International Journal of Advanced Research in Engineering and Applied Sciences ISSN: 2278-6252

NONWOVEN FOR ARTIFICIAL LEATHER

Kinge A. P.*

Landage S.M.*

Wasif A.I.*

Abstract: *Speciality coated fabrics combine the beneficial properties of a textile and a polymer, the textile component providing tensile strength, tearing strength, and elongation control, and the coating offering protection against the environment to which the fabric is subjected. Coated textiles have established themselves as one of the important products in the textile global market. There are various methods of application of coating. All these coating methods are developed based on the specific end use of the final product, its cost etc. Micro-level modification of the end product is actually governed by choosing proper coating technique. Coating is important method in the production of artificial leather. Artificial leather looks and feels like natural leather, but is made on a fabric base rather than from animal skin. The fabric, due to its leather-like finish, acts as a substitute for leather and is fast replacing it in many industries such as footwear, upholstery, and automobile.*

Keywords: *Artificial leather, Coating, Nonwovens,Textiles*

*D. K. T. E. Society's, Textile & Engineering Institute, Ichalkaranji, India

1. INTRODUCTION

The coating is important technique for adding value to technical textiles. Coatings enhances and extend the range of functional performance properties of textile, and the use of these techniques is increasing rapidly as the applications for technical textiles are become as vast. Cheaper or loose fabric structures may be coated to provide higher added value to end-users and to get profit margins for manufacturers [1]. The success in textile coating depends upon the application method used for coating. The parameters which are generally taken into consideration are machine productivity , flexibility in terms of production speed , the versatility of coating methods as well as proper process monitoring, process control and automation [2].

2. COATING TECHNOLOGY

The coating is a process in which a polymeric layer is applied directly to one or both surfaces of the fabric. The polymer coating must adhere to the textile and a blade or similar aperture controls the thickness of the viscous polymer. The coated fabric is heated and the polymer is cured. Where a thick coating is required this may be built up by applying successive coating layers, layer on layer. Interlayer adhesion must therefore be high. Finally, a thin top layer may be applied for aesthetic or technical enhancement of the coating [3]. Depending upon the end-use requirements, heavy-duty technical textile coatings may be applied at high weight, while other end-uses for high- technology apparel may require coating weights very low. The chemical formulation of the coating, the coating thickness and weight, the number of layers, the form of the technical textile and the nature of any pre-treatment (such as to stabilize the fabric dimensions prior to coating) are of great importance. Traditionally, coating has been applied to woven technical textiles, but increasingly warp-knitted, raschel, weft-knitted and nonwoven fabrics must be coated on the same line. The machinery and method of application of the coating formulation must be versatile, minimize tensions on the fabric that may lead to distortion or stretch, and eliminate problems in knitted fabrics such as curling selvedges. Scroll opening equipment, weft straightening, tension bars and selvedge uncurlers may thus be fitted. The lighter the weight of the technical textile, the more prone will be the base fabric for coating to weft line distortion and selvedge curling [4].

2.1 Chemistry of coated textiles

Coatings used in the production of technical textiles are largely limited to those products that can be produced in the form of a viscous liquid, which can be spread on the surface of the substrate.

This process is followed by a drying or curing process, which hardens the coating so that a non-blocking product is produced. Thus the coatings for these products are limited to linear polymers, which can be coated as a polymer melt or solution and on cooling form a solid film or form solid film by evaporation of solvent. There are some types of coatings that can be applied in the liquid form and then chemically cross linked to form a solid film. The coatings used in technical textiles are all thermoplastic polymers, which are long chain linear molecules, some of which have the ability to crosslink. The properties of these polymeric materials directly influence the durability and performance of the end product [5].

2.2 Applications of Coatings

- Coverings or as a barrier for protection, separation or containment.
- For appearance modification for decorative or functional purposes.
- Improving dimensional stability, controlling stretch, preventing edges from fraying or curling.
- For control of porosity for filtration.
- As a matrix for holding some functional material, chemical, pigment or other agent.
- As a processing aid, for example in '*in situ*' moulding, vacuum technique or thermo-moulding.
- Combining the specialized properties of polymers with the flexibility, strength, drapeability and covering power of a fabric [6].

