New Generation Application of Polypropylene Fibre

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Abstract In recent years, polypropylene (PP) is one of the most important and fastest growing polymers currently produced. And it is also a major synthetic material for textile and composite industry. A major virtue of polypropylene is its ability to be used in a wide range of fibrous forms. Fibrous forms of polypropylene include staple, bicomponent staple, monofilament, multifilament, slit film yarns, slit-fibrillated film yarns, nonwovens, composites for low velocity impact etc. Here in this article applications of polypropylene in the field of geotextiles, filtration, electrical, flame retardant, automobiles, disposable diapers, hospital/medical care, and protective clothing etc. Also here an attempt has been made to summerize the history and various application of polypropylene fibre.

Keywords: Polypropylene fibre, Ziggler-Natta catalyst, Metalocene catalyst, impact prperties, Filter, Nonwovens.

I. INTRODUCTION

Polypropylene is the first stereo regular polymer to have achieved industrial importance and it is presently the fastest growing fibre for technical end-uses where high tensile strength coupled with low-cost are essential features [1, 15]. The fibers from polypropylene were introduced to the textile arena in the 1950s and become an important member of the rapidly growing family of the synthetic fibers [1]. Today polypropylene enjoys fourth spot behind the big three fiber classes i.e. polyester, rayon and acrylics [1, 2].

The fiber can be dyed using conventional disperse dyes in a manner similar to that used for polyester fibers. The fibers feature a wide array of inherent benefits and properties including [14].

• light weight and comfort
• cottony softness
• easy care, easy wear
• moisture management
• durability
• breathability
• thermal insulation
• stain resista

Isotactic polypropylene (iPP) is apparently the major polymeric construction material of the future in view of its impressive growth figures of the past years. However, iPP as such has to be reinforced to meet the high demands on stiffness and strength in engineering applications and glass fibres are the major reinforcing elements used in these materials. Unfortunately, in view of recyclability, glass fibres are components, which still cause environmental problems, both in mechanical recycling and thermal recycling (incineration). Polypropylenes reinforced with polypropylene fibres may have the opportunity to overcome these problems. Such self-reinforced single-polymer composites have specific

economic and ecological advantages since, upon recycling, a polypropylene blend is obtained which can be re-used for PP-based applications.

Essential for this concept is that the PP fibres and matrices are optimised in structure, properties and processing performance. Beside recyclability the interest in the concept of singlepolymer composites is based upon the idea that interfacial bonding should improve if matrix and reinforcement are made from the same semi-crystalline polymer [43,44]. Next, other morphological features such as the so-called transcrystallisation of the matrix material onto fibre surfaces may be related to enhanced stress transfer capability alongthe fibre-matrix interface [45,46]. A possible reason for transcrystallisation is heterogeneous nucleation on fibre surfaces. Because of the good lattice match between iPP fibre and iPP matrix and the highly favourable energetics, an epitaxial nucleation seems to be favoured, as in the case of polyethylene fibre reinforced polyethylene composites [47,48], which initiates the formation of a transcrystalline layer. The idea of embedding high-modulus/high-strength polymeric fibres in thermoplastic matrices to enhance mechanical properties of the resulting composite is not new. However, in the case of high-modulus iPP fibres and iPP matrix such composites may present some specific features for industrial applications. The specific modulus and strength of highly drawn iPP fibres embedded in an iPP matrix may well be able to compete with standard glass-fibre reinforced polypropylene grades, whereas environmental advantages favour single-polymer composites. The aim of this research is the preparation of such polypropylene single-fibre reinforced polypropylene model composites is possible using a melt impregnation method based on constrained fibres.

II. PREPARATION OF POLYPROPYLENE

Initial attempts to polymerize polypropylene resulted in a polymer which was not crystalizable and demonstrate a low degree of polymerization and a low melting point; in short in essential requirement of a fiber forming polymer were missing in this polymer. The work of Zigler and Natta in the mid 1950s led to the preparation of crystalline polypropylene [1]. The key to their success lay in the discovery of a co-ordination catalyst system, now known as Zigler-Natta catalyst.

In the 1980s, interest was kindled in a new range of catalysts, the metalIocenes, following the discovery by Sinn and Karninsky [6] of a new catalyst system which was highly active in the polymerisation of polypropylene. Subsequently, Kaminsky and co-workers discovered a similar catalyst systém for the synthesis of isotactic PP. These catalysts are soluble. (Although soluble Ziegler-Natta catalysts had been prepared, they were found largely to catalyse the production of atactic polypropylene.) MetalIocenes are organometallic compounds based on Group *N* transition metals, such as titanium, zirconium and hafnium. Of these, zirconium is the most active, while titanocenes tend to be deactivated at higher temperatures. Metallocenes react

with methyl alum oxane (MAO), a co-catalyst, to form an active catalytic complex. MAO consists of oligomers, whose structure approximates to:
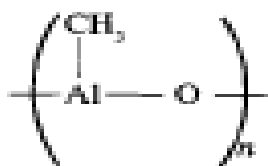

Figure-1 Structure of methyl alum oxane.

