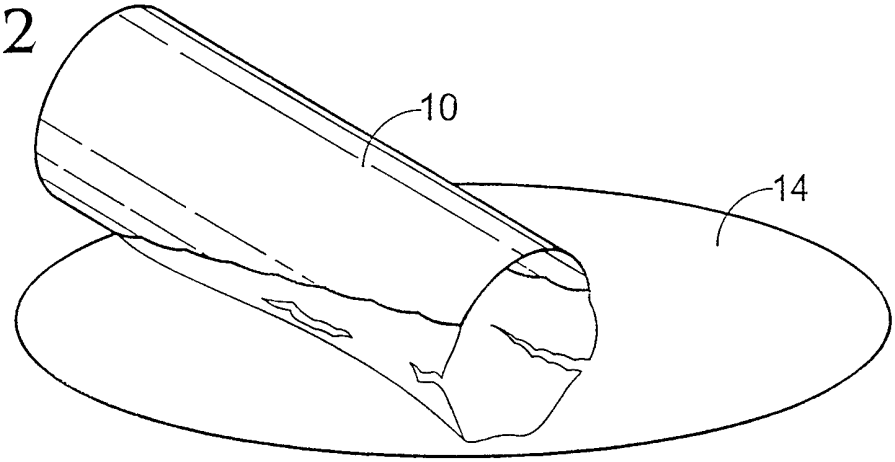


Fig. 3

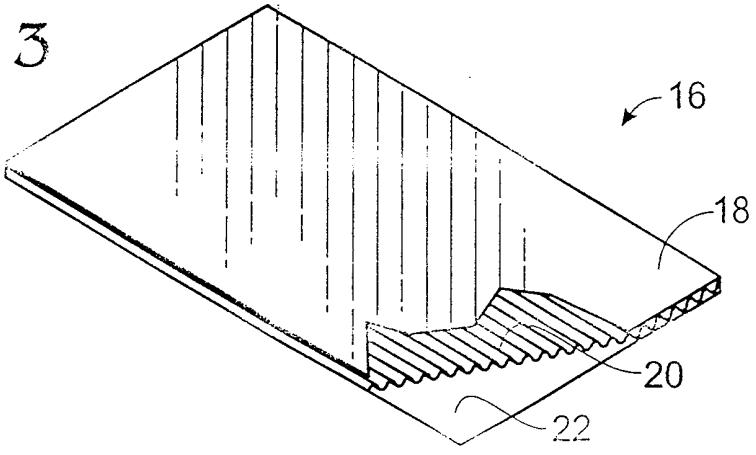


Fig. 4

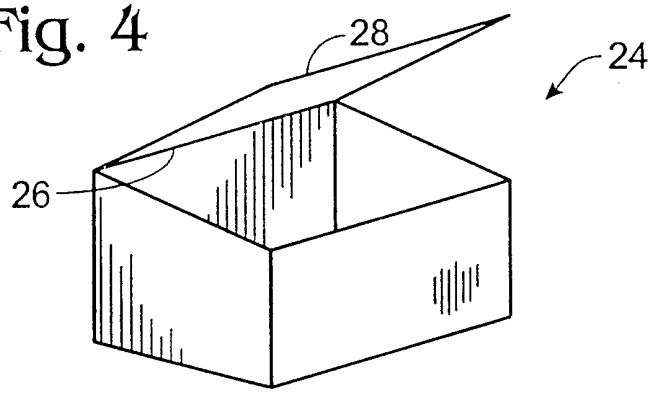


Fig. 5

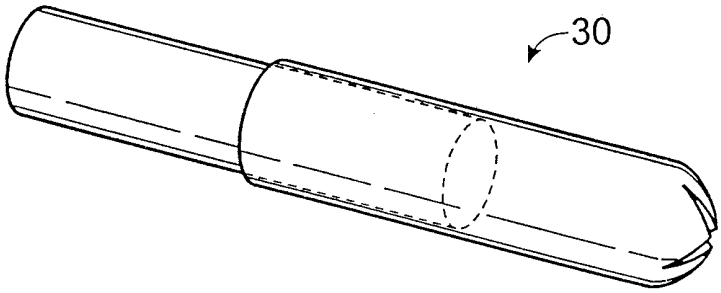
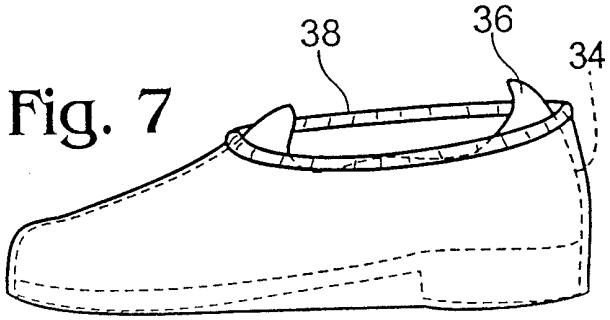


Fig. 6

Fig. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/02209

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :D21H 17/24, 21/18, 21/28, 23/04, 23/32
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 162/158, 175, 135; 427/391, 385, 361; 428/311.91, 294.1, 393, 535; 106/146.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

East, West, Dialog

Sugar solution, papermaking, sucrose, alcohol

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,690,790 A (HEADLAM et al) 25 Novemeber 1997, see entire document.	1-6, 8-11, 12-21, 26-30, 37-38
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Y		7, 22-25, 31-36
X	US 4,755,390 A (CALANDRO et al) 05 July 1988, see column 3, line 58 through column 4, line 16.	1-3, 7, 9, 12-15, 17-21, 26-27
X	US 5,753,284 A (GREEN et al) 19 May 1998, see column 2, lines 56-67.	17-21

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"B"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 11 MAY 2000	Date of mailing of the international search report 25 MAY 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JOSE A. FORTUNA Telephone No. (703) 308-0661

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INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

162/158, 175, 135, 152, 163, 183; 427/391, 385, 361; 428/311.91, 294.1, 393, 535; 106/146.1