PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) **International Patent Classification** 6 :
A61L 15/62, A61F 13/15, C08F 20/60

A1

(11) **International Publication Number:** **WO 97/24150**

(43) **International Publication Date:** 10 July 1997 (10.07.97)

(21) **International Application Number:** PCT/US96/20420

(22) **International Filing Date:** 20 December 1996 (20.12.96)

(30) **Priority Data:**

60/009,536	29 December 1995 (29.12.95)	US
60/009,535	29 December 1995 (29.12.95)	US

(71) **Applicant:** KIMBERLY-CLARK CORPORATION [US/US]; 401 North Lake Street, Neenah, WI 54956 (US).

(72) **Inventors:** CHANG, Yihua; N342 Candlelite Way, Appleton, WI 54915 (US). MUMICK, Pavneet, Singh; 1514 Schaefer Circle #5, Appleton, WI 54915 (US). SOERENS, Dave, Allen; 736 Kensington Road, Neenah, WI 54956 (US).

(74) **Agents:** SCHENIAN, John, R. et al.; Kimberly-Clark Corporation, 401 North Lake Street, Neenah, WI 54956 (US).

(81) **Designated States:** AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) **Title:** TEMPERATURE-RESPONSIVE MATERIALS

(57) **Abstract**

Disclosed is a polymeric film, prepared from a temperature-responsive polymer, which exhibits flushability properties and improved strength properties when immersed in water. The film may be used in a disposable absorbent product to impart flushability properties to the product after the product's use while providing desired strength properties to the product during its use. Also disclosed is a process for preparing temperature-responsive polymers. The process prepares the temperature-responsive polymer in an aqueous solution using a chain transfer agent.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia
AT	Austria
AU	Australia
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CS	Czechoslovakia
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgystan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakhstan
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam

TEMPERATURE-RESPONSIVE MATERIALS

Background of the Invention

Field of the Invention

The present invention relates to a polymeric film, prepared from a temperature-responsive polymer, which exhibits flushability properties and improved strength properties when immersed in water. The film may be used in a disposable absorbent product to impart flushability properties to the product after the product's use while providing desired strength properties to the product during its use. The present invention also relates to a process for preparing temperature-responsive polymers. The process prepares the temperature-responsive polymer in an aqueous solution using a chain transfer agent.

Description of the Related Art

Disposable absorbent products currently find widespread use in many applications. For example, in the infant and child care areas, diapers and training pants have generally replaced reusable cloth absorbent articles. Other typical disposable absorbent products include feminine care products such as sanitary napkins or tampons, adult incontinence products, and health care products such as surgical drapes or wound dressings. A typical disposable absorbent product generally comprises a composite structure including a topsheet, a backsheet, and an absorbent structure between the topsheet and backsheet. These products usually include some type of fastening system for fitting the product onto the wearer.

Disposable absorbent products are typically subjected to one or more liquid insults, such as of water, urine, menses, or blood, during use. As such, the outer cover backsheet materials of the disposable absorbent products are typically made of liquid-insoluble and liquid impermeable materials, such as polypropylene films, that exhibit a sufficient strength and handling capability so that the disposable absorbent product retains its integrity during use by a wearer and does not allow leakage of the liquid insulting the product.

Although current disposable baby diapers and other disposable absorbent products have been generally accepted by the public, these products still have need of improvement in specific areas. For example, many disposable absorbent products can be difficult to dispose of into an aqueous environment. For example, attempts to flush many disposable absorbent products down a toilet into a sewage system typically lead to blockage of the toilet or pipes connecting the toilet to the sewage system. In particular, the outer cover materials typically used in the disposable absorbent products generally do not disintegrate or disperse when flushed down a toilet so that the disposable absorbent product cannot be disposed of in this way. If the outer cover materials are made very thin in order to reduce the overall bulk of the disposable absorbent product so as to reduce the likelihood of blockage of a toilet or a sewage pipe, then the outer cover material typically will not exhibit sufficient strength to prevent tearing or ripping as the outer cover material is subjected to the stresses of normal use by a wearer.

As such, there is a need for new materials that are relatively easy to process and may be used in disposable absorbent products that generally retain their integrity and strength during use, but after such use, the materials may be disposed of into an aqueous environment. For example, the disposable absorbent product may be easily and efficiently disposed of by flushing the disposable absorbent product down a toilet. Such a disposable absorbent product would then be capable of being degraded by a liquid sewage system as compared to having to be disposed of into a landfill or other solid waste disposal system.