2.3 Special Features of Coating

i. Coated fabrics are normally sold at a lower price than laminated fabrics.

ii. By varying the number, the thickness and the type of coated layers, different performance level could be achieved providing high flexibility.

iii. Coated fabrics have a better handle than (lightweight) laminated fabrics.

iv. The coating gives better drape [7].

2.4 Choice of substrates

Popular textile substrates used for coating are polyester, cotton, viscose, polypropylene and also blended fabrics made out of these fibres. Characteristics such as tear strength, tensile strength, dimensional stability, and flexibility are heavily influenced by the choice of the textile fabric and the way in which it is constructed. The strength and weight of a fabric depend on the construction method, the size and weight of the yarn, and the number of yarns per unit area in the fabric.

Woven fabrics are very strong and are resistant to elongation. Knitted substrates allow the fabric to be stretched. Stretching allows for tear resistance, but the coating must be able to stretch and flex along with the fabric. Non-woven fabrics are less expensive to produce but are not strong unless they are coated. Knitted and non-woven base fabrics give a very soft feel to the final coated fabrics [8].

3. MATERIALS USED FOR COATING

3.1 Polymers used for coating

These polymers generally applied on the fabrics as a solution or dispersion in water or as a solvent in an uncrossed link. Cross linking of polymer can be affected after the deposition on the fabric, which improves the durability of the resultant coating to abrasion and its resistance to water and solvent. The degree of cross linking is influenced by the nature of the polymer itself, the type and concentration of cross linking agent etc.

- **Butyl rubber (isobutene-isoprene copolymers):** Good resistance to heat ageing, UV light, general chemical attack, oxidation, ozone. Low permeability to gases. Serviceable temperature range -50 to +125˚C. Difficult to seam. Low to moderate cost.
- **Hypalon (chlorosulfonated polyethylene)**: Similar to neoprene. Moderate cost. Relatively poor low temperature resistance.
- **Natural rubber (polyisoprene)**: Good tensile strength and flexibility. Tear strength and abrasion resistance cab be improved by reinforcing fillers (e.g., carbon black). Unaffected by dilute acids, alkalis, and water. Insoluble in all organic liquids when vulcanized. Highly swollen by hydrocarbons and chlorinated solvents. Susceptible to oxidation; less so to ozone. Contains 2–4% of protein, which enhances susceptibility

to biodegradation. Moderate cost. Serviceable temperature range-55 to+70˚C. Sewn or glued seams required.

- **Neoprene (polychloroprene)**: Good mechanical properties. Inferior low temperature properties to those of natural rubber. Swollen by chlorinated and aromatic solvents; resistant to most chemicals and organic liquids. Excellent weathering properties. The upper temperature limits about 120˚C. Low to moderate cost.
- **Nitrile rubber (acrylonitrile-butadiene copolymers)**: Similar to natural rubber except for improved resistance to swelling in organic liquids and improved resistance to light, oxidative aging and heat. Moderate cost.
- **PTFE (polytetrafluoroethylene)**: Exceptional resistance to chemicals, micro-organisms, heat, solvents, oxidation and weathering. Difficult to seam. Excellent electrical and non-stick properties. Serviceable temperature range -70 to +250˚C. Very high cost.
- **PU (polyurethanes)**: Variable compositions; properties range from inflexible, hard plastics to elastic, soft coatings. Some grades have good resistance to fuels and oils. Plasticizers not required. Excellent strength and resistance to tearing and abrasion. Moderate to high cost. Thermoplastic grades available.
- **PVC (polyvinyl chloride)**: naturally rigid material; requires careful formulating to produce durable, flexible coatings. Good chemical properties, although solvents tend to extract plasticizers and stiffen the polymer. High plasticizer content (up to 40% by weight). Good weathering properties and flame resistance. Unless special plasticizers are used, poor low temperature performance. Thermoplastic and can therefore be seamed by hot air, ultrasonic welding techniques and radio-frequency. Low cost.
- **PVDC (polyvinylidene chloride)**: Low permeability to gases. Similar to PVC. Low to moderate cost. Better flame resistance.
- **SBR (styrene butadiene rubber)**: Similar to natural rubber except for improved flex and abrasion resistance. Resistant to biodegradation. Inferior tear resistance and serviceable temperature range. Moderate cost [9,10].

