A composite uniplanar water soluble film comprising a strip of a cold water soluble plastic film bonded at its edge to a strip of a hot water soluble plastic film. Alternatively, there may be a plurality of cold water soluble strips and/or a plurality of hot water soluble strips constituting the uniplanar film. One of the uses of the film is in the manufacture of laundry bags.
WATER SOLUBLE PLASTIC FILM AND METHOD OF MANUFACTURING SAME

The present invention relates to a water soluble plastic film and more particularly to a composite film which is a unitary uniplanar structure comprised of at least one cold water soluble portion which has at least one of its edges bonded to the edge of at least one hot water soluble portion. The invention also relates to the method of producing the aforementioned composite film.

There are commercially available various hot water soluble films and also various cold water soluble films, both of which can be produced from polyvinyl alcohol (PVA) and derivatives thereof along with various additives. These films may be prepared from either one species of resin or from mixed resins.

One of the uses of the composite water soluble films of the present invention is to manufacture a laundry bag especially an infection-proof hospital laundry bag. It has been proposed to reduce the spread of bacteria from soiled hospital bed linens, garments, etc. by replacing cloth laundry bags with bags made of various plastic films. The prior art has recognized the possibility of making laundry bags of polyvinyl alcohol film which will dissolve during the washing cycle and be flushed away to a sewage disposal system. Frequently, hospital laundry contains blood stained laundry which should first be washed in cold water before washing with hot water since if hot water is used at the beginning of the cycle the blood solidifies and the blood stains tend to set and become hard to remove. Thus, provision should be made to enable the laundry bag to be opened so that the laundry may be dispersed in the initial cold water wash. Bags produced using the composite film of the present invention may be used for such purpose since the cold water portion of the film can be located in the bag in such a way that upon dissolution of the cold water portion the bag is opened and the contents spill out into the washing machine. Subsequently by elevation of the temperature during the hot water cycle the remainder of the bag dissolves and is flushed away. A bag made wholly of hot water soluble film is undesirable when the laundry should be subjected to a cold water cycle initially in order to remove stains as explained above. With the use of such bags it is necessary to either open the bags by hand or to make other provision for opening the mouths of the bags which still does not ensure that the contents of the bag will be thoroughly dispersed into the cold wash water.

Use of a laundry bag made of cold water soluble PVA film is undesirable since frequently the laundry is wet, and wet laundry may cause the film to split or break thereby allowing spread of bacteria and emission of odors from the bag. Therefore, cold water soluble film cannot be used where the bag may be employed for receiving wet laundry.

Preferably, bags constructed from the composite film of the invention are constructed so that the cold water soluble portion will normally not contact the laundry during storage or transportation of the bags. Thus, the composite film may be utilized to produce laundry bags for use with both wet and dry laundry.

The composite film of the invention may also be employed in any other application in which it is desirable to have a portion of the film or of a container made therefrom dissolve in cold water and the remainder dissolve in hot water. As an indication of such other use, when preparing an adhesive, paste, etc. from starch, wheat flour, PVA and the like powder in a dry condition, if these powders are placed directly in hot water, undissolved grains will result but if the powders are first swollen and dispersed in cold water and then heated the powder will dissolve into a paste free from undissolved grains. Such a two stage dissolution method which has been proposed by many people may be carried out utilizing containers produced from the composite film of the present invention.

It is a principal object of the present invention to provide an improved composite water soluble plastic film having regions of different solubility characteristics.

Another object of the invention is to provide a novel uniplanar film wherein sections of hot water soluble plastic film and cold water soluble plastic film are united to each other edge to edge without using an extraneous bonding agent and without laminating, i.e., overlapping, the edges of the film to each other.

Another object of the present invention is to provide a novel method for the production of a composite plastic film having regions of different solubility characteristics.

The above and other objects, features and advantages of this invention will become more apparent as this description proceeds.

In the drawings:

FIGS. 1 through 5 are plan views of sections of composite water soluble films according to five embodiments of the present invention.

FIG. 6 is a perspective view of a composite film of the invention formed into a tubular configuration.

FIG. 7 is a perspective view showing a portion of the apparatus for producing a composite film in accordance with the invention.

A laundry now to the drawing, FIG. 1 illustrates one embodiment of the present invention in which two relatively wide rows or strips 1 of hot water soluble film are united to the edges of a centrally disposed narrow row 2 of cold water soluble material without overlapping.

In the embodiment of FIG. 2, two rows 2 of cold water soluble material are united along each longitudinal edge of a larger row or strip 3 of hot water soluble material without overlapping of the edges of the rows.

Similarly, in FIG. 3 three narrow rows 2 of cold water soluble material are bonded to two larger rows 4 of hot water soluble material in an alternating sequence.