Processes known to be useful in preparing temperature-responsive polymers include free-radical solution polymerization, inverse suspension polymerization, or polymerization in organic solvents. However, such processes have generally been found to result in the temperature-responsive polymer being substantially crosslinked and/or exhibiting an intrinsic viscosity that is too high so as to prevent the temperature-responsive polymer from being capable of being thermally processable.

As such, there is a need for a process that is relatively easy to use and which process results in a temperature-responsive polymer that may then be thermally processed to prepare a material form that may be used in a disposable absorbent product to impart flushability properties to the product.

Summary of the Invention

In one aspect, the present invention concerns a polymeric film, prepared from a temperature-responsive polymer, which exhibits flushability properties and improved strength properties when immersed in water.

In one embodiment of the present invention, the polymeric film comprises a temperature-responsive polymer exhibiting an intrinsic viscosity less than about 500 cubic centimeters per gram, wherein the film exhibits a dry tensile strength of at least about 50 grams of force per 2.54 centimeters of width and a wet tensile strength that is at least about 2 percent of its dry tensile strength.

In another aspect, it is desirable to provide a thin, disposable absorbent product, such as an infant diaper, which product includes a flushable polymeric film as disclosed herein.

In one embodiment, these goals are achieved in a disposable absorbent product comprising a liquid-permeable topsheet, a backsheet attached to the topsheet, an absorbent structure positioned between the topsheet and the backsheet, wherein the backsheet comprises the film of the present invention .

In another embodiment, these goals are achieved in a disposable absorbent product comprising a liquid-permeable topsheet, a backsheet attached to the topsheet, an absorbent structure positioned between the topsheet and the backsheet, wherein the topsheet comprises fibers bound together with the film of the present invention.

In another aspect, the present invention concerns a process for preparing a temperature-responsive polymer that exhibits an effectively low intrinsic viscosity such that the temperature-responsive polymer may then be thermally processed to prepare a flushable material.

In one embodiment of the present invention, the process comprises forming a mixture comprising water, an effective amount of a chain transfer agent, a monomer capable of being polymerized to prepare a temperature-responsive polymer, and a reaction catalyst, wherein the mixture is prepared under conditions effective to polymerize the monomer to form a temperature-responsive polymer that exhibits an intrinsic viscosity that is at least about 50 percent less than the intrinsic viscosity exhibited by an otherwise substantially identical temperature-responsive polymer that is prepared without using the chain transfer agent.

In another aspect, it is desirable to provide a temperature-responsive polymer that exhibits an effectively low intrinsic viscosity such that the temperature-responsive polymer may then be thermally processed to prepare a flushable material.

In one embodiment, these goals are achieved in a temperature-responsive polymer that exhibits an intrinsic viscosity that is less than about 200 cubic centimeters per gram.

Detailed Description of the Invention

In one aspect, the present invention concerns a polymeric film, prepared from a temperature-responsive polymer, which exhibits flushability properties and improved strength properties when immersed in water.

As used herein, the term "temperature-responsive polymer" is meant to represent a polymer whose water-solubility is dependent on temperature such that the polymer will be generally water soluble below a specific temperature but will be generally water insoluble above the specific temperature. As will be appreciated by those skilled in the art, the specific temperature upon which the water-solubility of a polymer is dependent will generally vary from polymer to polymer. For purposes of the present invention, it is generally desired that the temperature upon which the water-solubility of a polymer is dependent will desirably be between about 20°C to about 65°C, suitably between about 20°C to about 35°C, more suitably between about 23°C to about 28°C, and most suitably about 24°C.

Examples of polymers that are temperature-responsive include, but are not limited to, poly(N-substituted acrylamides) such as poly(N-isopropylacrylamide), poly(N-propylacrylamide), poly(N-ethoxypropylacrylamide), and poly(N,N-diethylacrylamide), and poly(N-substituted methacrylamides) such as poly(N-isopropyl methacrylamide) and poly(N-ethoxypropyl methacrylamide). In addition, copolymers of these materials may also be prepared that is temperature-responsive. Copolymerization may permit the selection and commingling of advantageous properties of various polymers.

The temperature-responsive polymer useful in the present invention desirably exhibits effective intrinsic viscosity properties. In particular, the temperature-responsive polymer prepared by the process of the present invention exhibits significantly lower intrinsic viscosity values as compared to known temperature-responsive polymers.

As such, the temperature-responsive polymer of the present invention exhibits an intrinsic viscosity that is beneficially less than about 500 cubic centimeters per gram, suitably less than about 300 cubic centimeters per gram, more suitably less than about 200 cubic centimeters per gram, and most suitably less than about 100 cubic centimeters per gram.

