Journal of Textiles, Coloration and Polymer Science
https://jtcps.journals.ekb.eg/

Egyptian Society for Textile Science and Technology
الجمعية المصرية لعلوم وتكنولوجيا النسيج

A survey of conventional and smart polymers, with an emphasis on their novel uses in the textile industry

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Abstract

This review encompasses the basic information's about polymers and smart polymers, which are materials can have remarkable changes in their physical or chemical properties with environmental stimulation. smart polymers can be divided into many types such as color change polymers, shelf healing polymers, shape memory polymers, smart polymer gels. By incorporating smart polymers into textiles, novel functionality may be added to them. To improve or create textile smart capabilities, smart polymers, such as thermal- and pH-responsive hydrogels, thermal-, moisture-, and light-responsive polymers, have been applied to textiles. The applications of smart polymers in the textile and garment industries are discussed.

Keywords: polymers, smart polymers, stimuli-responsive materials, shape memory polymers, smart polymer gel, smart textile

Introduction

Polymers derived from natural sources have been around for a very long time. Proteins, deoxyribonucleic acid (DNA), and ribonucleic acid (RNA) are all polymers of amino acids. Every known form of life relies on them. Among other things, nucleotides consist of sugars, phosphoric acid, and bases that include nitrogen. [1]

As a material, synthetic polymers are considered to be relatively new, having just entered the technical and practical sphere in the early 1900s. Because of this, they are drastically different from any other substance that humans have encountered in the last few thousand years. The possibilities for creating new polymers using synthetic polymers are almost endless; these polymers may be synthesized via chemical reactions and are only limited by the laws of thermodynamics and chemistry as well as the imagination of the synthetic polymer chemist. Because of these boundless possibilities, a wide variety of synthetic polymers have been developed, and these materials are used in almost every human activity involving matter or physical objects. Materials may have many different functions and attributes due to the vast molecular structural variability made possible by the abundance of synthetic options **[1]**

Many of the things around us contain polymers, including but not limited to apparel, footwear, personal care products, furniture, electrical and electronic appliances, packaging, utensils, car parts, coatings, paints, adhesives, tyres, and many more. Although there are many more instances, you should now have an idea of the practical and economic importance of synthetic polymers to modern society. [1]

Polymers' broad appeal and acceptability stem from the fact that they are the most versatile materials, capable of exhibiting a wide range of mechanical properties from very strong fibers to soft gels and rubbers. This flexibility is directly aided by the regulatory control over chain length (or molecular weight), chain architecture, and the large latitude offered by the design of the repeat-unit structure. Although the majority of polymers include carbon-

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Receive Date: 10 August 2024, **Accept Date:** 03 September 2024
DOI: 10.21608/jtcps.2024.311367.1386

based backbones, the addition of inorganic backbones (such silicones) allows for even more material feature customization.

A brief overview of polymers

Polymer Definition

The etymology of the term "polymer" may be traced back to the Greek words poly (meaning "many") and mers (meaning "units"). When broken down to their molecular level, polymers consist of very long chains of molecules. The chemical interaction of many kinds of smaller, monomeric molecules with low molecular weights results in a large, high-molecular-weight molecule known as a polymer. How much polymerization occurs is dependent on the amount of monomers used in the process. **[2]**

Synthesis of Polymers

The formation of polymers is caused by the interlinking of monomers. The process of creating a polymer from a large number of monomers is called polymerization. There are essentially two types of processes involved in polymerization. A kind of process called an addition reaction or chain polymerization occurs when monomers are linked together without any elimination. Reacting monomer reactive groups eliminate low-molecular-weight compounds in condensation process, also called step polymerization. **[3, 4]**

Addition process involving chain polymerization

It is possible for monomers with two or three links to react without being eliminated. This kind of polymerization involves the monomers combining at a rather rapid rate. There are no byproducts in this kind of polymerization, therefore the monomer and the polymer are identical in terms of their elemental composition. Monomers are functional because they include double or triple bonds. The three primary steps of chain polymerization are starting the process, moving the chain forward, and stopping it. Beginning the chain polymerization process is possible using either a free radical (Figure 1), an ionic (Figure 2), or a coordination (Figure 3) strategy. From free-radical to ionic to coordination polymerization, the processes involved in chain polymerization may be classified accordingly. **[5]**

Polymerization step (reaction involving condensation)