Where n= 10 to 30.

The mechanism underlying catalysis by metalIocenes has been discussed by Brintzinger *et al* [7]. The metal in the metallocene molecule is the active centre for polymerisation and is sandwiched between two [6] cyclopentadienyl (CP) ligands. In addition, two a-ligands, usually chlorine atoms, are also coordinated to the metal atom. However, molecules of simple metalIocenes are too flexible to confer sufficient rigidity to the catalytic complex, and catalytic activity is consequently low. The two CP rings are, therefore, also bridged through one or more carbon atoms or a silicon atom, to provide the rigidity required. The structure of a zirconocene can be represented as:
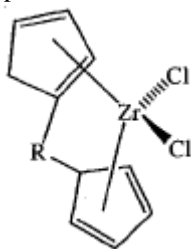

Figure-2 Structure of zirconocene

It should be noted that the two CP rings are not situated directly opposite one another. The CP rings remain attached to the metal atom during polymerisation, but the chlorine atoms leave the complex during fonnation of the active catalyst. Alkyl or aryl substituents may be present on the CP rings. Different substituents and different bridging entities alter the structural character of the CP ligand, the metalCP distance and the CP-metal-CP angle. There is thus considerable electronic and structural versatility in metallocene catalysts. The activity of the catalyst system is strongly influenced by the CP-metal-CP angle. A short bridge between the two rings reduces this angle, and catalytic activity is increased in consequence. A smaller angle is particularly important for propene polymerization [5]. The ratio of MAO to metallocene concentrations is also important, the ratio required for maximum catalytic activity varies among different metalIocenes. In addition, the molar mass of the polymer produced is dependent on the structure of the CP ligands. A methyl substituent in the 2-position of each CP ligand, for example, gives rise to polypropylene of much higher molar mass. As with Ziegler-Natta catalysis, the true catalyst site is the metal, with the growing polyolefm chain as a ligand, and there is a vacancy at the metal atom to allow co-ordination of the incoming monomer.

Metallocene catalyst systems are becoming increasingly important for the production of PP polymer . They are more specific and more active than Ziegler-Natta catalysts and can

be designed so that only chains of isotactic PP are produced. By contrast, isotactic grades of PP made using Ziegler-Natta catalysts contain small proportions of atactic PP, typically up to 5%. Moreover, metallocene grades of PP possess a narrower molar mass distribution, of dispersity 2.5 [6,7]. However, owing to small regio-irregularities in the polymer chains, where individual propene monomers have been inserted in a reverse manner, the melting points of commercial metallocene grades of PP are often about 15°C lower than PP grades produced using conventional Ziegler-Natta catalysts [4].

Fibres based on metallocene PP grades possess a number of advantages [4]. The more uniform distribution of PP chain length results in arheology more favourable for melt processing. Thus, finer fibres may be extruded to create spun-bonded nonwoven fabrics with more cloth-like qualities [8,9]. The greater control of fibre processing also leads ultimately to fibres of improved tensile strength. In addition, metallocene catalysts allow the incorporation of special comonomers into PP chains, thus permitting the modification of the structure and properties of PP fibres. These comonomers include flame-retardant units, chromophores, and compounds that, by increasing inter molecular attraction between the PP chains, can improve fibre residence [9]. Polymers of low dispersity can, in principle, be synthesised by 'living' polymerisation, [12] in which there is virtually no chain termination or transfer. A living polymerisation of propene has recently been reported, [13] giving rise to PP of dispersities as low as 1.2 $(M_w$ -42 000 g mol^{-1}). The stereo specific polymer with all the methyl groups in regular order is called isotactic polypropylene [1, 2]. It was crystalizable and melting point is 160^0c -176^0c and could be converted in to fibers capable of retaining molecular orientation at normal usage temperature [2].

Polypropylene can be pigmented or can be dyed by mass drying process [1,2]. But due to their other excellent mechanical property, excellent impart property at low temperature and inherent nature of recyclability the polypropylene fiber gain its importance in modern era. Polypropylene monomer is a liquefiable hydrocarbon gas boiling at -47^0C [1].

III. STRUCTURE OF POLYPROPYLENE

Polypropylene consists of two elements i.e. carbon and hydrogens. Since the molecular chain of polypropylene contains methyl group, the polymer chain becomes stiffer and results in a higher glass transition temperature about -20^0c [2] and a higher melting point of 176^0c [1,2].