Because the temperature-responsive polymer of the present invention exhibits effective intrinsic viscosity values, the temperature-responsive polymer is capable of being thermally processed to form such materials as fibers, films, and other thermally processed forms of the temperature-responsive polymer. Such a thermal process may include, for example, thermal extrusion. Those skilled in the art will recognize that the intrinsic viscosity may be adjusted according to the particular form in which the temperature-responsive polymer is used.

When a temperature-responsive polymer of the present invention is to be used in a disposable absorbent product as, for example, in a backsheet composite, the temperature-responsive polymer is desirably used in the form of a thin polymeric film. Desirably, such a thin polymeric film exhibits both effective dry and wet tensile strengths such that the thin polymeric film retains its integrity and strength during use.

A material will often exhibit a different tensile strength when in a dry condition as compared to when the material is in a wet condition. This is because the liquid saturating the material will often interact with the material and affect the elastic properties of the material. As will be recognized by one skilled in the art, such a difference in the tensile strength values for a material when in a dry condition as compared to when the material is in a wet condition will depend on the composition and structure of the material.

As will be appreciated by one skilled in the art, a material such as a polymeric film may entrap a relatively minor amount of liquid, such as water, within the material prior to use. For example, such liquid may be absorbed by the polymeric film from humidity in the air. Such a material is still intended to be considered in a dry condition for purposes of the present invention. Thus, as used herein, the "dry" condition of a material is meant to represent that the material comprises an amount of water that is suitably less than about 5 weight percent, more suitably less than about 3 weight percent, and most suitably less than about 1 weight percent, based on the total weight of the material.

As used herein, the "wet" condition of a material is meant to represent that the material comprises an amount of water that is about 100 percent of the absolute liquid saturated retention capacity of the material which may be obtained after the material has been allowed to soak in an excess of water until fully hydrated at a temperature about 5°C above the temperature at which the change in water-solubility of the material is dependent.

It is desired that a polymeric film of the present invention, having a thickness of about 0.002 inch, exhibits a dry tensile strength that is beneficially at least about 50 grams of force, suitably at least about 100 grams of force, and more suitably at least about 200 grams of force per 2.54 centimeters of width of the film.

It is also desired that a polymeric film of the present invention, having a thickness of about 0.002 inch, exhibits a wet tensile strength that is beneficially at least about 2 percent, suitably at least about 5 percent, more suitably at least about 7 percent, and most suitably at least about 10 percent of the dry tensile strength exhibited by the material. The tensile strengths of a material may be determined using a commercial tensile tester.

The present invention includes a process for preparing a temperature-responsive polymer that exhibits an effectively low intrinsic viscosity such that the temperature-responsive polymer may then be thermally processed to prepare a flushable material.

The process of the present invention generally comprises forming a mixture comprising water, an effective amount of a chain transfer agent, a monomer capable of being polymerized to prepare a temperature-responsive polymer, and a reaction catalyst, wherein the mixture is prepared under conditions effective to polymerize the monomer to form a temperature-responsive polymer that exhibits an intrinsic viscosity that is at least about 50 percent less than the intrinsic viscosity exhibited by an otherwise substantially identical temperature-responsive polymer that is prepared without using a chain transfer agent such as isopropanol.

The reaction mixture is typically prepared with an aqueous mixture beneficially comprising at least about 30 weight percent water, suitably at least about 50 weight percent water, more suitably at least about 75 weight percent water, and most suitably about 100 weight percent water. When another liquid is employed with the water, such other suitable liquids include methanol, ethanol, and acetone. However, the use or presence of such other non-aqueous liquids may impede the formation of a reaction mixture that results in a temperature-responsive polymer that exhibits an effective intrinsic viscosity as described herein.

Generally, the order of mixing of the water, chain transfer agent, a reaction catalyst, and monomers capable of undergoing free radical polymerization is not critical in the process of the present invention. However, it may be beneficial to first add the chain transfer agent to the water, then add the monomers to the solution, and finally add a reaction catalyst.

A chain transfer agent suitable for use in the present invention includes isopropanol and water-soluble thiols. The chain transfer agent should be used in an amount effective to result in a temperature-responsive polymer that exhibits an effective intrinsic viscosity as described herein. Generally, the chain transfer agent will be used in an amount that is beneficially within the range of greater than 0 volume percent to about 50 volume percent of the reaction mixture, suitably from about 1 volume percent to about 40 volume percent of the reaction mixture, and more suitably from about 5 volume percent to about 30 volume percent of the reaction mixture.

A reaction catalyst suitable for use in the present invention includes potassium persulfate. The reaction catalyst should be used in an amount effective to result in a temperature-responsive polymer that exhibits an effective intrinsic viscosity as described herein. Generally, the reaction catalyst will be used in an amount that is beneficially within the range of about 0.001 mole percent to about 1 mole percent, suitably from about 0.01 mole percent to about 0.8 mole percent of the reaction mixture, and more suitably from about 0.02 mole percent to about 0.6 mole percent.

