DEVELOPMENT OF BIO-DEGRADABLE BABY DIAPERS

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Abstract

A diaper or nappy is an absorbent garment worn by babies until they are potty trained. The disposable baby diapers are multi-layer structures consisting of layers of different materials. The disposable diapers are comprised of a polypropylene top cover stock, an absorbent layer, a polyethylene back sheet and elastic bands. The top polypropylene sheet is a Hydrophilic non-woven sheet which permits the urine to pass through it and reaches the absorbent core. The middle portion is a super absorbent polymer which helps to hold the urine away from the skin and faecal enzymes. The diapers back/bottom-most sheet is hydrophobic non-woven films made up of polypropylene fibers.

In our project an attempt was made to produce a bio degradable baby diaper by eliminating the polypropylene non-woven with specially finished bio degradable viscose non-woven so that the pollution will be reduced and expecting the product will fulfil the functional properties of the diaper.

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1. INTRODUCTION

This invention relates to absorbent products and more particularly, is directed to improved absorbent products having biodegradable, fluid impervious, barrier sheets rendering them flushable after use.

It has long been the practice in making absorbent products such as surgical dressings, sanitary napkins and diapers, barrier sheet have been made of one or more piles of impregnated paper to render, repellent or semi repellent, cellophane, rubber, thin films of polyethylene or polypropylene, and the like, The polyethylene films having proven most successful from a functional and commercial standpoint.

However, because polyethylene and other polymeric films are relatively inert and are not attacked or broken down by bacteria normally found in public and private sewage disposal systems, absorbent products incorporating such films as moisture barriers cannot be safely flushed away in sewage disposal systems. Even though the other components of the absorbent product will rapidly disintegrate and be attacked by the bacteria in a public or private sewage disposal system, the polyethylene or polymeric films used as a barrier sheet remain intact and if they do not clog up piping and sewage disposal equipment, the sheets will pass through the sewage treatment plant causing pollution problems.

While some absorbent products in the past have used biodegradable materials for the purpose of preventing strike-through of body exudates mostly in the form of impregnated papers, the porosity of such papers have prevented them from functioning entirely satisfactorily in the manner intended. Similarly, cellophane films have been proposed which, being regenerated cellulose, are also biodegradable. However, in absorbent products, particularly sanitary napkins, the cellophane films are noisy tending to crinkle and be objectionable from the wears standpoint.

From the above, it is readily seen that providing a truly flushable absorbent product containing a fluid impermeable barrier sheet for the prevention of strike-through of body exudates has presented those skilled in the art with a two-fold problem. Barrier materials which are satisfactory from a functional standpoint when the absorbent products are in use are not attacked and broken down in private and municipal sewage treatment systems and most of those materials which are broken down in municipal and thus fail to function in the manner intended.

We produced a truly flushable absorbent product incorporating a fluid impermeable barrier sheet which sheet is readily broken down by bacterial action in private and municipal sewage treatment systems.

1.1 Baby Diapers

In terms of disposable baby diapers, training pants and pant diapers, the principal requirement of this is that they provide an effective absorbent structure to receive, absorb and contain urine and faecal waste from babies over the early period of their life when they have the problem of double incontinence.

The initial phase of handling the baby's incontinence is covered by the baby diaper, while the more recent introduction of the training pant/pant diaper (which normally differs in its absorbent capacity) as a concept has extended into the "toilet training" phase of the Childs's development

Disposable baby diapers should be capable of providing the functionality in such a way to not encourage irritation of the baby's skin and to prevent contamination of the baby's clothing and/or surroundings.

They should also be capable of disposal in a safe and efficient manner, be cost effective in use and of a design and construction appropriate to the geographic market served.

1.2 Diaper Construction

Disposable diapers are mostly made using the following components and Materials viz., Bottom back sheet, Polypropylene Non-woven – Hydrophobic and Hydrophilic, Absorbent core - Wood pulp fluff, Super Absorbent Polymers, Elastics – Lycra/Spandex, Quick wicking layer, Adhesive – Hot melts and Elastomeric, Fastening tape – Stick type/Hook and loop type, Moisturizer lotions and fragrance lotions and Breathable/Cloth-like back sheet

Among all parts, first four are very essential layers in a diaper. Most disposable diapers are made with these basic components:

1.2.1 Cloth-Like Film

This is used as back sheet, and it helps to stop the liquids from leaking out of the diaper. The back-sheet can also be made to look as a cloth like back sheet, by adding a polypropylene non-woven to the film using either hot melts or heat and pressure.