Polymers are formed when reactive monomers undergo a sequence of gradual reactions to combine with one another. This kind of process is slower than chain polymerization since it is step-by-step. It is still possible for this kind of reaction to take place, even though it usually goes hand-in-hand with the elimination of a small molecule by step polymerization. The composition of the monomer and repeat unit will be either same or different depending on the elimination. If elimination is not a part of the polymerization process, the monomer and the repeat unit will have the same composition. The formation of a byproduct will cause a change in the composition of the monomer and the repeat unit. Among the several forms of step polymerization, poly-condensation (Figure 4) and polyaddition (Figure 5) are the most common. **[5]**

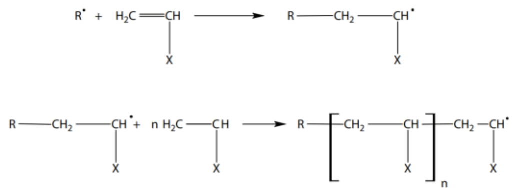

Figure 1: Free radical polymerization.

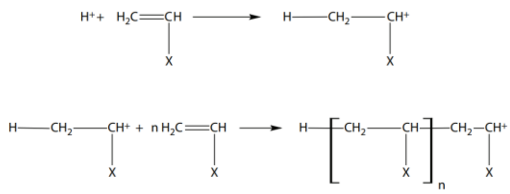

Figure 2: Ionic polymerization.

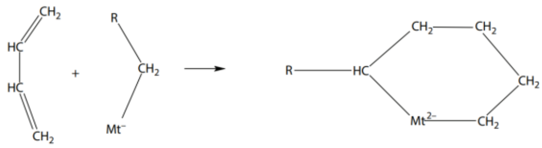

Figure 3: Coordination polymerization.

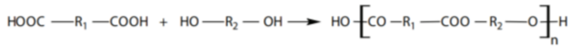

Figure 4:polycondensation polymerization

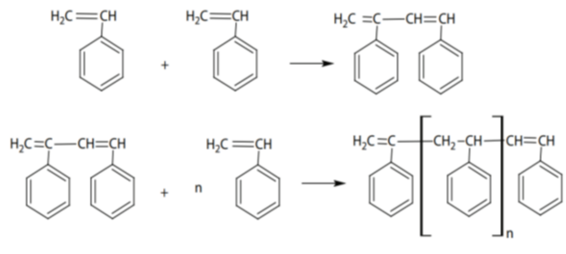

Figure 5: polyaddition polymerization

Characteristics of Plastics

The characteristics of different polymers are defined by the molecular interactions and repetitions that occur throughout their long chains. Materials are more sensitive to small changes in their surroundings because of their molecular arrangement and cross-linking, as well as their fundamental structure. **[6-15]**

There are many broad categories for polymer characteristics, defined by the physical basis and the scale at which the feature is stated. The most basic characteristic of a polymer is the ability to identify its component monomers. nonetheless, a commonality exists in the form of: -

- Molecules that consist of polymers are quite large. Additionally, they are known as macro-molecules.
- Polymers include semi-crystalline materials. They feature amorphous and crystalline regions. Amorphous sections of polymers really include crystallites, or zones of crystallinity. Amorphous regions lend the polymeric material its pliability, while crystal-lites give it its hardness and strength.
- Polymers do not melt, but rather go through a phase change from crystalline to semi-crystalline.
- Insulators pertaining to heat and electricity.
- Demonstrate exceptional corrosion resistance
- Despite their low weight, polymers are very strong.
- State tensile strength of the polymer grows with increasing chain length and crosslinking.
- • The cross-linking strength of the polymer is enhanced by its hydrogen and ionic bonding capabilities, as opposed to normal molecules with separate side molecules.
- • Raise the polymer's pliability. Their spectroscopic and analytical laser applications are due to their temperature-dependent refractive index changes. **[16, 17]**

Polymer Categorization

Many different behaviors may be shown by various polymers. They may be classified in several ways according to their origin, physical properties, and thermal behavior.

Based on Sources

I. Sorting polymers by their place of production is the quickest and easiest method. Origin is the defining characteristic that distinguishes natural and manufactured polymers.
II. Polymer Found in Nature: Polymers found in nature, such as in plants and animals, are known as natural polymers. Some examples are the carbs and cellulose in veggies, the protein in animals, and the latex that makes rubber from plants.
III. The term "synthetic polymer" refers to a material whose molecular weight is intentionally reduced by laboratory processes. They are mass-produced by many sectors according to demand. Everyday life is filled with the use of synthetic polymers such as polyethylene, polyvinyl chloride, polyester, nylon, and many more.
IV. Modifications to naturally occurring polymers give rise to semi-synthetic polymers. In the same way that vulcanized rubber is essential to industry, these types of polymers are also cross-linked using a sulfur treatment. Celulose is another example of a polymer that is not fully synthetic. The process of acetylating cellulose polymers found in nature produces cellulose acetate, a cellu-lose derivative. [18]