The reaction mixture should be prepared under conditions effective to polymerize the monomer to form a temperature-responsive polymer that exhibits a desired intrinsic viscosity. Thus, the mixture can generally be prepared at any combination of temperature and pressure effective to form the desired temperature-responsive polymer. Generally, such temperatures will beneficially be within the range of from about 10°C to about 100°C and suitably within the range of from about 20°C to about 80°C.

It has been found that the temperature-responsive polymer prepared by the process of the present invention, wherein a chain transfer agent such as isopropanol is used, exhibits surprisingly improved intrinsic viscosity properties. In particular, the temperature-responsive polymer prepared by the process of the present invention exhibits significantly lower intrinsic viscosity values as compared to an otherwise substantially identical temperature-responsive polymer that is prepared without using the chain transfer agent.

As such, the temperature-responsive polymer prepared using the process of the present invention exhibits an intrinsic viscosity that is beneficially less than about 200 cubic centimeters per gram, suitably less than about 150 cubic centimeters per gram, more suitably less than about 100 cubic centimeters per gram, and most suitably less than about 75 cubic centimeters per gram. In addition, the temperature-responsive polymer of the present invention exhibits an intrinsic viscosity that is beneficially less than about 50 percent, suitably less than about 40 percent, more suitably less than about 30 percent, and most suitably less than about 20 percent of the intrinsic viscosity exhibited by an otherwise substantially identical temperature-responsive polymer that is prepared without using the chain transfer agent.

As used herein, the term "an otherwise substantially identical temperature-responsive polymer that is prepared without using a chain transfer agent" or other similar terms are intended to refer to a control temperature-responsive polymer that is prepared using substantially identical materials and a substantially identical process as compared to a temperature-responsive polymer of the present invention, except that the control temperature-responsive polymer is prepared by a process that does not use a chain transfer agent as described herein. As a result of not being prepared according to the method of the present invention, the control temperature-responsive polymer generally will not exhibit the improved intrinsic viscosity properties as described herein.

Because the temperature-responsive polymer of the present invention exhibits improved intrinsic viscosity values, the temperature-responsive polymer is capable of being thermally processed to form such materials as fibers, films, and other thermally processed forms of the temperature-responsive polymer. Such a thermal process may include, for example, thermal extrusion.

In one embodiment of the present invention, a disposable absorbent product is provided, which disposable absorbent product comprises a liquid-permeable topsheet, a backsheet attached to the topsheet, an absorbent structure positioned between the topsheet and the backsheet, wherein the backsheet comprises a temperature-responsive polymer prepared by the process of the present invention.

Those skilled in the art will recognize materials suitable for use as the topsheet and backsheet. Exemplary of materials suitable for use as the topsheet are liquid-permeable materials, such as spunbonded polypropylene or polyethylene having a basis weight of from about 15 to about 25 grams per square meter. Exemplary of materials suitable for use as the backsheet, in addition to the temperature-responsive polymer of the present invention, are liquid-impervious materials, such as polyolefin films, as well as vapor-pervious materials, such as microporous polyolefin films.

The temperature-responsive polymer of the present invention will generally be employed in a disposable absorbent product comprising an absorbent structure. Such an absorbent structure will generally comprise a fibrous matrix into which an absorbent material such as, for example, a hydrogel-forming polymeric material is dispersed such that the fibrous matrix constrains or entraps the absorbent material.

The fibrous matrix may be formed by air-laying fibers, through a spunbond or meltblown process, a carding process, a wet-laid process, or through essentially any other means, known to those skilled in the art, for forming a fibrous matrix.

Methods of incorporating an absorbent material into a fibrous matrix are known to those skilled in the art. Suitable methods include incorporating an absorbent material into the matrix during formation of the matrix, such as by air laying the fibers of the fibrous matrix and the absorbent material at the same time or wet-laying the fibers of the fibrous matrix and the absorbent material at the same time. Alternatively, it is possible to apply the absorbent material to the fibrous matrix after formation of the fibrous matrix. Other methods include sandwiching the absorbent material between two sheets of material, at least one of which is fibrous and liquid permeable. The absorbent material may be generally uniformly located between the two sheets of material or may be located in discrete pockets formed by the two sheets. The absorbent material may be distributed in the individual layers in a generally uniform manner or may be present in the fibrous layers as a layer or other nonuniform distribution.