1.2.2 Adhesives

They are used to glue the different components of the diaper, such as the pad and the elastics. They are made of a mixture of resins and oils. The hot melt adhesive is applied melted and when it cools down provides the bonding force to glue the materials.

1.2.3 Hydrophobic Non-Woven

It is used as a top sheet for the leg cuffs, it will not allow water to pass through. It is made of polypropylene resin without any added surface surfactants. The phobic nonwoven is used to make the leg cuffs that prevent leakage to the outside of the diaper. It is also possible to make a roll of nonwoven only partially philic applying surfactant to a restricted area (called the Zebra process).

1.2.4 Hydrophilic Non-Woven

It is the main top sheet, the top surface that is in contact with the baby's skin allowing the liquids to flow into the diaper core. Flow dynamics within the diaper core prevent liquids from returning to the surface. Most nonwovens used in diapers are made with the spun bond process, however it is also possible to use thermal bonded nonwovens, which are softer but with lower resistance, and Trough Air.

1.2.5 Elastics

Used to improve the fit of the diaper, usually made of polyurethane foam, rubber or Lycra (spandex). They are used for the waist and also for the legs, they can also be used as lateral side panels and in tape construction.

1.2.6 Cellulose

Used in the construction of the pad, it gives integrity and absorbing capacity to the diaper. The capacity of pulp is around 10 cc of water per gram of pulp when the diaper is in "free swell" but less than 2 cc when subjected to 5 KPa of pressure that is why superabsorbent is also needed to hold the liquids under pressure.

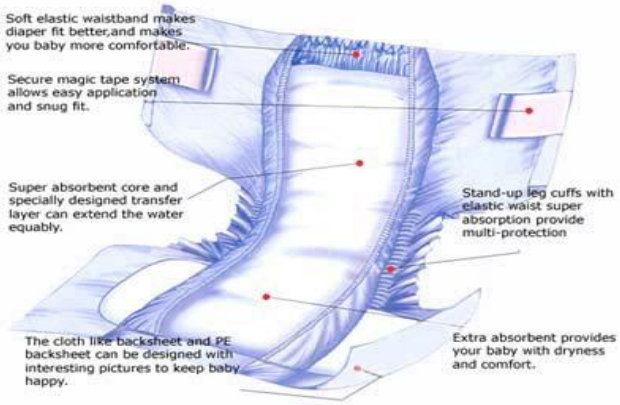

Fig. 2.1 Components of diaper

Shows the components of the commercially available disposable baby diapers, and also their purposes and properties are briefly discussed above.

1.3 Super Absorbent Polymers (SAP)

Superabsorbent polymers are primarily used as an absorbent for water and aqueous solutions for diapers, adult incontinence products, feminine hygiene products, and similar applications. Undoubtedly, in these applications, superabsorbent materials will replace traditional absorbent materials such as cloth, cotton, paper wadding, and cellulose fiber.

Superabsorbent polymers absorb, and retain under a slight mechanical pressure, about 30 times their weight in urine.

The swollen gel holds the liquid in a solid, rubbery state and prevents the liquid from leaking onto the baby's skin and clothing.

1.4 Non Woven

Nonwovens are developed to impart special properties to product. Here the advantage of nonwovens compared with textiles, as e.g. fabrics, is the high economic efficiency of production and their performance capability while at the same time offering lower weights. In order to be competitive today, nonwovens producers must show high productivity at low cost.

1.4.1 Viscose Non-Woven

Viscose consists of cellulose like cotton. Cellulose is obtained from wood and is used for the production of rayon and cellulose acetate fibres. Hence rayon is synthetic fibre produced from regenerated cellulose. The product advantages are similar to those of cotton: skin tolerance, physiological safety, decomposable, good moisture absorbency and simple finished.

1.5 Cotton Wood Pulp

Wood pulp is a cellulose which is used as the core of the diaper to absorb liquids. It gives good absorbing capacity to the diaper. The capacity of normal wood pulp is around 10 cc of water per gram of pulp when the diaper is not under pressure, but when subjected to 5 KPa of pressure its capacity becomes less than 2cc, hence super absorbent polymer is also needed to hold the liquids under pressure.

2. EXPERIMENTAL DETAILS

2.1 Materials

For this disposable diaper manufacturing, the following basic materials are necessary for the fulfilment of functional property are taken for the study

i) Viscose Nonwoven
ii) Cotton Wood pulp
iii) Super absorbent Polymers (SAP) – Sodium polyacrylate
iv) Elastic Thread

2.2 Methodology

The following methodology is followed

2.2.1 Selection of Viscose Nonwoven

Nonwovens are developed to impart special properties to product. The non wovens are more advantageous than conventional textiles. Considering the constantly growing environmental awareness, the possible decomposition of nonwovens gains more.