3.2 Fabrics used for coating

The different fibres used in the coating as base material are

Table 1: Fibres used for Coating

Fibre	Advantages	Disadvantages
Cotton	• No bonding agent • Low thermal shrinkage	• Low shrinkage per weight ratio • Absorb moisture • Vulnerable to mildew rotting, insects
Polyester	• Strong with HT, LOW shrinkage • Relatively inexpensive	• Low moisture absorbency • Limited resilience.
Nylon	• Resistant to mildew, rotting, and insects. • Strong with HT variations available • Good elasticity and resilience • High abrasion resistance • Resistance to mildew rotting and insect	• UV resistance low unless protected • Fabrics may sag due to moisture absorption • Relatively expensive compared to PET
Polyethylene, Polypropylene	• Good thermal absorbency • Inexpensive • Chemically inert	• Low melting point especially PE • Adhesive difficult to some substances
Aramid	• Very high tensile strength • Good FR properties	• Degraded by UV or sun

3.3 Fabric construction

3.3.1 Woven Fabrics

Most commonly used are the woven fabrics. Only a relatively very small number of fabric constructions are employed for polymer coating, i.e. plain weave, twill, and basket constructions. The plain weave is by far stronger because it has interlacing of the fibres, it is used most often. Twill weaving produces distinct surface appearances and used for effects [11].

3.3.2 Knitted Fabrics

Knitted fabrics are used where moderate strength and elongation are required. Where high elongation is required, nylon is used. Knit are predominantly circular jersey, however, patterned knit are becoming more and more prevalent when a polymeric coating is put on a knit fabric. The strength properties are somewhat less than that of woven fabric.

3.3.3 Non-wovens

Nonwovens, with some exceptions, generally have limited tear strength, poor handle and drape and are not used for apparel, apart from disposable protective clothing. Many can not generally be directly coated because of their rough surface, and because they are not strong enough to be tensioned on the coating machine [12].

4. POLYMER COATING ON THE TEXTILE MATERIAL TO PRODUCE THE ARTIFICIAL LEATHER

Polymer coating on the textile material provides new properties to the fabric. Polymer coated textile materials have a wide range of application, from the textile industry to technical textiles. The advantage of this kind of textiles in the clothing industry is their water impermeability, while on the other hand they have air and water vapor permeability, resulting in good properties of concurrent protection and comfort. Depending on the use, non-woven, woven or knitted fabrics are used as coating substrate. As far as their properties are concerned, new man-made fibres or materials can be similar to natural or even they can surpass the properties of natural fibres, resulting in an increasing application for coated materials.

As the substrate for coated materials synthetic materials are frequently used due to their relatively high strength and good abrasion resistance. Artificial materials possessing high elasticity, airiness and appropriate strength are used as the substrate for coated materials. They are mostly used for protection and sports clothing for children and adults [13].

4.1 What is natural leather?

Leather is a material obtained from tanning the skins of animals such as cattle, goats, pigs, crocodiles and horses [14].

Advantages of natural leather

- Durable
- Natural Product
- Breathable
- Partly waterproof
- Resistance to Fungal Attacks
- Resistant to Dry Abrasion
- Resistant to Fire
- Lint and Dust Free
- Resistant to Dust Mites

Limitations of natural leather

- Expensive

- High cost
- Bulky in weight
- Breaks down easily
- Obtained from animals

4.2 What is artificial leather?

Artificial leather is a leather substitute consisting of natural or synthetic fibre cloth coated with plasticized polyvinyl chloride (PVC) or polyurethane (PUR) [15]. These coatings can be dense or foamed depending on the application. Usually it gives the appearance of natural leather. Artificial leather is used for shoes, bags and tops of convertible cars [16].