The fibrous matrix may be in the form of a single, integrally formed layer or of a composite comprising multiple layers. If the fibrous matrix comprises multiple layers, the layers are preferably in liquid communication with one another such that a liquid present in one fibrous layer can flow or be transported to the other fibrous layer. For example, the fibrous layers may be separated by cellulosic tissue wrap sheets known to those skilled in the art.

When the fibrous matrix comprises a single, integrally formed layer, the concentration of absorbent material may increase along the thickness of the fibrous matrix in a gradual, nonstepwise fashion or in a more stepwise fashion. Similarly, the density may decrease through the thickness in a nonstepwise manner or in a stepwise manner. Absorbent structures may generally be of any size or dimension as long as the absorbent structure exhibits desired absorbent characteristics.

Absorbent structures are generally suited to absorb many liquids, such as water, saline, and synthetic urine, and body liquids such as urine, menses, and blood, and are suited for use in disposable absorbent products such as diapers, adult incontinent products, and bed pads; in catamenial devices such as sanitary napkins, and tampons; and in other absorbent products such as wipes, bibs, wound dressings, and surgical capes or drapes.

Disposable absorbent products, according to all aspects of the present invention, are generally subjected during use to multiple insults of a body liquid. Accordingly, the disposable absorbent products are desirably capable of absorbing multiple insults of body liquids in quantities to which the absorbent products and structures will be exposed during use. The insults are generally separated from one another by a period of time.

After the disposable absorbent product has been used, it will be desirable to dispose of the disposable absorbent product. If the disposable absorbent product includes the temperature-responsive polymer of the present invention, it may be possible to dispose of the product directly to a liquid disposal system, such as by disposing of the product into a toilet. When placed into a toilet, an excess of water will generally be present and the temperature of the water will generally be lower than the temperature of the liquid insulting the product such that the temperature-responsive polymer of the present invention may rapidly disperse into the water. The disposable absorbent product may then be capable of being flushed down the toilet without fear of the disposable absorbent product clogging the piping of the toilet. By this method of disposal, the disposable absorbent product may then be successfully treated and degraded by the sewage system to which the toilet is attached instead of disposing of the disposable absorbent product through a solid waste disposable system. By not having to be disposed of through a solid waste disposable system, the use of the temperature-responsive polymer of the present invention may reduce the amount of solid waste that has to be landfilled, incinerated, or otherwise disposed of.

Test Methods

Intrinsic Viscosity

Intrinsic viscosity is a parameter which directly reflects the molecular properties of a dissolved polymer. For a flexible polymer the intrinsic viscosity is related to M^a where M represents the molecular weight of the polymer and $0.50 \leq a \leq 0.80$. Intrinsic viscosity ($[\eta]$) is calculated using the following equations:

$$([\eta]) = \lim_{c \to 0} (1/c)\{(\eta/\eta_o) - 1\} \qquad \text{Equation 1}$$

wherein:

η = the solution viscosity at a given polymer concentration

η_o = the solvent viscosity

and:

$$\eta/\eta_o = t/t_o \qquad \text{Equation 2}$$

wherein:

t = the time for a polymer solution to flow through a viscometer

t_o = the time for a solvent to flow through a viscometer

A Canon Fenske viscometer was used to measure the relative viscosity of a polymer solution with respect to viscosity of deionized water, which was used as the solvent. Viscometer numbers 100 and 150 were used. The flow time for deionized water at room temperature for viscometer number 100 was about 58.5 seconds and that for viscometer number 150 was about 28.5 seconds. Higher viscosity polymer samples, such as poly(N-iospropylacrylamide), were studied using viscometer number 150 and lower viscosity polymer samples were studied using viscometer number 100.

The relative viscosities for a polymer sample were measured at 5 different polymer concentrations. The right hand side of Equation 1 (y-axis) was plotted against polymer concentration (x-axis). On extrapolation to zero concentration, the intercept on the y-axis yields the intrinsic viscosity for the polymer sample.

Water Solubility Temperature

Polymers that are temperature responsive exhibit cloud points wherein the polymer precipitates out of solution on heating the solution above the cloud point. On precipitation the solution turns turbid and the cloud point can be measured. Solutions containing between about 0.2 weight percent to about 1.0 weight percent are used for determining the water solubility temperature for a polymer. The solution was poured into a scintillation vial. A thermometer was dipped into this solution and clamped in position with the help of a laboratory stand. A small magnetic stirrer was used for agitation. The solution in the vial was heated at a temperature increase of about 1°C per minute. The temperature at which the thermometer bulb became invisible due to solution turbidity was recorded as the cloud point.

Dry Tensile Strength

Dry tensile strength measurements were performed on a Sintech 1/D tensile testing system. Film samples, having a thickness of about 0.002 inch and prepared from a polymer sample, was cut to a width of about 0.75 inch. The distance between the grips of the tensile tester was about 1.5 inch. The stretch rate of the grips was about 3 millimeters per second.

