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A STUDY ON FIBRE CHEMISTRY OF SYNTHETIC FIBRE

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ABSTRACT

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The natural fibers have definite physical and chemical properties which cannot be changed at will, but the synthetics can be made with a variety of properties. Some of the newer synthetic fibers have properties quite different from the natural fibers. No doubt others will be created having still more varied characteristics. Improvement of production has enabled the textile manufacturer to vary the properties of synthetic fibers. The fibers and yarns are uniform when produced under exacting conditions. The size of filaments has been varied and made considerably smaller. The synthetic fibers not only make possible fabrics of great variety, but some also have qualities that are superior to the natural fibers. Many of the synthetic textiles have been in using long enough to prove their desirable qualities which have made them preferred to those of the natural fibers.

Key words: *polyethylene, polyvinyl, polyvinylidene, polyester, nylon*

INTRODUCTION

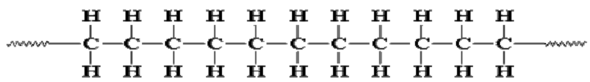
Synthetic fiber has its beginning with chemistry; after a media is developed, it is filtered under pressure; it is then extruded into continuous filaments; the filaments are allowed to solidify; they are then stretched; a finishing solution is now applied; the bundle of filaments is then crimped, or given a zigzag kink; the final step before packaging and shipping is cutting the fiber bundle into staple lengths. The user can procure a wide variety of fibers to fulfill his needs, ranging from very high performance to very low performance. The wide use of synthetic textiles has made it desirable for the consumer to know the relative serviceability of fabrics made of the synthetic and the natural fibers. Fabrics of the natural fibers are not always superior to synthetic fabrics.

Polyethylene

Polyethylene at a glance:

Uses:	Thermoplastics, fibers
Monomer:	Ethylene
Polymerization:	Free radical chain polymerization, Ziegler-Natta polymerization, metallocene catalysis polymerization
Morphology:	Highly crystalline (linear), highly amorphous (branched)
Melting temperature:	137°C
Glass transition temperature:	-130 to -80°C

A molecule of polyethylene is nothing more than a long chain of carbon atoms, with two hydrogen atoms attached to each carbon atom.



Sometimes it's a little more complicated. Sometimes some of the carbons, instead of having hydrogens attached to them, will have long chains of polyethylene attached to them. This is called branched, or low-density polyethylene, or LDPE. When there is no branching, it is called linear polyethylene, or HDPE.

Linear polyethylene is much stronger than branched polyethylene, but branched polyethylene is cheaper and easier to make. Polyethylene with molecular weights of three to six million is referred to as ultra-high molecular weight polyethylene, or UHMWPE. UHMWPE can be used to make fibers which are so strong they replaced Kevlar for use in bullet proof vests (http://www.fibreindia.org/userfiles/int_hplc2.jpg).

Polypropylene

Polypropylene at a glance:

Uses:	Thermoplastics, fibers, thermoplastic elastomers
Monomer:	Propylene
Polymerization:	Zieglar-Natta polymerization, metallocene catalysis polymerization
Morphology:	Highly crystalline (isotactic), highly amorphous (atactic)
Melting temperature:	174°C (100% isotactic)
Glass transition temperature:	-17°C

Structurally, it's a vinyl polymer, and is similar to polyethylene, only that on every other carbon atom in the backbone chain has a methyl group attached to it. Polypropylene can be made from the monomer propylene by Ziegler-Natta polymerization and by metallocene catalysis polymerization.

Polyvinyl chloride

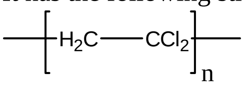
Polyvinyl chloride at a glance

Uses:	Thermoplastics
Monomer:	Vinyl chloride
Polymerization:	Free radical chain polymerization
Morphology:	Highly amorphous, ~11% crystallinity
Glass transition temperature:	~84°C

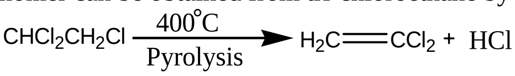
Structurally, PVC is a vinyl polymer. It's similar to polyethylene, but on every other carbon in the backbone chain, one of the hydrogen atoms is replaced with a chlorine atom. It's produced by the free radical polymerization of vinyl chloride (http://www.chemestryethiopianchamber.com).