FIG. 4 illustrates an embodiment in which the strip or row of cold water soluble material indicated by reference numeral 2 has a wavy configuration indicated on opposite sides to rows or strips 5 and 6 of hot water soluble material. Such a configuration may be obtained by extruding the composite film and suitably oscillating the portion of the die orifice which is extruding the central strip 2.

FIG. 5 illustrates an embodiment in which the relative sizes of the hot water soluble strip 5 and cold water soluble strip indicated by reference numeral 2 and 5 are approximately equal.

An embodiment of the invention in which the composite film is in a tubular form is shown in FIG. 6 wherein there is a small narrow strip 2 of cold water soluble material and the remainder of the film is comprised of a considerably larger hot water soluble film 8. Such a tubular body may be formed in many ways, for example, by extrusion utilizing a circular orifice and an internal mandrel and are approximately equal.

FIG. 7 illustrates a portion of a suitable apparatus for producing composite films in accordance with the present invention. This figure shows an extrusion head 9 having an elongated die orifice 10 which discharges the composite film onto the surface of a cooled roller 11. One or more parting plates 12 which have a thickness preferably of less than 5 mm. are disposed in the head 9 to subdivide the interior of the head and the die orifice into a plurality of separate supply channels for the cold water soluble material and for the hot water soluble material. In the illustrated embodiment, there are three parting plates 12 dividing the interior of the head 9 into three small chambers 13, 14 and 15 and two larger chambers 16 and 17. If cold water soluble material is supplied to the three smaller chambers 13, 14 and 15, and hot water soluble material is independently supplied to the larger chambers 16 and 17 there will be produced a composite film having the alternate arrangement of three narrow rows of cold water soluble material and two larger rows of hot water soluble material as illustrated in FIG. 2.

It will be appreciated that by changing the number of parting plates and/or their location composite films having different structural relationships between the cold water soluble row(s) and the hot water soluble row(s) may be obtained.
The composite films of the invention, which have as excellent appearance and strength as films produced either solely of hot water soluble film or solely of cold water soluble film, may be produced using molten materials or solutions of moldable materials having the previously described solubility characteristics.

When the cold water soluble substance used in the invention is made into a film sample 15 mm. wide and 50 mm. long, and the sample is suspended vertically with 30 mm. of the sample immersed in 30° C. water with a weight of about 2 g./mm.² per 1 mm. of the sectional area of the film at the end, it will start partially dissolving within 3 minutes and will break and drop to the bottom. Suitable cold water soluble substances comprise, for example, partly saponified PVA and the derivatives thereof such as partly urethanated PVA (degree of urethanation of about 4 to 15 mol percent), partly formylated PVA (degree of formalization of about 10 to 25 mol percent), partly acetoacetylated PVA (degree of acetoacetylation of about 10 to 20 mol percent), methyl cellulose, carboxymethyl cellulose, polyethylene oxide, etc. individually or in a mixture. Of the above substances partly saponified PVA (degree of saponification about 80 to 95 mol percent, desirably 87 to 92 mol percent; a degree of polymerization of 500 to 2,000, desirably 550 to 1,700) is most desirable in view of its cold water solubility and strength. The hot water soluble substances of the invention take more than 3 minutes to dissolve and flow down under the same testing conditions as above, and completely dissolve in hot water at 90° C. Suitable hot water soluble materials are, for example, fully saponified PVA and the derivatives thereof which have excellent appearance, strength and homogeneity, and particularly PVA (degree of polymerization of 500 to 2,000, desirably 550 to 1,700; a degree of saponification more than 95 mol percent, desirably more than 98 mol percent) is most desirable. Pigments, dyes, starch, dextrin and the like additives and extending agents may be added to the films as required. When the cold water soluble substance is partly saponified PVA and the hot water soluble substance is fully saponified PVA, the sheet exhibits a high miscibility and is free from uneven flow, at the boundary, rough surface, and marred transparency.

When partly saponified PVA is used as the cold water soluble substance it can be used in an aqueous solution or in a molten condition. When it is used in an aqueous solution, the PVA concentration generally ranges between 5 to 80 w/o e.g., when used in casting method the concentration is 10 to 18 w/o and a concentration of 30 to 80 w/o in an extrusion method is desirable.

When PVA is used in an extruding method, a concentration of more than 50 weight percent is desirable and a plasticizer should be added in abundance. When fully saponified PVA is used as the hot water soluble substance, it can be used in an aqueous solution or in a molten condition. When it is used in an aqueous solution the concentration of PVA is desirable in the range of 5 to 80 weight percent, e.g., 8 to 15 weight percent when cast and 30 to 80 weight percent when extruded. When it is used in a molten condition, a concentration of more than 50 weight percent is necessary along with abundant addition of a plasticizer. The films of the invention may have a thickness in the order of from 0.01 to 0.20 mm. preferably from 0.02 to 0.08 mm.