4.3 Artificial leather composed of

i. A fibrous substrate, non-woven, or woven or knitted fabric
ii. A urethane polymer layer containing finely divided inorganic particles
iii. A thinner urethane polymer layer consisting of at least about 80% by weight of polyurethane
iv. A coating layer consisting of at least about 80% by weight of polyurethane [17, 18].

Requirements for artificial leather

- Maintain their form
- Porosity
- Durable
- Good mechanical properties
- Good elasticity
- Absorb steam
- Be soft with good hand
- Easily cut, sewn and glued together
- Uniform properties in all directions
- Good stitch tear resistance

Advantages of artificial leather

- Resistant to colour fading
- Crease free
- Washable

- Easy to care
- Odourless
- Uniform surface
- Low Price

4.4 Specifications for Manufacturing of Artificial Leather

Artificial leather comprising a fibrous substrate having a thickness of about 0.3 mm to 3.0 mm. The fibrous substrate comprising a sheet of ultra fine fibre bundles and polymer impregnated therein, in which the denier of each fibre is about 0.01 to 1.0 denier and coating layers (III), (II) and (I) adhered in that order to the surface of said substrate, with the coating layer (III) immediately on the surface of the substrate. Coating layer (I) is prepared by a dry-coagulating method. Coating layer (I) is coated on coating layer (II) and dried to remove solvent. The satisfactory range of thickness of the coating layer (I) is about 0.001 mm to 0.1 mm, more satisfactory about 0.003 mm to 0.05 mm, and the most satisfactory about 0.005 mm to 0.02 mm. In the case of a thickness of the coating layer (I) larger than 0.3 mm, the appearance of creases and the feeling and appearance of the artificial leather obtained are not those of natural leather (the appearance of creases becomes too small), and water vapor permeability and flexibility resistance become worse, and the touch of the artificial leather becomes hard [19, 20, 21].

4.5 Types of Artificial leathers

a) Poromeric Imitation Leather

Sometimes referred to as poromerics, poromeric imitation leathers are a group of artificial ‘breathable’ leather substitutes made from a plastic coating (usually a polyurethane) on a fibrous base layer (typically a polyester) [22]. The term poromeric was coined as a derivative of the terms micro porous and polymeric. Its major advantages over natural leather are its durability and its high gloss finish which can be easily cleaned with a damp cloth. Its disadvantages are its stiffness which can not be lessen of during wearing and its relative lack of breathability [23].

b) Koskin

Koskin is an artificial leather material commonly found in computer laptop cases. It is commonly used in Hewlett-Packard, Targus and Belkin laptop cases, CD wallets, and other consumer goods [24]. It is made to look and feel like authentic leather. In Swedish, Koskin means cow's skin, often causing much confusion for consumers [25].

c) Leatherette

Leatherette is a form of artificial leather, usually made by covering a fabric base with plastic. The fabric can be made of a natural or artificial fibre which is then covered with a soft PVC layer [26]. A disadvantage of plastic "leatherette" is that it is not porous and does not allow air to pass through it, thus sweat can accumulate if it is used for clothing, car seat coverings, etc. However, one of its primary advantages, especially in cars, is that it requires little maintenance in comparison to leather and not crack or fade as easily [27].

d) Vegan leather

Vegan Leather is an artificial alternative to traditional leather. It may be chosen for ethical reasons or as a designed material which may have different properties but a similar look to the natural material [28].

5. PRODUCTION PROCESS OF ARTIFICIAL LEATHER:

Artificial leather can be made from several processes. Some of the common ones include direct coating process, transfer coating process, and wet process.

5.1 Direct coating process

This was the original technology used to manufacture artificial cloth. In this process the plastisol was directly coated to a woven fabric before passing through the oven and then embossed. However, the end product made from this process had limited use in industries such as the bag and luggage industry [29].