Polyvinylidene Chloride

It has the following structure-

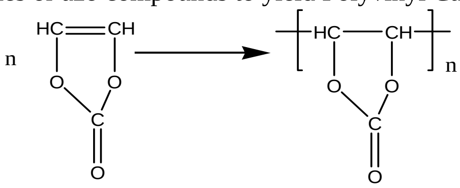


The polyvinylidene chloride monomer can be obtained from tri-chloroethane by pyrolysis-



Polyvinyl Carbonate

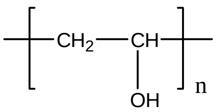
It can be polymerized with peroxides or azo compounds to yield Polyvinyl Carbonate as follows-



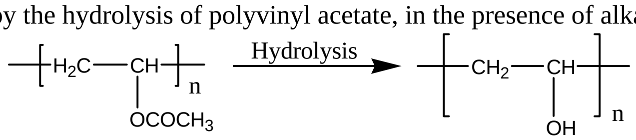
This polymerization can be done in bulk, solution or emulsion systems. These fibers has high tensile strength.

Polyvinyl Alcohol

Polyvinyl alcohol has the following structure-



This polymer is obtained by the hydrolysis of polyvinyl acetate, in the presence of alkalies as follows-

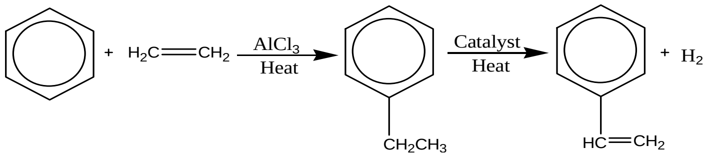


Polystyrene

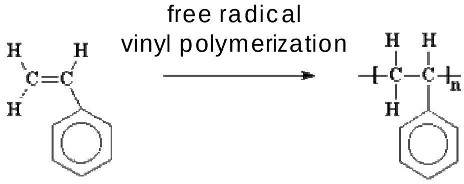
Polystyrene at a glance

Uses:	Thermoplastics
Monomer:	Styrene
Polymerization:	Free radical chain polymerization (atactic), Ziegler-Natta polymerization (syndiotactic)
Morphology:	Highly amorphous (atactic), highly crystalline (syndiotactic)
Melting temperature:	270°C (syndiotactic)
Glass transition temperature:	100°C

Polystyrene is an inexpensive and hard plastic. Polystyrene is a vinyl polymer. Structurally, it is a long hydrocarbon chain, with a phenyl group attached to every other carbon atom. Styrene is produced from ethylene and benzene as shown below-



Polystyrene is produced by free radical vinyl polymerization, from the monomer styrene.



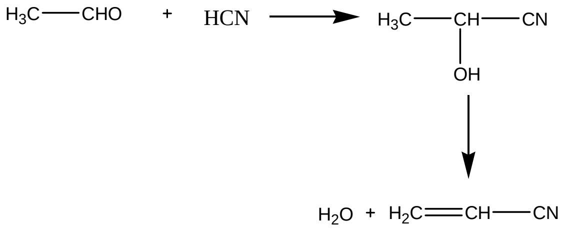
styrene polystyrene

Poly-acrylonitrile

Poly-acrylonitrile at a glance:

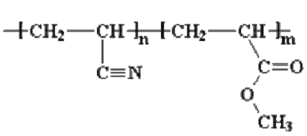
Uses:	Fibers, precursor for carbon fiber
Monomer:	Acrylonitrile
Polymerization:	Free radical chain polymerization,
Morphology:	Highly crystalline
Melting temperature:	319°C
Glass transition temperature:	87°C

It is produced from acrylonitrile by the radical polymerization technique using peroxide initiators. Acrylonitrile monomer can be produced from acetaldehyde and hydrogen cyanide:

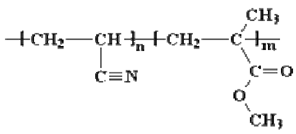


Poly-acrylonitrile is produced by free radical vinyl polymerization, from the monomer acrylonitrile.