Containers, e.g., bags made from the film of the invention dissolve in two stages. The cold water soluble portion dissolves in cold water and the hot water soluble portion subsequently dissolves upon elevation of the temperature. By cold water is meant water having a temperature up to about 30° C., and the hot water material preferably dissolves completely and rather quickly at a temperature of about 90° C. and frequently will dissolve at lower temperatures. The exact temperature at which dissolution starts depends upon the particular material employed. After the cold water soluble portion is dissolved, the hot water soluble portions frequently remains in a somewhat swollen state, and can be taken out of the bath if required or it can remain in the bath and subsequently be dissolved by elevating the temperature of the bath water, and disposed of in the resultant waste water.

Bags may be formed from the composite film of the present invention by employing essentially conventional bag forming techniques. For example, longitudinal ends of the film may be sealed either by an adhesive or heat sealing step, the resulting flattened tubular structure may be cut into appropriate lengths for making bags at which time an open mouth may be formed on the bag, and either simultaneously with this cutting step or subsequently the bottom of the bag may be sealed by a heat sealing step.

Several embodiments of the present invention are especially adapted for the production of laundry bags in which the cold water soluble portion is maintained out of contact with the laundry, and thus the bag may be utilized for holding wet laundry. Taking the composite film of FIG. 2 by way of example, this composite film may be bonded to another film of hot water soluble film approximately the size of the hot water soluble strip 3 shown in FIG. 2 by folding the cold water soluble rows 2 over onto the outside of the additional hot water soluble sheet and adhesively bonding these elements together. The bag may then be made so that these elements extend longitudinally of the bag. Upon immersing such a bag in cold water, the cold water soluble strips 2 will dissolve thereby allowing the contents of the bag to be discharged into the cold water in the washing machine. In such a bag the cold water soluble portion is at the outside of the bag and thus is not contacted by wet laundry in the bag.

The invention will be further described in accordance with the following examples.

**EXAMPLE 1**

A composite film in accordance with the embodiment of FIG. 1 was produced utilizing the apparatus of FIG. 7 but employing only two parting plates 12 which were spaced apart by a distance of 5 centimeters, which parting plates were 2 mm. wide. In this manner the die orifice (1 m. long) was divided into three sections including two large outer sections and a small central section 5 centimeters wide. A 12 w/o aqueous solution of PVA having a degree of polymerization of 1,700 and a degree of saponification of 98.5 mol percent (the hot water soluble material) was continuously supplied to the two larger sections. A 12 w/o aqueous solution of PVA having a degree of polymerization of 1,700 and a degree of saponification of 88 mol percent (the hot water soluble material) containing 1 percent blue pigment based on the amount of PVA was supplied to the small central section. The solutions flowed onto the roller 11 at a rate of 1.5 meters per minute with the rollers being heated to 85° C. to produce a composite film having the configuration shown in FIG. 1. There was obtained a film 40 microns thick, having a blue stripe in the center and having good appearance and strength.

**EXAMPLE 2**

A film making die as illustrated in FIG. 7 was divided into three small sections 13, 14 and 15 of about 5 centimeters wide respectively and two larger sections 16 and 17 of about 17 centimeters wide respectively by use of four parting plates 12, with the two outer parting plates being disposed about 5 centimeters from the sides of the chamber. One of the 5 centimeter wide end sections 13 was continuously supplied with an 11 w/o aqueous solution of partially urethanated PVA having a degree of polymerization of 575 and a degree of saponification of 99 mol percent and partial urethanation of 4.01 mol percent. The central section 14 of about 5 centimeters width was continuously supplied with an 11 w/o aqueous solution of PVA having a degree of polymerization of 1,700, a degree of saponification of 99 mol percent, and partial formalization of 20.2 mol percent. The other end section 13 was continuously supplied with an 11 weight percent aqueous solution of acetoacetylated PVA having a degree of polymerization of 520, a degree of saponification of 99 mol...
percent, and a partial acetooacetalization of 14.4 mol percent. The two larger sections 16 and 17 which were each about 17 centimeters wide were each supplied with 11 weight percent aqueous solution of PVA having a degree of polymerization of 1,200 and a degree of saponification of 99.5 mol percent. Two respective solutions flowed out of the orifice 10 onto the film making roller 11 which was heated to 97°C. at a rate of 2 meters per minute. The resultant film had the arrangement of hot water and cold water soluble portions illustrated in Fig. 3. This film had a thickness of 35±2 microns and had good appearance and strength. The film was made into a bag which was packed with dry bed sheets, diapers and shirts and the opening of the bag was sealed. The filled bag was put in a laundry machine containing cold water at 24±2°C. After rotating the machine for 30 seconds the results were checked. The cold water soluble film portions were completely dissolved and the bag was split and the contents were dispersed in the machine. The hot water soluble portion, (that corresponding to the film produced from the material from regions 16 and 17 of the extruder head and which material had a degree of polymerization of 1,200 and a degree of saponification of 99.5 percent) remained in a swollen condition, and when subsequently heated to 90°C it thoroughly dissolved.