Isotactic structure: If the functional groups -(CH$_3$)- are regularly arranged in one sides of the polymer chain then it is called isotactic polypropylene
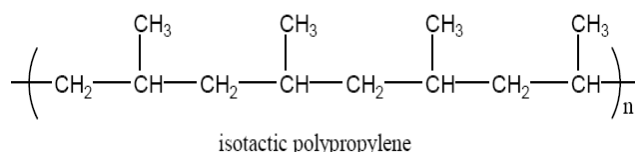

isotactic polypropylene

Figure-3

Syndiotactic structure: If the functional groups -(CH$_3$)- are alternatively arranged in either sides of the polymer chain then it is called isotactic polypropylene.
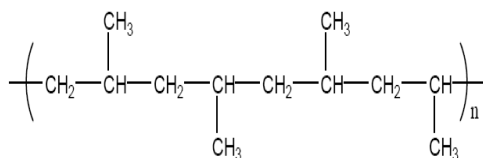
Figure -4

Atactic structure: If the functional groups -(CH3)- are randomly arranged in both sides of the polymer chain then it is called isotactic polypropylene.
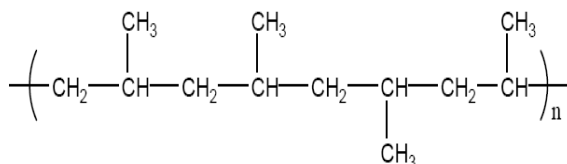

Figure-5

IV. STABILIZATION AGAINST DEGRADATION

In the absence of oxygen, polypropylene is relatively stable. However as such polypropylene is unstable to both heat and light, particularly in the presence of oxygen, at high temperature, as used in the melt for extrusion, polymer molecular weight and melt viscosity change causing difficulties in processing. The oxidation resistance of polypropylene is very poor so that it is impossible to process polypropylene under commercial operating condition without the presence of antioxidants [1, 2].

V. FIBER PRODUCTION

Polypropylene fibres can be produced by melt extrusion processes, which are followed by drawing and other after-treatments such as texturing and entanglement. While this technology is practised on a commercial scale for PP fibre production. Although the commercial production of PP fibre involves melt extrusion, a number of different melt extrusion processes are used, The choice depends on the type of fibre to be produced and the use for which it is destined. Different processes can be identified for the production of multifilament yams, monofilaments, staple, tapes and non-wovens.

A. Fiber structure

Polypropylene fibers are composed of crystalline and non-crystalline regions. The spherulites developed from a nucleus can range in size from fractions of a micrometer to centimeters in diameter. The a-axis of the crystal unit cell is aligned radially and the chain axis is homogeneously distributed in planes perpendicular to this radial direction. Each crystal is surrounded by non-crystalline material. Fiber spinning and drawing may cause the orientation of both crystalline and amorphous regions. If the extension is less than 0.5%, the spherulite deformation is elastic and no disruption of the structure occurs, otherwise spherulites are highly oriented in the direction of the force and finally are converted to microfibrils. These highly anisotropic microfibrillar structures lead to anisotropic fiber properties.

B. Structure development during solidification:

The rate of crystallization of polypropylene is very high. As the molten fluid emerges from the spinneret, it cools as it is being attenuated and develops molecular orientation as well as morphological order. The spun fiber exhibits a skin-core effect with the skin having higher orientation than the core. When crystallized from the melt isotactic polypropylene molecules adopt a β1 helical conformation.

Depending on the crystallization condition, these helices packs in different geometry giving rise to three well known polymorphs, names the α-monoclinic, the β-hexagonal and the γ-triclinic crystals forms which exists in conjuction with an amorphous phases.

C. Crystallinity of pp fiber

The degree of crystallinity of PP fiber is generally between 50-65%, depending on processing conditions. Crystallization occurs between glass transition temperature (Tg) and the equilibrium melting point (Tm). The crystallization rate of PP is fast at low temperature. It is reported [18] that the crystallization rate decreases with increasing crystallization temperatures and also decreases with the increase of molecular weight[17,18]. A paracrystalline structure with only 45% crystallinity resulting from immediate quenching after extrusion was observed. A significantly higher crystallinity of 62% was achieved when quenching further downstream of the die. Although the drawing orients the crystallites, it also might decrease the crystallinity, which is different from that of PET and PAN fibers. The crystalline structure of PP has different forms, subject to its respective drawing condition. For example, the "alpha-form" is thermodynamically more stable and accordingly requires greater drawing force than the other two. Heat setting removes the residual strains and produces a defect-free and stable crystalline structure to make fiber/fabrics dimensionally stable. It also improves the percentage of overall crystallinity. The smectic structure changes to a more perfect monoclinic structure. During the process of heat setting if the temperature is above 70°C. At 145°C the conversion is almost complete. In comparison to the predominantly smectic form, the monoclinic form does not experience any major change in crystalline structure during the course of drawing and heat setting.