Homopolymers of poly-acrylonitrile have been uses as fibers in hot gas filtration systems, outdoor awnings, sails for yachts, and even fiber reinforced concrete. But mostly copolymers containing poly-acrylonitrile are used as fibers to make knitted clothing, like socks and sweaters, as well as outdoor products like tents and such. If the label of some piece of clothing says "acrylic", then it's made out of some copolymer of poly-acrylonitrile. Usually they're copolymers of acrylonitrile and methyl acrylate, or acrylonitrile and methyl methacrylate:

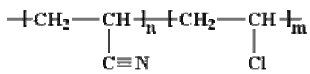


poly(acrylonitrile-co-methyl acrylate)



poly(acrylonitrile-co-methyl methacrylate)

Also, sometimes we make copolymers of acrylonitrile and vinyl chloride. These copolymers are flame-retardant, and the fibers made from them are called modacrylic fibers.



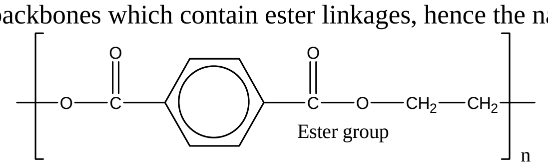
poly(acrylonitrile-co-vinyl chloride)

Polyester

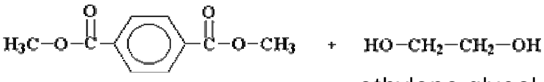
Poly (ethylene terephthalate) at a glance:

Uses:	Thermoplastics, fibers
Monomer:	Ethylene glycol and dimethyl terephthalate
Polymerization:	Transesterification
Morphology:	Highly crystalline
Melting temperature:	265°C
Glass transition temperature:	74°C

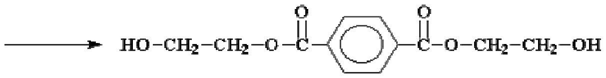
Polyesters have hydrocarbon backbones which contain ester linkages, hence the name.



Dimethyl terephthalate is reacted with ethylene glycol is a reaction called transesterification. The result is bis-(2-hydroxyethyl)terephthalate and methanol. But if we heat the reaction to around 210°C the methanol will boil away.



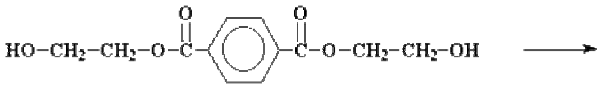
dimethyl terephthalate ethylene glycol

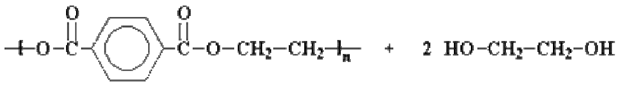


Bis-(2-hydroxyethyl)terephthalate

methanol

Then the bis-(2-hydroxyethyl)terephthalate is heated up to a balmy 270°C, and it reacts to give the poly ethylene terephthalate and, oddly, ethylene glycol as a by product.

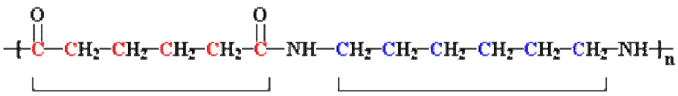




poly(ethylene terephthalate ethylene glycol

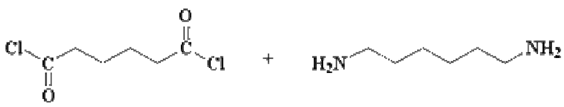
Nylon

Nylons are also called polyamides, because of the characteristic amide groups in the backbone chain. Proteins, such as the silk nylon was made to replace, are also polyamides. These amide groups are very polar, and can hydrogen bond with each other.

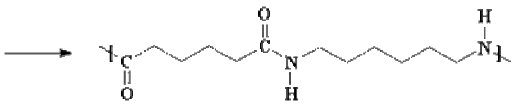


six carbon atoms six carbon atoms

Nylons can be made from diacid chlorides and diamines. Nylon 6,6 is made from the monomers adipoyl chloride and hexamethylene diamine.



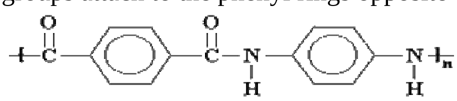
adipoyl chloride hexamethylene diamine



Nylon6,6

Aramid

Aramids are a family of nylons, including Nomex® and Kevlar®. Kevlar® is used to make things like bullet proof vests and puncture resistant bicycle tires. Blends of Nomex® and Kevlar® are used to make fireproof clothing. Nomex® is what keeps the monster truck and tractor drivers from burning to death should their fire-breathing rigs breathe a little too much fire. Kevlar® is a polyamide, in which all the amide groups are separated by para-phenylene groups, that is, the amide groups attach to the phenyl rings opposite to each other, at carbons 1 and 4.