The product advantages are similar to those of cotton: skin tolerance, physiological safety, decomposable, good moisture absorbency and simple finished.

The absorption capacity of pulp is around 10 cc of water per gram of pulp when the diaper is in "free swell" but less than 2 cc when subjected to 5KPa of pressure so we selected and sourced the viscose non-woven material made with 45gsm.

2.2.2 Water Repellent Finish

Water repellent finishes are a type of barrier, which function to lower the critical surface tension of the fiber surface. To be most effective it is important that the fibers are treated evenly on all surfaces to give the lowest critical surface tension possible. Water repellency can be achieved with a variety of chemical finishes such as waxes, wax dispersions, melamine wax extenders, chrome complexes, silicones, and flourochemicals. The finishes require curing to develop the best repellency and are also prone to destabilizing with shear, heat or changes of pH or ionic strength.

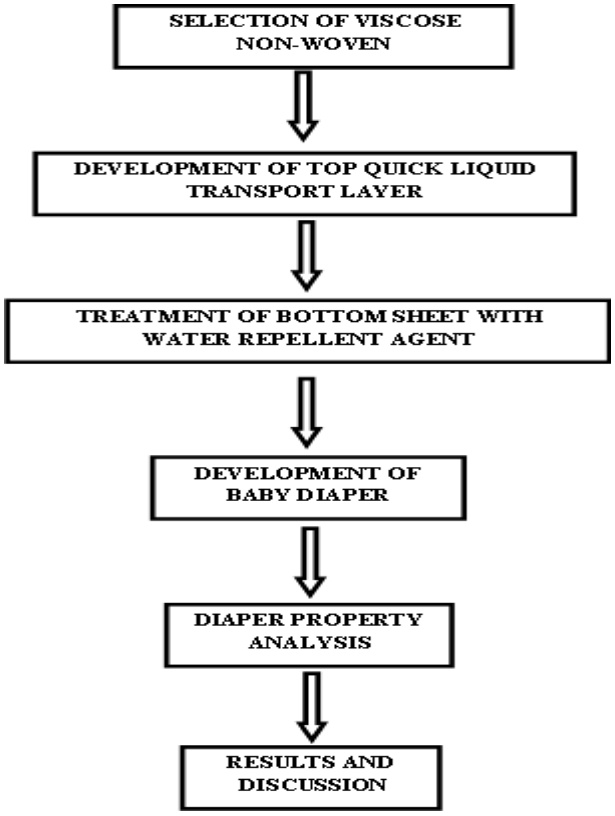

Fig. 2.1 Methodology of the work

2.2.2.1 Treatment of Viscose Non-Woven

- Chemical used - Super FX™ Repellan 655 (Avensa chemicals ltd)
- Water Soluble Co Polymer
- Method – PAD DRY CURE
- DRYING – 130℃
- PH - 5-5.5
- Ionic Nature - Weakly Cationic

The above recipe is used to treat the selected viscose non-woven to get water repellence effect.

2.2.3 Development of Baby Diaper

The bio degradable baby diaper is prepared manually. The well powdered wood pulp is mixed with super absorbent polymer with the respective ratio. The middle layer is prepared with the pack like structure which is filled with the mixture.

2.2.3.1 Preparation of Baby Diapers

- The well grinded wood pulp of 20 grams is mixed with super absorbent polymer of 4 grams.
- The prepared top layer is stitched with the bottom layer leaving space to set the absorbent core.
- The single needle lock stitch has been used to seam the two layers.
- Bobbin elastic thread is used in the side seam of the diaper to get expandable nature, so that it will collect the fluid without leakage.
- The comfort to the wearer is improved with the usage of the elastic thread.

Fig. 2.2 Prepared acquisition and distribution layer

Fig. 2.3 Side view of "U" shaped structure

The developed baby diaper looks like "U" shaped structure which fits to the body of the baby better.

Fig. 2.4 The developed diaper

The ADL is prepared as shown below

2.2.4 Diaper Testing

Diapers have been tested through processing laboratory for the following parameters.

1. Liquid strike through
2. Total Absorption capacity
3. Wetback
4. Absorption area
5. Retention capacity
6. SAP absorption capacity

2.2.4.1 Liquid Strike Through

The test carried out in EDANA 150.5 standard. A drop of test solution is allowed to fall on the sample and the time taken for the solution to transport from the upper layer of the diaper to the inner layers of the sample.