VI. MECHANICAL PROPERTIES

The physical properties of PP fibers are very important from technical point of view. Polypropylene fibers are produced in a variety of types with different tenacities designed to suit varying market requirements. Fibers for general textile uses have tenacities in the range of 40.5-54.0 (cN/dtex). High tenacity yarns up to 81.0 (cN/dtex) are produced for the use in ropes, nets and other similar applications. High performance PP fibers have been made with high strength and high modulus. The techniques include ultra-drawing [19], solid-state extrusion [20] and crystal surface growth [21]. The filaments with tenacities over 117.0 (cN/dtex) can be made. The degree of orientation achieved by drawing influences the mechanical properties of PP filaments. Commercial PP monofilaments have an elongation-at-break in the range of 12-25%. Multifilaments and staple fibers are in the range of 20-30% and 20-35%, respectively.

The tensile properties of melt-spun iPP fibres are influenced by their physical structure, which is controlled by the fibre processing conditions. Common fibres produced by a commercial spin line have tensile moduli up to 3±5 GPa, tensile strengths up to 600 MPa and an elongation at break in

the range of 50±600% [49]. Through optimised colddrawing of single filaments a high overall draw ratio could be reached. Such highly cold-drawn iPP filaments have excellent mechanical properties. Young's modulus and tensile strength improves with increasing draw ratio and the highest values are observed for the highest draw ratio. Elongation at break, on the other hand, decreases with increasing draw ratio. Fibres cold-drawn at 1458C with a draw ratio of 10 have reached a Young's modulus in the order of12 GPa and a strength of 730 MPa at an elongation at break of 8%. Typical stress-strain curves of cold-drawn single-filament fibres are shown in Fig. 6. The as-spun fibres show after an initial linear portion a yield point, and up to break, a region of low slope, where large extensions are produced by small increases in stress. This behaviour indicates the developments of a neck and large plastic deformations before the stress starts to rise again followed by fracture of the fibres. The cold-drawn fibres exhibit higher moduli, no apparent yield point and a considerably lowered elongation to break but increased tensile strength compared to the filaments from which they were drawn. These qualitative similarities exist in all drawn fibres. Further investigations of the melting behaviour of optimist fibres were performed. Fig. 7 shows DSC heating traces of constrained and unconstrained iPP fibres of the highest draw ratio. Compared with isotropic iPP, after spinning and drawing a small shift of the melting temperature and an increased enthalpy of melting is observed. The higher melting temperature can be assigned to an increase of crystal size caused by the stress-induced recrystallisation during the cold-drawing process. Constraining the same fibre results in differences in the DSC trace. Again, the melting temperature shifts to higher values and the melting enthalpy increases further. Almost the complete melting area is localised above the original melting temperature of the isotrope, as delivered iPP, and the peak maximum of the melting temperature reaches a value of about 1908C. Therefore, the difference in melting temperature between constrained fibres and the isotrope, as delivered iPP, offers an enlarged temperature window for processing of iPP fibre reinforced iPP composites. The overheating behaviour of constrained fibres has been reported for gel-spun UHMWPE [50] and gel-spun UHMW-iPP [51], and for melt-spun iPP fibres with a low (cold) draw-down [52] and drawn iPP fillms [53], but in the latter studies only melting temperature shifts of about 108C are observed.
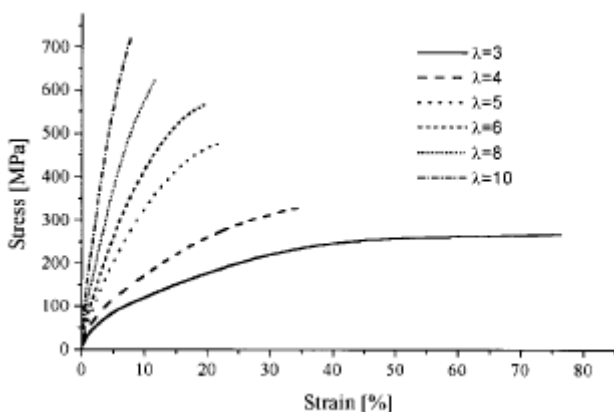