EXAMPLE 3

A film having the structure shown in Fig. 8 was produced by utilizing a film making die similar to that in Example 1, wherein a parting plate was employed to divide the orifice into two sections. Into one section a 12 w/o aqueous solution of PVA having a degree of polymerization of 1,700 and a degree of saponification of 98.6 mol percent and containing 3 percent titanium oxide based on the weight of PVA was continuously supplied. The other section was continuously supplied with a 13 w/o aqueous solution of PVA having a degree of polymerization of 550 and a degree of saponification of 90 mol percent and containing 1 percent by weight red pigment based on the amount of PVA. Both solutions flowed out at a rate of 3 meters per minute onto the film making roller which was heated to 97°C. The resultant film was further heat treated at 140°C for 8 seconds to obtain a film 30±2 microns thick and having red and white portions on the same plane, good appearance and good strength. This film was made into a bag having a size of 20 x 12 centimeters and both a hot water soluble portion and a cold water soluble portion. One hundred grams of dry wheat flour was packed in the bag, and the packed bag was placed in a vessel containing 500 grams of water at 30°C. The vessel was manually stirred. The cold water soluble portion of the bag opened within 25 seconds. At this temperature the wheat flour was dispersed in 3 minutes but the hot water soluble portion of the bag was only swollen. Upon further heating to 95°C with stirring, the swollen portion of the film, which started dissolving at about 70°C, was completely dissolved and dispersed. The thus produced paste was homogenous, reddish in color, and free from undissolved grains. On the other hand, when wheat flour was placed in a bag consisting only of the hot water soluble portion under the same conditions and rapidly placed into hot water at 70°C without first being dispersed in cold water, and heated up to 95°C the film was dissolved and dispersed, but the resultant paste contained undissolved grains.

EXAMPLE 4

A single parting plate was disposed in a film making die which was 1 meter long and which was similar to that described in previous examples at 25 centimeters from one end. Into one of the sections was continuously supplied a 35 w/o aqueous solution of PVA having a degree of polymerization of 1,700 and a degree of saponification of 99 mol percent. A 40 weight percent aqueous solution of PVA having a degree of polymerization of 1,700 and a degree of saponification of 88 mol percent and containing 0.3 percent blue pigment based on the weight of PVA was continuously supplied to the other section. The two solutions flowed simultaneously from the die at a rate of 20 per minute onto a film making roller which was heated to 60°C, and drawn out along a drying roller heated at 60°C to produce a film 25±2 microns thick. The resultant film had good appearance and strength and had a blue tinted cold water soluble portion and a clear hot water soluble portion with both portions being on the same plane.

While the presently preferred embodiments of the present invention have been shown and described with particularity, it will be appreciated that various changes and modifications can be made without departing from the inventive concept. It is intended to encompass all such changes and modifications as fall within the scope and spirit of the appended claims. What is claimed is:

1. A water soluble plastic film comprising a cold water soluble portion and a hot water soluble portion arranged in rows, the rows of said film being coplanar with each other, said cold water soluble portion being soluble in water having a temperature up to about 30°C, and said hot water soluble portion being substantially completely soluble in water having a temperature of about 90°C.

2. A water soluble plastic film according to claim 1, wherein said cold water soluble portion consists essentially of polyvinyl alcohol having a degree of polymerization of 500 to 2,000 and a degree of saponification of 90 mol percent, and said hot water soluble portion consists essentially of polyvinyl alcohol having a degree of polymerization of 500 to 2,000 and a degree of saponification of more than 95 mol percent.

3. A water soluble plastic film according to claim 1, wherein the hot water soluble portion extends over the greater portion of the width of the film, and wherein a cold water soluble portion row is disposed along one longitudinal edge of the film.

4. A water soluble plastic film according to claim 1, wherein said film includes three rows including a relatively wide middle row comprised of said hot water soluble portion and two edge rows comprised of said cold water soluble portion disposed along each longitudinal edge of said middle row.

5. A method of manufacturing a composite, uniplanar water soluble plastic film having a cold water soluble portion and a hot water soluble portion arranged in longitudinally extending rows, comprising producing the film by flowing onto a film making roller from separate sources a film forming cold water soluble substance and a film forming hot water soluble substance, and forming the film by edge contact of both substances without overlapping each other.

6. A method according to claim 5, wherein said cold water soluble substance consists essentially of polyvinyl alcohol having a degree of polymerization of 500 to 2,000 and a degree of saponification of 90 to 95 mol percent, and wherein said hot water soluble substance consists essentially of polyvinyl alcohol having a degree of polymerization of 500 to 2,000 and a degree of saponification of more than 95 mol percent.