5.2 Transfer coating process

In this process the coating is done on a release paper and then the film is released and laminated onto the fabric, usually knitted fabric. The end product from this process can be used in several industries such as upholstery, shoes, bags, etc [30].

5.3 Wet process or coagulation

This process is used for producing PU cloth. The fabric is dipped into a bath of PU and the PU is then impregnated into the fabric. Compared to PVC, PU leather cloth is more flexible with a higher tensile, tearing, and bursting strength. Due to this, PU leather cloth has an advantage when used in making products with high stress tolerance like shoes and luggage bags. Another difference between PU and PVC leather cloth is that the former is washable, can be dry-cleaned, and allows some air to flow through. On the other hand, PVC leather cloth does not breathe and cannot be dry-cleaned, because that can make it stiff. Split leather is also made using this process. For the fabric coating different processes are used such as calendar coating, solution coating dispersion coating. Dispersion coating has been described as the most appropriate technology [31].

6. MACHINERY FOR ARTIFICIAL LEATHER

1. Coating line
2. Foaming station
3. PU artificial leather wet production line
4. PU, PVC artificial leather dry production line

7. ARTIFICIAL LEATHER PRODUCTS IN DEMAND

7. 1. Artificial Leather bags

The artificial leather bag can easily be designed in such a way that it withstands today's active lifestyle. They are suitable for corporate, formal & casual usage that comes with the unique combination of large interior and exterior compartment, which can be used to carry bulky as well as heavy goods from one place to another. Such kinds of accessories can be made in various sizes and its design changes according to the fashion thus artificial leather bags are the first preference of young generation. These bags are made from superior quality artificial leather and are highly durable. They are also strong enough to carry large sports equipment and exhibit different patterns and colours to gain innumerable buyer's attention. Wide ranges of artificial leather bags available in the textile market include ladies handbags & purse, artificial leather laptop bags, leather travel bag, large artificial leather handbags, etc [32].

Figure 1: Artificial leather bag

7. 2. Home Furnishings & Upholstery Fabrics

With increased use of artificial leather in various aspects, it is also widely used in the furniture industry, especially for sofas. Sofa leather products can be divided into two categories according to their lifespan of ordinary sofa leather and endurable (3~6 years) sofa leather. Sofa leather products developed are favoured by customers for their unique features [33].

Figure 2: Home Furnishings & Upholstery Fabrics

- Good anti-abrasion property: By use of resin of high solidity for furniture leather with excellent features of anti-scraping and anti-abrasion.
- Anti-hydrolyzation: As sofas are furniture that have constant contact with vapor in the atmosphere, sofa leather assures lifespan of 3~6 years with good anti-hydrolyzation.
- Anti-aging: Sofa leather always exposes in the air with long time contact with ultraviolet radiation, sulphur dioxide, nitrogen dioxide, etc. Therefore, sofa leather goes through a treatment process of anti ultraviolet radiation, anti sulfuration, anti oxidation, etc. so as to extend its lifespan.
- Excellent environmental property: As the material that popularly used in sofa making PVC is commonly known as harmful to human health, certainly PVC sofa leathers will be replaced by environmental (harmless) materials such as PU sofa leathers.
- Variety of designs and colours with good hand feel: entrepreneur can develop different designs and colours according to customer's requirements.

7.3. Jackets, Garments

Leather, a material made from tanned animal hides, has been used as clothing since the earliest days of human existence. Prehistoric people wrapped animal skins around their bodies for warmth and to absorb the magical powers that they believed the skins imparted to them. Phoenician sailors often brought brightly embroidered leather garments from Babylonia to the countries they visited.

Figure 3: Jackets, Garments

As with the fur industry, the leather industry has been the target of some animal rights groups who denounce the killing of animals for human benefit, particularly to create "luxury" items. In an effort to address these concerns, now clothing manufacturers have increased production of artificial leather [34].