This is measured by observing the drop closely such that dull wet spot is seen on the wet area of the sample. All the samples were conditioned for 24 hours before the tests.

2.2.4.2 Absorption Capacity

This method determines the total absorptive capacity of the diaper. This is assessed by immersing the product into a known test solution for a standard time and measuring the difference in weight. All the samples were conditioned for 24 hours before the tests.

The absorption capacity measurements were performed using the TEFO disc method on 80-mm diameter discs of diaper cut from the crotch region , which were compressed under a pressure of 100 Pa and 150 ml of 0.9% NaCl solution applied at 7 ml/s via a hole in the centre of the compression weight.

After a delay of ten minutes, the weight of fluid retained by the sample is calculated by subtracting the weight of fluid

not absorbed from the weight of the original 150 ml, and recording the result as the absorption capacity.

2.2.4.3 Wetback

This method determines the rewet under load and acquisition time under load for disposable baby diapers. This method is to assess the time required for the diaper to fully absorb a known amount of test fluid under load.

The load is applied to stimulate the baby weight. In addition rewetting of diaper is also measured. It shows the ability of the diaper to transport the liquid on to the surface of diaper under load. All the samples were conditioned for 24 hours before the tests.

This method involves running 25 ml of 1% NaCl solution into the crotch region of a diaper and, as soon as the fluid has been absorbed, applying a disc of filter paper (110 mm diameter) with a mass on top for one minute. The weight is rectangular (115 mm × 60 mm) with a mass of 1.05 kg (pressure = 1.49kPa).

The weight of fluid absorbed by the filter paper was recorded as the wetback weight.

2.2.4.4 Absorption Area

This method determines the completion of the wetback test on the diaper. This is measured by the maximum width and maximum length of the wet area of the diaper. All the samples were conditioned for 24 hours before the tests.

The absorption area test consisted of measuring the maximum width and maximum length of the wet area of the diaper on completion of the wetback test, and recording the product of these two as an estimate of the absorption area.

2.2.4.5 Retention Capacity

This method determines the completion of the absorption capacity test of the diaper. This is assessed by an additional weight is applied on the diaper. After the delay of five minutes, the weight of fluid retained by the sample is calculated.

All the samples were conditioned for 24 hours before the tests.
After absorption capacity tested on sample next, an additional weight is applied to the disc, giving a pressure of 3kPa, and after a further delay of five minutes, the weight of fluid retained by the sample is calculated and recorded as the retention capacity.

2.2.4.6 SAP Absorption Capacity

Super absorbent polymer absorbency has been found out by the following procedure as given in United States Patent (5,419,955), This method determines the total absorptive capacity of the SAP. This is assessed by immersing the product into a known test solution for a standard time and measuring the difference in weight.

1. Cut Nylon cloth into 6 x12 cm strips and seal two of the three open sides so the inside edges of the seals are about 3 -5 mm from the edge of the bag. Predetermine the setting required on the sealer.
2. Accurately weigh 0.500 g(W1) of SAP and place into the Nylon bag and seal the bag.
3. Prepare five nylon bags containing SAP and two blanks (empty nylon bag) for each sample of SAP
4. Fill plastic container with 0.9% saline or blood to 1.5 inches in depth
5. Hold the nylon bag containing the SAP horizontally and distribute the SAP throughout the nylon bag.
6. Lay nylon bag on the surface of the saline. Allow nylon bag to wet out for one minute before submerging
7. After a soaking period of 60 minutes, remove bag, Hang on line to drip for 15 minutes
8. After 15 minutes drip time, weigh the blanks (W2) and each bag containing SAP (W3) and record weights

$$\text{Total Absorbency (g/g)} = \frac{[\text{Wet Wt. (W3)}–\text{B Wt. (W2)}] - [\text{Net Dry Wt. (W1)}]}{\text{Net Dry Wt. (W1)}}$$

3. RESULTS AND DISCUSSION

3.1 Diaper Test Results

Baby diapers have been assessed for their absorption performance. The primary purpose of disposable diapers is to absorb the urine dispersed quickly and retain the absorbed fluid without rewetting of the surface.