Wet Tensile Strength

Wet tensile strength measurements were performed in deionized water using a Vitrodyne V1000 mini-tensile tester with the testing speed of about 3 millimeters per second. The distance between the grips of the tensile tester was about 1.5 inch. Film samples, having a thickness of about 0.002 inch and prepared from a polymer sample, was cut to a width of about 1.0 inch. The wet tensile strength measurements were performed in cold water at ambient temperature and in warm water at temperatures about 5°C above the water solubility temperature of polymer samples. The samples were immersed in water for about 30 seconds before testing in the tensile tester for the binder testing and for about 5 minutes before testing in the tensile tester for the film testing.

Examples

Example 1

To a 0.45 M aqueous solution of N-isopropylacrylamide, available from Eastman Chemical Company, was added 0.4 mole percent potassium persulfate, available from Aldrich Chemical Company, at about room temperature (about 23°C) under a nitrogen atmosphere. The reaction was allowed to proceed for about 8 hours at about 30°C. The polymer was removed from the reaction mixture by heating the mixture above the cloud point of the polymer so that the polymer could be recovered. The polymer was then washed with warm water and dried under vacuum. The yield of the polymer was about 50 percent. The prepared polymer was found to exhibit an intrinsic viscosity of about 437 cubic centimeters per gram. Because of its high intrinsic viscosity, the polymer was not thermally processable.

Example 2

About 22.8 grams (about 0.2 mole) of N-isopropylacrylamide was dissolved in about 200 milliliters of deionized water at about room temperature (about 23°C) under a nitrogen atmosphere. The solution was heated to about 55°C and about 0.123 gram (about 0.0004 mole) of potassium persulfate was added to the solution at once. A white precipitate was observed to form immediately in the solution. The reaction was allowed to proceed for about 4 hours at about 55°C. The polymer was then removed from the reaction vessel, washed with warm water, and dried under vacuum at about 50°C to a constant weight. The yield of the polymer was quantitative. The polymer was placed into water and allowed to stand for about 48 hours at the end of which gel particles of the polymer were still observed. Since the polymer was not completely soluble in water, the polymer was believed to be crosslinked.

Example 3

About 113.1 grams (about 1 mole) of N-isopropylacrylamide was dissolved in a mixture of about 712 milliliters of deionized water and about 38 milliliters of isopropanol (about 5 percent by volume), available from Mallinchrodt Specialty Chemicals Company, at about room temperature (about 23°C) under a nitrogen atmosphere. The solution was heated to about 52°C and potassium persulfate was added to the solution at once. The solution was observed to become cloudy in a few minutes. The temperature of the mixture increased to about 68°C, believed to be because of the heat generated during the polymerization. The reaction was allowed to proceed for about 4 hours. The polymer was then removed from the reaction vessel, washed with warm water, and dried under vacuum at about 50°C to a constant weight. The yield of the polymer was quantitative. The polymer was completely water soluble in water, indicating essentially no crosslinking of the polymer. The prepared polymer was found to exhibit an intrinsic viscosity of about 131 cubic centimeters per gram. Fibers with good mechanical strength and clarity were prepared using the polymer in a thermal extrusion process.

Example 4

A process similar to that described in Example 3 was used except that about 10 percent by volume of isopropanol was used to prepare the initial mixture with water. The prepared polymer was found to exhibit an intrinsic viscosity of about 83 cubic centimeters per gram. Fibers with good mechanical strength and clarity were prepared using the polymer in a thermal extrusion process.

Example 5

A process similar to that described in Example 3 was used except that about 15 percent by volume of isopropanol was used to prepare the initial mixture with water. The prepared polymer was found to exhibit an intrinsic viscosity of about 68 cubic centimeters per gram. Fibers with good mechanical strength and clarity were prepared using the polymer in a thermal extrusion process.

Example 6

A process similar to that described in Example 3 was used except that about 20 percent by volume of isopropanol was used to prepare the initial mixture with water. The prepared polymer was found to exhibit an intrinsic viscosity of about 50 cubic centimeters per gram. Fibers with good mechanical strength and clarity were prepared using the polymer in a thermal extrusion process.

Example 7

To an about 1 M aqueous solution of N,N-diethylacrylamide was added about 0.2 mole percent potassium persulfate at about room temperature (about 23°C) under a nitrogen atmosphere. The reaction was allowed to proceed for about 24 hours at about 21.6°C. The polymer was precipitated in warm water, washed with warm water, and dried under vacuum. The prepared polymer was found to exhibit an intrinsic viscosity of about 292 cubic centimeters per gram.