7.4. Shoe upper, Shoe Linings, Chappals etc.

Artificial leather shoe, comprising: a shoe upper and a shoe sole; wherein shoe upper comprises, in order:

(A) A substrate layer having an inner surface and at least an outer surface and comprising: an entangled non-woven first fabric comprising ultra fine fibres having a fineness of not more than 0.01 decitex; and a first elastomeric polymer impregnated in said first fabric;

(B) An adhesive layer; and

(C) A substrate layer, comprising: an entangled non-woven second fabric comprising fibres having a fineness of not less than 0.05 decitex; and a second elastomeric polymer impregnated with second fabric; wherein the outer surface of substrate layer [35].

Figure 4: Shoe upper, Shoe Linings, Chappals etc.

7.5. Accessories (Photo Album Covers, Jewellery case cover, spectacle cover, cell phone cover etc.)

7.6. Purses & wallets,

7.7. Car Seat cover fabric

7.8. Automotive Decorations

7.9. Commercial Vehicle interiors [35].

CONCLUSION

Since coating has a vast application area in almost every field of technical textiles, demand for coating is increasing at a great pace both in India as well as globally. It has been proved that coating technology has been transformed into an extensive field of materials research. Today's industry demands additional requirements and functionalities from coatings, in addition to their basic protective and decorative values. Today, many objects that we come across in our daily lives, including the house in which we live and the materials we use (e.g., toothbrushes, pots and pans, refrigerators, televisions, computers, cars, furniture) all come under the "umbrella" of coated materials. Likewise, fields such as military applications – for example, vehicles, artilleries and invisible radars – and aerospace products such as aircraft, satellites and solar panels all involve the widespread use of coated materials. In today's competitive era coating products having vast applications in the field of protection and decoration and so it has become need today.

REFERENCES

1. Singha K., *A Review on Coating and Lamination in Textiles: Processes and Applications*, American Journal of Polymer Science, Vol. 2, March 2012, P 39-49.
2. Anon,www.indiantextilejournal.com
3. Shekar R. Indu., Kasturiya N.,Hans Raj, Sen A. K., Bajpai U., *Studies On PVC Coated Cotton Fabric*, Man-Made Textiles In India, Vol. XLII, June 1999, P 215-220.
4. Sarkar. R., Gurudatta K., Purushottam D., *Coated Textile As Thermal Insulators*, Man-Made Textiles In India, Vol. XLIII, No.7, July 2000, P 279-285.
5. Hall E. M., *Coating of Technical Textiles*, New Cloth Market, Jan-April 2010, P 42-51.
6. Mccurry J. W. *Flexibility Is Key To Growth For Precision Custom Coatings,* Technical Textile Technology, April 2006.

7. Kusumgar Y. K., Talukdar M. K., *Application of Coated Textiles-An Opportunity for Indian Textile Industry*, Journal Of Textile Association, Vol. 60 , March-April 2000, P 275-279.
8. Wilkinson C. L., *A Review of Industrial Coated Fabric Substrates*, Journal of Industrial Textiles, Vol.26, June 1996, P 45-62.
9. Naik S. R., Rakesh., Chauan S., *Chemicals for Coating, Lamination and Their Formulations*, Indian Textile Journal, Nov.2008, P 144-152.
10. Rekha V. D., *Breathable Coatings*, Man-Made Textiles in India, Vol. XLII, Feb. 1999, P 67-70.
11. Teli M. D., Sheikh J., *Chemicals Used For Coating and Lamination,* Mantra Textile Magazine, Vol. 05, Feb. 2010, P 1-5.
12. Venkatesan H., Gowrishankar V. N., *Coated and Laminated Textile Materials and Process*. http://www.fibre2fashion.com
13. Kovacevic S., Ujevic D., Brnada S., *Coated textile materials* http://www.intechopen.com/books/woven-fabric-engineering/coated-textile
14. Anon, *Artificial Leather, Real comfort*, *Science Tech Entrepreneur*, June 2000.
http://www.jyxtplastic.com/html-news/Artificial-leather-&Real
15. Saurabh., Jahan S., *Artificial Leather- An Eco-friendly Alternative Textile Material for Leather,* China Textile Science, 3rd 2011.
16. Hans H., *Non-woven Fabrics for Artificial Leather*, Journal of Textile Association, Vol. 59, Sept-Oct 1998, P 157-157.
17. Okazaki., *Artificial leather and method of preparation*, U. S. Pat. No. 3,908,060, Sept 1975, P 1-28.
18. Ujevic D., Kovacevic S., *Analysis Of Artificial Leather With The Textile Fabric On Backside And Chemical, Physical-Mechanical Properties Of Artificial Leather With Bonded Textile Fabric On Back Side,* Journal Of Textile And Apparel, Technology And Management, Vol. 6, Feb. 2009, P 1-9.
19. Chang S. H., Young W. K., *Preparation And Properties Polyurethane Leather Having Good Permeability To Moisture Vapor By Dry Process*, Polymer (Korea), Vol. 17, Sept. 1993, P 504-512.
20. Lilyquist M., Raleigh N. C., *Coating Composition for Nonwoven Fabrics*, U.S.Pat.No.3, 988, 343, Oct.26, 1976, P 1-4.
21. Wang C., Lin M., Feng C., Artificial *leather*, U. S. Pat. No. US2005/2005/0244654A1, Nov 2005, P 1-3.