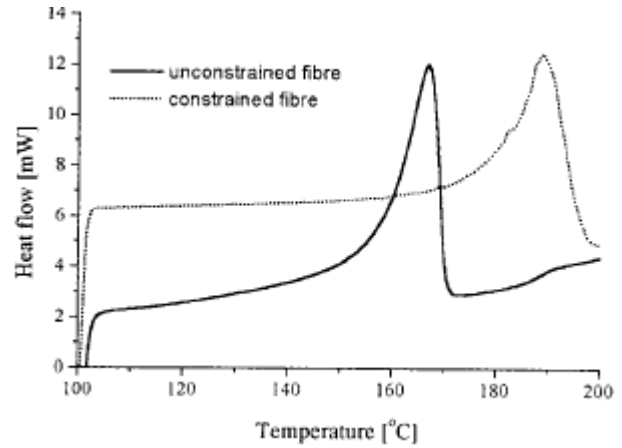Fig-6(stress-strain curves of PP fiber at different draw ratio λ) [50,51]

Fig-7 (DSC curves of i PP fibers) [50,51]

VII. THERMAL PROPERTIES

Polypropylene fibers have a softening point in the region of 150°C and a melting point at 160-176°C. At temperatures of -70°C or lower, PP fibers retain their excellent flexibility. At higher temperature (but below 120°C) PP fibers nearly remain their normal mechanical properties. PP fibers have the lowest thermal conductivity of all commercial fibers. In this respect, it is the warmest fiber of all. The thermal conductivity of common textile fibers is shown in Table 1.

Table-1 Thermal properties of different fiber

Material	Thermal Conductivity (W/m.K)
Air	1.0
PP	6.0
Wool	6.4
Acetate	8.6
Viscose	11
Cotton	17.0

VIII.DEVELOPMENT OF METALOCENE BASED POLYPROPYLENE

In past decades, the use of polypropylene, has dominated in the production of melt blown and spun bonded nonwovens. The main reasons for the growing use of PP in polymer-laid nonwovens are that the raw materials are relatively inexpensive and available throughout the world, and PP resins can offer a relatively attractive cost combined with good value and ease of use when compared to conventional resins, such as polyester and polyamides. Continuing advances in PP fiber grade resins are strengthening the olefins price / properties ratio, which make them more suitable for polymer-laid nonwovens applications. Polypropylene resins have been produced from Ziegler-Natta catalysts for over many years.

The drive for technology evolution has been the industry's desire to continuously improve control of the molecular architecture that leads to improved polymer performance. In 1980's, the introduction of single site catalyst for making superior polyolefin resins set another technological trend, marked with Metallocene Catalysts having a precise control over molecular architecture for highly tailored polymers; improved processing; and properties for all polyolefins. This technology has been developed and designed for nonwoven applications [26]. The manufacturer may be able to take properties and very low extractables. Advantage of the higher barrier properties is to reduce basis weight or increase line speed. Because this material is so clean, the nonwoven manufacturer may be able to extend the intervals between die changes and process clean-ups. The absence of peroxide in this product leads to reduced viscosity variations and more consistent extrusion performance. Reduced process air rates are possible with this material, which can reduce energy costs. Due to these advantages, this innovative new melt blown material is expected to gain rapid acceptance in the nonwovens industry.

A. Advantages of metallocene pp

Metallocene catalysts offer unique advantages versus conventional catalysts. They allow producing consistent, controllable molecular structures that can be designed to:

- Improve toughness
- Provide excellent impact resistance
- Reduce haze
- Provide excellent organoleptics (low off-taste and odor)
- Allow tailoring of processing characteristics to fit the conversion process
- It allows control the molecular structure of polyolefines.
- It enables to virtually eliminate non-targeted molecular weight species in resins
- It allows incorporation of co-monomers and ter-monomers with precision.
- It offers a greater control of molecular weight distribution (MWD).
- It leaves a small amount of catalyst residue in the finished product.

B. Metallocene based pp nonwovens

Metallocene based PP resins for nonwovens and fiber applications can help to produce polymers with very low catalyst residues and very high purity. The polymer modification process, called controlled rheology, enables us to tailor the resin for the specific need of nonwovens applications. Advantages of the fiber grade metallocene based PP resin in spunbonding and melt blowing over the conventional resin:

- It produces finer denier fibers than conventional resins.
- The optimum bonding temperatures are lower because of the lower melting point
- Excellent spinning continuity or fewer breaks in spinning.
- Spinning can be carried out at higher draw force.
- Substantial reduction in volatile deposits.
- Available in broader MFR range, especially helpful for melt blowing.
- Key features of Metallocene Polymers

The primary feature that makes metallocene-catalyzed polymers preferable to conventional polymers is structural uniformity, which eliminates very low and high molecular weight polymer components present with conventional catalysts.