Example 8

About 41.3 grams (about 0.325 mole) of N,N-diethylacrylamide was dissolved in a mixture of about 244 milliliters of deionized water and about 27 milliliters of isopropanol. The solution was purged with nitrogen at about 65°C for about 30 minutes. Potassium persulfate (about 0.18 gram; about 0.00065 mole) was added to the solution at once. The reaction was allowed to proceed for about 3 hours. The polymer was then removed from the reaction vessel, washed with warm water, and dried under vacuum. The prepared polymer was found to exhibit an intrinsic viscosity of about 23 cubic centimeters per gram.

While the invention has been described in detail with respect to specific embodiments thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing, may readily conceive of alterations to, variations of, and equivalents to these embodiments. Accordingly, the scope of the present invention should be assessed as that of the appended claims and any equivalents thereto.

What is claimed is:

1. A polymeric film comprising a temperature-responsive polymer wherein the temperature-responsive polymer exhibits an intrinsic viscosity less than about 500 cubic centimeters per gram, and the polymeric film exhibits a dry tensile strength of at least about 50 grams of force per 2.54 centimeters of width and a wet tensile strength that is at least about 2 percent of the dry tensile strength.

2. The polymeric film of Claim 1 wherein the temperature-responsive polymer is selected from the group consisting of poly(N-substituted acrylamides), poly(N-substituted methacrylamides, and copolymers thereof.

3. The polymeric film of Claim 2 wherein the temperature-responsive polymer is selected from the group consisting of poly(N-isopropylacrylamide), poly(N-propylacrylamide), poly(N-ethoxypropylacrylamide), poly(N,N-diethylacrylamide), poly(N-isopropyl methacrylamide), poly(N-ethoxypropyl methacrylamide), and copolymers thereof.

4. The polymeric film of Claim 1 wherein the temperature-responsive polymer exhibits an intrinsic viscosity that is less than about 500 cubic centimeters per gram.

5. The polymeric film of Claim 1 wherein the temperature-responsive polymer exhibits an intrinsic viscosity that is less than about 300 cubic centimeters per gram.

6. The polymeric film of Claim 1 wherein the polymeric film exhibits a dry tensile strength that is at least about 100 grams of force.

7. A disposable absorbent product comprising a liquid-permeable topsheet, a backsheet attached to the topsheet, an absorbent structure positioned between the topsheet and the backsheet, wherein the topsheet comprises a polymeric film comprising a temperature-responsive polymer wherein the temperature-responsive polymer exhibits an intrinsic viscosity less than about 500 cubic centimeters per gram, and the polymeric film exhibits a dry tensile strength of at least about 50 grams of force per 2.54 centimeters of width and a wet tensile strength that is at least about 2 percent of the dry tensile strength.

8. A process for preparing a temperature-responsive polymer, the process comprising forming a mixture comprising water, a chain transfer agent, a monomer capable of being polymerized to prepare a temperature-responsive polymer that is soluble in

water below a temperature that is between about 20°C to about 65°C, and a reaction catalyst, wherein the mixture is prepared under conditions effective to polymerize the monomer to form a temperature-responsive polymer that exhibits an intrinsic viscosity that is at least about 50 percent less than an intrinsic viscosity exhibited by an otherwise substantially identical temperature-responsive polymer that is prepared without using the chain transfer agent, wherein the conditions comprise using a temperature that is greater than the water-solubility temperature of the temperature-responsive polymer.

9. The process of Claim 8 wherein the temperature-responsive polymer is soluble in water below a temperature that is between about 20°C to about 35°C.

10. The process of Claim 9 wherein the temperature-responsive polymer is soluble in water below a temperature that is suitably between about 20°C to about 35°C.

11. The process of Claim 8 wherein the temperature-responsive polymer is selected from the group consisting of poly(N-substituted acrylamides), poly(N-substituted methacrylamides), and copolymers thereof.

12. The process of Claim 11 wherein the temperature-responsive polymer is selected from the group consisting of poly(N-isopropylacrylamide), poly(N-propylacrylamide), poly(N-ethoxypropylacrylamide), poly(N,N-diethylacrylamide), poly(N-isopropyl methacrylamide), poly(N-ethoxypropyl methacrylamide), and copolymers thereof.

13. The process of Claim 8 wherein the temperature-responsive polymer exhibits an intrinsic viscosity that is less than about 200 cubic centimeters per gram.

14. The process of Claim 13 wherein the temperature-responsive polymer exhibits an intrinsic viscosity that is less than about 150 cubic centimeters per gram

15. The process of Claim 14 wherein the temperature-responsive polymer exhibits an intrinsic viscosity that is less than about 100 cubic centimeters per gram.