22. Park J. W., Won Y. J., Kook S., Lee J. H., *Transfer and Mechanical Properties Of Polyurethane Film Treated By Ultrasonic Energy*, Textile Research Journal, Vol.75, May 2005, P 425-300.
23. Yoneda., Susmu K., *Artificial Leather Shoe and Artificial Leather Suited Therefore*, U.S.2001/0024709A1, Sept.27, 2001, P 1-12.
24. Tsang B., Dhingra R.C., *Performance of Polyurethane-Coated Silk Fabrics*, Asian Textile Journal, Vol.17, August 1996, P 44-45.
25. Kozlowski R., Mieleniak B., Fiedorow R., *Flammability And Flame Retardancy Of Leather*, Road vehicles ISO, 3795, 1989.
26. Chen S., Ding X., Honglei Y., *On the Anisotropic Tensile Behaviour of Flexible Polyvinyl Chloride-Coated Fabrics*, Textile Research Journal, Vol.77, June 2007, P 369-374.
27. Schulze H., Seibert G., *Process for Production of an Artificial Leather and Product*, U.S.Pat.No.3, 645, 775, Feb.29, 1972, P 1-6.
28. Adnan M., Sudha T., *A Study on the Properties of Natural and Synthetic Leathers Used For Apparels and Accessories*, Colourage, Vol.LVI, June 2009, P 83-90.
29. Roy D., Chen R., Callaghan P., *Study of Bond Strengths of Water-Borne Polyurethane (PU) Adhesives for Shoe-Soiling Materials*, Journal of Textile Institute, Vol.96, Jan. 2005, P 17-20.
30. Hanada K., Watanabe. Kimura., *Artificial Leather*, U. S. Pat. No. 2002/0041965A1, Apr.11, 2002, P 1-12.
31. Okada., *Artificial Leather and Processes for Production of It,* E.PPat.No.1867 779 B1.Feb.7, 2006, P 1-17.
32. Fukushima O., *Latest Progress of Man Made Leather*, Polymer (Korea), Vol.4, Sept.1980, P 386-391.
33. Takeyama N., Mimura M., *Nonwoven Fabrics and Artificial Leather*, U.S.Pat.No.6, 299,977B1, Oct.9, 2001, P 1-28.
34. Sommer E., Obernburg E., *The Production of a Micro porous Artificial Leather Coating*, U.S.Pat. No.3, 527, 653, Sept 1970, P 1-12.
35. Bedeschi., Edoardo., Vedrani. *Process for Manufacture of Synthetic Leather and Synthetic Leather Obtainable From Such a Process*, U. S. Pat. No. PCT/EP2006/002101, Sept 2006, P 1-12.