IX. APPLICATIONS

Presently, the metallocene based polyolefin polymers are produced by many companies in the world, but among those, BASF, Germany, and ExxonMobile Chemical Co., USA are the main producers of metallocene based PP. Exxon began development of *Escorene* Polypropylene grades used for nonwovens in 1960, and introduced Achieve[TM] propylene polymers based on *Exxpol* catalyst technology in 1995. This brought in overall property improvements versus conventional polypropylene yielding finer and stronger fibers at a lower production cost. Applications of Metallocene Polypropylene:

Hygiene: diapers, disposals

Medical: operation gowns and covers

Filtration: air purification systems

Household: mattress covers, upholstery, disposable products

Wipes: wet wipes.

Geotextiles

Comparison of Metallocene PP with Conventional PP

Product Attribute	Metallocene	Conventional PP
Melting Point (°C)	148	162
Flexural Modulus (MPa)	1380	1360
MWD (Mw/Mn)	2.0	3.5 / (2.8)
Recoverable Compliance	0.4	3.5 / (0.9)

A. Applications of PP fibers in Textile and Non-textile area

Because of its superior performance characteristics and comparatively low-cost, PP fiber finds extensive use in the nonwovens industry. PP is a very important fiber in nonwoven processing and dominates in many nonwoven markets. The main application areas include: nonwoven fabrics, particularly absorbent product cover stock markets, home furnishings and automotive markets.

B. Carpets and Upholestry

Since polypropylene became a commercially available fiber more than 40 years ago, it has historically been a fiber for carpet and upholstery. About 90% of all carpet backing and more than 25% of all carpet face fiber is polypropylene [27].

In 1997 almost 3.8 billion pounds - approximately 39 percent of all fibers shipped by domestic manufacturers - were delivered to U.S. and Canadian carpet mills. Roughly 1.6 billion pounds of these shipments, 42 percent, were polypropylene filament and staple, representing more than 61 percent of all polypropylene shipments [28]. In 1998, 44% polypropylene filament shipments were used as carpet-face fibers, with slightly more than half this amount, 514 million pounds or 24 percent of all filament shipments, were consumed in backing materials. Polypropylene BCF (bulked continuous filament) yarns now account for almost 1 billion lbs/yr of the face fiber used in carpets and rugs in the U.S. Carpet mills that have back-integrated into fiber production make most of the BCF yarns used in the U.S. carpet industry. In 1998, the relatively low prices for polypropylene resins were a major factor in increased earnings for the major U.S. carpet and rug producers.

C. Absorbent products (Diapers)

Absorbent products are very important in the nonwovens business. Of the absorbent product applications, the baby diaper area is the largest volume user, however, applications in adult incontinence currently show the highest growth in recent years. The major structural components of current diapers are [29] Top sheet (coverstock), Acquisition and/or transport or distribution layer, Absorbent core and Backsheet. Secondary component materials are Barrier leg cuffs, Elastomeric materials and hot melt glues.

Current nonwoven materials used in topsheet applications include spunbonded polypropylene (usually produced on a multibeam system), SMS (spunbond/melt blown/spunbond) polypropylene composites and carded polypropylene thermal bonds. In some applications, thermally bonded bicomponent structures are being used. Polypropylene spunbonded webs, treated to render them hydrophilic (or partially treated to make them hydrophilic in zones) have proved popular materials for coverstock applications, but they have not always been rated as soft as other materials, i.e. staple fiber-based thermally bonded polypropylene. However, recent developments in polymer technology with the availability of metallocene polypropylene would appear to provide a route to improve the resultant web softness. Alternative web-forming technologies, (such as those of Ason Engineering, Ft. Lauderdale, FL and Kobe, Tokyo, Japan) with the capability to produce bicomponent and microdenier webs, can now provide materials with better web formation, better softness and improved strength, allowing a reduction in web weight and consequently the possibility of a reduction in cost.

D. Automotive Products

The nonwovens business in South America has continued to expand in more and more automotive product segments despite an automotive industry crisis [29]. The past year saw only 1.6 million units produced, a 24% drop from 1997. Sales during the year fell 21% and exports dropped 7.7%, from 416,000 to 384,000 units. Imports were another story, with new car imports growing 13.8%, from 303,000 to 345,000 in numbers of units. The negative trends in 1998 can largely be attributed to a combination of economic problems, increased unemployment levels, higher interest rates and tributary charges. Principal polypropylene applications for nonwovens in automobiles are interior fabrics used in or on kick panel, package shelf, seat construction, truck liners, load decks, cabin air filters etc [30].