In order to determine the above performance, four parameters were chosen and they are
1. Liquid strike through
2. Total absorption capacity
3. Wetback
4. Retention capacity

Table 4.1 Diaper test results

TEST	UNIT	BABY DIAPER SAMPLE		
		1	2	3
Weight of diaper	G	52.32	52.75	51.95
Size of diaper	cm x cm	21x46	21x46	21x46
Average Thickness	Mm	9.1	9.0	9.3
Liquid strike Through	S	4.2	4.8	3.9
Absorption Capacity	g/g	3.8	3.6	3.7

Wet Back	g/g	1.03	1.06	1.08
Absorption Area	cm x cm	7.8x11.4	7.9x11.2	7.7x11.1
Retention Capacity	g/g	1.02	1.03	1.01

3.2 Liquid Strike Through

This is the taken by the sample to absorb the drop of liquid fed on the surface of the diaper, which is in slanting position. Three samples were tested and time taken by the samples are 4.2, 4.8, and 3.9 seconds. This shows that the diaper having better absorbing capacity with respect to the time. An average time of 4.3 seconds are taken to absorb the liquid.

3.3 Absorption Capacity

The sample is made with 80 mm circumference disk, which is used to cut the crotch part of the diaper. The specimen is then loaded with 100 Pa. Then 150 ml of liquid is poured over the hole made on the centre part of specimen, the total liquid absorbed by the diaper is noted. This is measured by weighing the diaper before absorption and after absorption. This shows the ratio of liquid absorbed to not absorbed almost 3.8(g/g) of liquid is absorbed by sample one and 3.6(g/g) of liquid is by sample two and 3.7(g/g) by sample three. The whole three samples show better results.

3.4 Wet Back

This test is carried out to test whether the product leaks the liquid during the load applied over the diaper, A 1kpa of weight is loaded over the liquid absorbed diaper, during the loading filter paper is placed over the diaper. The weight of the filter paper before and after loaded is measured. The wet back is 1.03(g/g) of the sample 1, 1.06(g/g) of the sample 2 and 1.08(g/g) wet back in sample 3. This shows better liquid locking capacity in the diaper.

3.5 Retention Capacity

A 3kpa of load is applied over the 80mm circumference crotch area in fluid absorbed diaper. The weight of the diaper before loading and after loading is measured. The ratio of both weights given retention capacity. The percentile of retention in sample 1 are 1.02(g/g), sample 2are 1.03(g/g) and sample 3 are 1.01(g/g). This result shows that the product having good retention capacity.

4. CONCLUSIONS

In this project an attempt is made to produce a bio degradable baby diaper by eliminating the polypropylene non-woven with specially finished bio degradable viscose non woven so that the pollution will be reduced and expecting the product will fulfil the functional properties of the diaper.

From the results it was found that the absorption capacity is (3.8 g/g) very good. The primary need of the diaper is fulfilled. In liquid strike through test the sample takes 4.2 seconds to transport the liquid, this result is somewhat lesser than the other commercial products.

The wetback results show that very less value (1.03 g/g).Retention capacity of diaper (3kpa) under load is only 3.8 g/g and less chance of diaper detriment.

Hence it is concluded that the developed bio degradable diapers satisfies the functional properties. These diapers are more environments friendly.

REFERENCES

[1] Hirko Yokura & Masko Niwa (2007), Changes in disposable diaper properties caused by wetting,Textile Research Journal, pp 135.
[2] Janniger C.K, Thomas I (1993), Diaper dermatitis: an approach to prevent Employing effective diaper care, paediatric dermatology 52, pp153-155
[3] Kyung Hwa Hong Boo Changkim & Tae Jin Kang (2005), Effect of abrasion and absorbed water on the handle of nonwoven for disposable diaper, Textile Research Journal 75, pp 544.
[4] 'Cotton for diapers', (2001) Textile Asia, Vol. 32/6, pp 68.
[5] Flory, Principles of Polymer Chemistry, Cornell U. Press, 1953.
[6] Novel elastic baby nappy fastener systems (1996),International Textile Bulletin, Nonwoven/Industrial Textiles 42/4, pp 32-34.
[7] Wet comfort of small disposable incontinence pads, (1998)Textile Research Journal, 68 (7), pp 479-488
[8] Yokur H., and Niva M (1997), objective hand evaluation of nonwoven used for nappies, 9(3), 207-213.
[9] Buchholz and Graham, Modern Superabsorbent Polymer Technology, John Wiley & Sons, 1998.
[10] Absorbent Polymers, AMCOL International, 1996
[11] www.nonwovens-report.com
[12] www.disposablediaper.net
[13] www.babynaturale.com
[14] www.mothering.com
[15] www.freepatentsonline.com