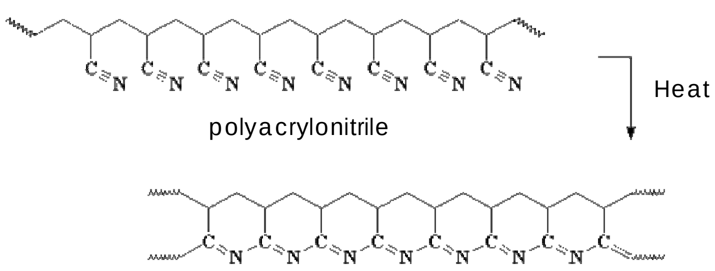
In Kevlar the aromatic groups are all linked into the backbone chain through the 1 and 4 positions. This is called *para*- linkage.

Spandex

One unusual polyurethane thermoplastic elastomer is spandex, which DuPont sells under the trade name Lycra. It has both urea and urethane linkages in its backbone. What gives spandex its special properties is the fact that it has hard and soft blocks in its repeat structure. The short polymeric chain of a polyglycol, usually about forty or so repeats units long, is soft and rubbery. The rest of the repeat unit, you know, the stretch with the urethane linkages, the urea linkages, and the aromatic groups, is extremely rigid. This section is stiff enough that the rigid sections from different chains clump together and align to form fibers. Of course, they are unusual fibers, as the fibrous domains formed by the stiff blocks are linked together by the rubbery soft sections. The result is a fiber that acts like an elastomer. This allows us to make fabric that stretches for exercise clothing and the like.

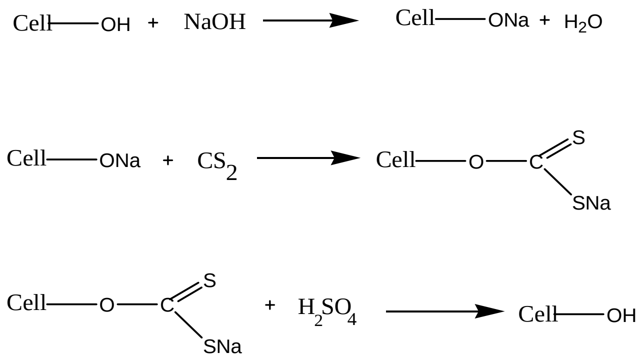
Carbon fiber

This made from polyacrylonitrile by heating which causes the cyano repeat units to form cycles.



Viscose rayon

This is regenerated cellulose. In the initial step alkali cellulose is prepared which is obtained by treating cellulose obtained from wood pulp with strong alkali at relatively low temperature. This alkali cellulose is treated with carbon disulfide to produce cellulose xanthate from which cellulose is regenerated by treating with sulfuric acid as follows-



Cellulose acetate

Cellulose Acetate is manufactured by treating purified cellulose refined from cotton linters and/or wood pulp with acetic anhydride in the presence of a catalyst. The resultant product, cellulose acetate flake, is precipitated, purified, dried, and dissolved in acetone to prepare the spinning solution. After filtration, the highly viscous solution is extruded through spinnerets into a column of warm air in which the acetone is evaporated, leaving solid continuous filaments of cellulose acetate. The evaporated acetone is recovered using a solvent recovery system to prepare additional spinning solution. Acetate fibers are environmentally friendly.

CONCLUSION

The natural fibers have definite physical and chemical properties which cannot be changed at will, but the synthetics can be made with a variety of properties. Some of the newer synthetic fibers have properties quite different from the natural fibers. No doubt others will be created having still more varied characteristics. Improvement of production has enabled the textile manufacturer to vary the properties of synthetic fibers. The fibers and yarns are uniform when produced under exacting conditions. The size of filaments has been varied and made considerably smaller. The synthetic fibers not only make possible fabrics of great variety, but some also have qualities that are superior to the natural fibers. Many of the synthetic textiles have been in using long enough to prove their desirable qualities which have made them preferred to those of the natural fibers.

REFERENCES

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