E. Geotextiles

Geotextiles have a wide variety of uses. They can provide reinforcement in roads and stabilisation in embankments, by absorbing forces from which other components in a construction must be protected. They can also provide filtration and drainage of water in foundations and keep materials separate, to prevent intermixing of layers of these materials. Geotextiles are manufactured from woven and non-woven fabrics, the choice of fabric depending on the function required. Thus, woven fabrics, often from slit tapes, are used where strength and stability are important, but non-wovens are used where filtration, drainage and cushioning are among the principal requirements. The chemical inertness, high strength, low density and low cost of PP fibre render it an attractive option for many geotextile applications. In addition, for those geotextile applications where the PP fibres are below ground level, their susceptibility to photodegradation is a less serious factor. Nevertheless, there are some problems associated with the use of PP fibre in geotextile applications, one of these being poor creep resistance. Thus, during use, many geotextiles constructed from PP fibres are readily deformable and should, therefore, be used in roles where the stress to them is limited. A further problem is sensitisation under stress to oxidative degradation. Evidence has been obtained that stress increases the rate of oxidative attack through the promotion of PP chainscission [33]. Furthermore ,it has been pointed out that this observation has implications for durability tests and predictions of the lifetimes of PP textiles not only in geotextile applications but in any application where a PP textile is continuously under stress. Indeed, it has been suggested that creep tendency and stress sensitivity to oxidation are related via a common mechanism. Thus, strategies for reducing creep may also reduce stress sensitivity to oxidative degradation, with consequent improvement in durability. The presence of some grades of carbon black in PP fibres appears to be beneficial in this respect.[34]

F. Sports surfaces

The replacement of grass by artificial sports surfaces is becoming increasingly widespread. In winter ,natural grass is prone to severe erosion if used for more than a few hours per week. The erosion can be all too obvious around goalmouths during a football match on a wet day! Even in summer, heavy use of sports surfaces, as in lawn tennis courts, can wear grass away [35, 36]. Polyolefin fibres are now being increasingly used as artificial grass. While PP fibres have been historically used, the more sophisticated present-day systems often employ PE-based fibres, in order to achieve the required flexibility and performance. Polyolefin fibres are almost completely unaffected by ambient temperature and humidity, in that they retain their dimensions, strength and abrasion resistance. The green colour is provided by pigments dispersed within the fibres, such as chlorinated copper phthalocyanine pigments. The pigment too must be resistant to temperature, humidity and light.

G. Filters

PP fibres are used extensively in filters, both for solid-gas and solid-liquid filtration systems. Although ftltration products

used to be typically manufactured from woven fabrics, non-woven fabrics are now being increasingly utilised. Non wovens are considered to possess greater versatility, in that they can often be readily used on their own or in conjunction with some other material. Moreover, in dry filtration, non-wovens permit greater flow of gas without reduction in filtration efficiency [37]. Improvements in filtration systems are being driven by the need for higher rates of filtration, improved efficiency of filtration and stricter environmental legislation. These factors have led to the increasing use of PP textiles, with additional factors being their superior chemical and abrasion resistance and low cost of manufacture. In wet filtration applications, woven and non-woven PP textiles are used more than any other types of textile. The rapidly increasing application of melt-blown nonwovens for dry ftltration has also promoted the use of PP fibres [38].

H. Electrical Properties

PP is an excellent electrical insulator, as can be expected from a non-polar hydrocarbon. The electrical properties of PP [39] are very similar to those of PE which is given in below table:

Table - Comparison of electrical properties

Property	PP	LDPE	HDPE
Volume resistance(Ω cm)	10^{17}	10^{16}	10^{17}
Dielectric strength(MV/m)	28	27	22
Dielectric constant at 1 kHz	2.28	2.3	2.3
Dissipation factor at 1kHz	0.0001	0.0003	0.0005

I. Flame Retardants

PP is basically flammable and ignites at a temperature of about 600 °C [40, 41], although its burning rate is slow. PP ignites in contact with flame and burns with a faintly luminous flame. It continues to burn when the ignition source is removed and melts with burning drips. The spontaneous burning temperature of PP is 360 °C and the temperature at which ignition is induced from an external source is 345 °C [42]. Combustion of unfilled PP produces no environmentally relevant pollutants. The burning produces very little soot, unlike PS or styrene-acrylonitrile copolymer (SAN), and no char, unlike oxygencontaining polymers such as polyphenylene ether (PPE) or PC. Polymers with superior fire resistance are thermosetting resins, fluorinated plastics and other plastics containing sulphur such as polyether sulphone and polyphenylene sulphide.

The key fire properties of some plastics are compared with PP. Suitable flame retarded grades of PP can have a LOI of 28 [39, 41, 42]. A table for the above numerical data is proposed below

Table - Flammability and oxygen index of different polymers

Polymers	Flammability	Limiting Oxygen Index
PE	HB	17
PP	HB	17
PS	HB	18
UPVC	V-0	45
CPVC	V-0	50
ABS	HB	19

Explanation of symbols:
HB- Horizontal Burn
V-0 is the most stringent specification.