16. The process of Claim 8 wherein the temperature-responsive polymer exhibits an intrinsic viscosity that is less than about 40 percent less than an intrinsic viscosity exhibited by an otherwise substantially identical temperature-responsive polymer that is prepared without using the chain transfer agent.

17. The process of Claim 8 wherein the chain transfer agent is selected from the group consisting of isopropanol and water-soluble thiols.

18. The process of Claim 17 wherein the chain transfer agent is isopropanol.

19. The process of Claim 18 wherein the reaction mixture has a volume and the chain transfer agent is used in an amount that is within the range of greater than 0 volume percent to about 50 volume percent of the reaction mixture.

20. The process of Claim 8 wherein the reaction mixture has a volume and the chain transfer agent is used in an amount that is within the range of about 1 volume percent to about 40 volume percent of the reaction mixture.

21. The process of Claim 8 wherein the reaction catalyst is potassium persulfate.

22. The process of Claim 8 wherein the reaction catalyst is used in an amount that is within the range of about 0.001 mole percent to about 1 mole percent of the reaction mixture.

23. The process of Claim 8 wherein the temperature-responsive polymer is selected from the group consisting of poly(N-substituted acrylamides), poly(N-substituted methacrylamides), and copolymers thereof and exhibits an intrinsic viscosity that is less than about 200 cubic centimeters per gram, the chain transfer agent is selected from the group consisting of isopropanol and water-soluble thiols, and the reaction mixture has a volume and the chain transfer agent is used in an amount that is within the range of greater than 0 volume percent to about 50 volume percent of the reaction mixture.

24. The process of Claim 23 wherein the reaction catalyst is potassium persulfate.

25. A temperature-responsive polymer wherein the temperature-responsive polymer is prepared by a process comprising forming a mixture comprising water, a chain transfer agent, a monomer capable of being polymerized to prepare a temperature-responsive polymer that is soluble in water below a temperature that is between about 20°C to about 65°C, and a reaction catalyst, wherein the mixture is prepared under conditions effective to polymerize the monomer to form a temperature-responsive polymer that exhibits an intrinsic viscosity that is at least about 50 percent less than an intrinsic viscosity exhibited by an otherwise substantially identical temperature-responsive polymer that is prepared without using

the chain transfer agent, wherein the conditions comprise using a temperature that is greater than the water-solubility temperature of the temperature-responsive polymer.

26. A disposable absorbent product comprising a liquid-permeable topsheet, a backsheet attached to the topsheet, an absorbent structure positioned between the topsheet and the backsheet, wherein the topsheet comprises a temperature-responsive polymer prepared by a process comprising forming a mixture comprising water, a chain transfer agent, a monomer capable of being polymerized to prepare a temperature-responsive polymer that is soluble in water below a temperature that is between about 20°C to about 65°C, and a reaction catalyst, wherein the mixture is prepared under conditions effective to polymerize the monomer to form a temperature-responsive polymer that exhibits an intrinsic viscosity that is at least about 50 percent less than an intrinsic viscosity exhibited by an otherwise substantially identical temperature-responsive polymer that is prepared without using the chain transfer agent, wherein the conditions comprise using a temperature that is greater than the water-solubility temperature of the temperature-responsive polymer.

INTERNATIONAL SEARCH REPORT

International application No.
PL./US 96/20420

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: A61L 15/62, A61F 13/15, C08F 20/60

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)

IPC6: A61L, A61F, C08F

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0604730 A1 (KIMBERLY-CLARK CORPORATION), 6 July 1994 (06.07.94) --	1-26
A	WO 9516474 A1 (KIMBERLY-CLARK CORPORATION), 22 June 1995 (22.06.95) --	1-26
A	US 5300358 A (GLENN R. EVERS), 5 April 1994 (05.04.94) -- --------	1-26

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" ertier document but published on or after the international filing date

"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)

"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

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search 14 April 1997	Date of mailing of the international search report 20 -05- 1997
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016 Facsimile No.	Authorized officer JACK HEDLUND

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US 96/20420

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0604730 A1	06/07/94	AU 666591 B	15/02/96
		AU 5231293 A	14/07/94
		CA 2093050 A	30/06/94
		JP 6228443 A	16/08/94
WO 9516474 A1	22/06/95	AU 1336395 A	03/07/95
		CA 2128483 A	17/06/95
		DE 4499925 T	19/12/96
		GB 2284820 A	21/06/95
		GB 9425378 D	00/00/00
		US 5509913 A	23/04/96
		ZA 9409979 A	22/08/95
US 5300358 A	05/04/94	NONE	