J. Impact properties

The response of a material to impact loading will depend on various factors such as the geometry of the structure and striker, the mass and velocity of the striker, and frequency of impact [54]. Due to their high strength and stiffness, and good energy absorption due to delaminating failure modes, composite materials generally perform well in impact applications. Carbon and glass fibres suffer from a lack of plasticity which means that non-penetrativeimpact loads can lead to (often invisible, subsurface) fibre damage, which can drastically reduce the residual mechanical properties of the composite [55]. Thermoplastic fibre composites typically possess sufficient elastic limits to make them less sensitive to damage from lower energy impact. Highly oriented polypropylene (PP) tapes, with high tensile strength and stiffness achieved by molecular orientation during solid state drawing, are consolidated to create fully recyclable, high performance ''all polypropylene'' (all-PP) composites. These composites possess a large processing temperature window ($>30^0$ C) and a high volume fraction of highly oriented PP reinforcement phase ($>90\%$). This large processing window is achieved by using co-extruded, highly drawn PP tapes [56].

Ballistic analysis of the all-PP plates was performed to determine the effect of high-speed impact on all-PP plates. Specimens processed for optimised falling weight penetrative impact resistence.The impact performance of all-PP composite material has been analysed at a range of temperatures and strain rates through penetrating impact by falling weight impact testing and ballistic impact testing (figure- 8& 9).
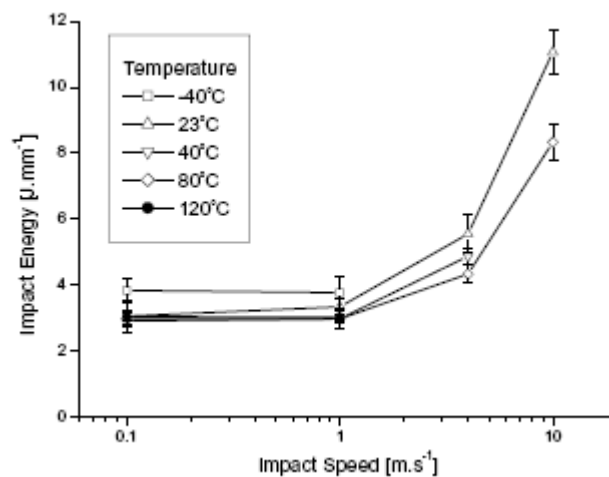

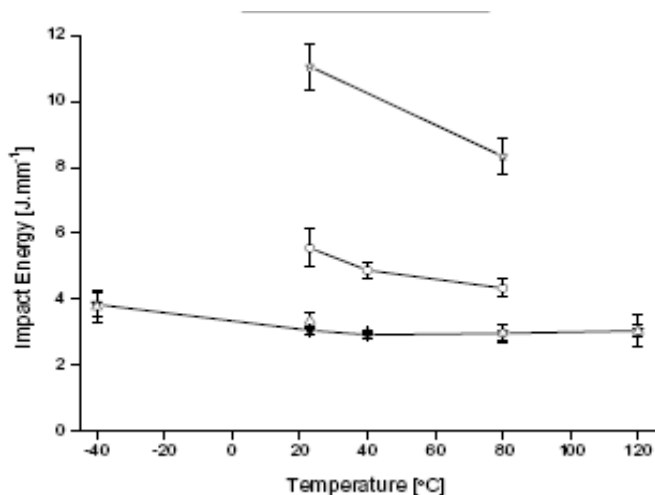Figure-8 Falling weight penetrative impact energy vs. impact speed

Figure -9 Falling weight penetrative impact energy vs. impact temperatures

The normal glass transition temperature which results in a significant decrease in impact resistance of isotropic PP at low temperatures ($<0^0$ C), is absent in all-PP composites leading to high impact energy absorption even below Tg. Since the impact resistance of all-PP composites depends on the interfacial strength of the composite and hence the composite processing conditions, all-PP composites possess the versatility to be tailored for specific application during processing.

X.CONCLUSION

The current trend of R &D activites in advanced materials, polymers and textiles clearly indicates a shift to technical textiles as the new tool to improve properties and gain newer multifunctionalities. However, challenges and the success of the every individuals working in this area would depend to a large extent on the selection of various catalyst described in this paper. As far as fibrous materials are concerned, the flexibility, processsbility of materials and structure of the materials plays an important role on properties of the concerned materials. Thus it can be summarized that the polypropylene fibres has a lot of potentials as a future scope of approach but would be largely goverened by simultaneous progress in the newer, faster, simpler and more efficient selection of raw materials, process of production and application in the suitable field described in this paper.

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