Based on Polymer Structure

The following categories apply to polymers based on their structure:

I. Polymers with long, straight chains are known as linear polymers. Because of their compact structure and ease of straightening, these polymers are considered high-density. Polymers can have very high melting points because of their high density. Among the many types of polymers, one that has a straight chain is PVC.
II. Chain Polymer: Polymers may have branch chains anywhere along the main chain, as the name suggests. The production of low-density polymers with lower melting temperatures is facilitated by branching, which inhibits the tight packing of polymers.
III. Polymers with internal linkages between them are called cross-linked polymers. A cross-linked network is more likely to be formed by tri-functional monomers. Hard and brittle are adjectives that describe cross-linked polymers. Polymers that are cross-linked include urea and melamine formaldehyde.

According to the Polymerization Type

The process of linking monomers to form a polymer is called polymerization. The following groups of polymers are defined by their polymerization state:

I. One method for making polymers is the addition polymerization process. The procedure included the joining of monomers without their removal. Here, a functional group is provided by the chemically inherent double or triple bonds in the monomers. Monomers and polymers are chemically identical since no monomer species is removed. There are various types of polymers, such as polyethylene and polyvinyl chloride.
II. One way to make polymers is to combine monomers and then evaporate small molecules, such as water or methanol, to form condensation polymers. The reactive active sites of the monomer behave as functional

groups in this case. Polyester and nylon are examples of compressed polymers.

Based on Thermal Behavior

Different polymer reactions occur when heat is introduced. The way polymers react when heated is used to classify them into the following groups:

I. Thermoplastic polymers may be shaped into almost any form since they do not undergo cross-linking when heated. These polymers re-harden and retain their shape after cooling. Polymers that undergo phase changes when exposed to heat and cold are known as thermoplastics. It is possible to repeat this procedure several times without changing the properties of the polymers. Polyester, Ny-lon, and polyvinyl chloride are a few examples of common thermo-plastic polymers.

II. Thermosetting polymer: a group of materials known as "thermosetting polymer" undergoes a chemical transformation when subjected to heat. Usually, they are semi-liquid compounds with a low molecular weight that, when heated, start cross-linking to create solid, insoluble masses. When heated, they form a permanent three-dimensional bond. Bakelite, urea, and melamine-formaldehyde are some common examples.

Based on the Most Extensive Use and Form

When it comes to polymers, the forces that hold individual atoms in place are known as intramolecular forces, while the forces that hold molecules together are known as intermolecular forces. The final form of a polymer is dictated by these two forces. Based on their form and function, polymers fall into the following classes:

I. The intermolecular interactions in plastics keep the long-chain polymers from breaking apart. They may be heated and compressed into strong, durable forms without cross-links. A few of polymers that find use in plastic include polystyrene and polyvinyl chloride.

II. Solid elastomers are composed of naturally elastic polymers and have a texture similar to rubber. Polymers undergo cross-linking so that they may re-shape themselves upon removal of stress. When subjected to stress, elastomers may be easily stretched and then returned to their original form. Rubbers that have been vulcanized and synthetic rubbers are two examples of elastomers.

III. The high strength and limited flexibility of polymers, which are created by strong intermolecular forces, make them ideal for use as fibers. A fiber is a substance that is easier to weave, has a smoother surface, and is more malleable. Fibers have a limited range and a high melting point. Nylon 66 and polyester are two common kind of fiber.

Innovative Polymers for the Textile Industry

One of the most important and prominent uses of polymers is in the textile industry, and more specifically, in the production of fiber. In order to make tex-tiles, certain chemicals known as polymers are required. From the initial fiber generation all the way through the dying and finishing processes, polymers are used in every step of the textile manufacturing process. [**[19, 20]** This portion concentrating on SMART polymers used in textile indus-try.

A class of materials known as SMART and functional includes adaptive polymers. Adaptive polymers, often called "stimuli-responsive" or "intelligent/SMART" polymers, are able to reorganize their molecular structure and modify their functionality in response to small physical or chemical external stimuli or changes in their environment. These polymers can be described as highly responsive, intelligent, SMART, or environmentally sensitive. External stimuli include things like changes in biological stimuli, mechanical deformation or pressure, electric or magnetic fields, pH, light intensity, temperature, and so on. **[6, 21, 22]**

In response to environmental cues, smart polymers may exhibit dramatic and rapid structural changes. To rephrase, SSPs are polymeric compounds that may change their size, shape, or other characteristics in reaction to external stimuli. These polymers may adapt to their environments by modifying their physical structure or chemical makeup in response to very small changes. The adaptive polymer has the potential to perceive an external input as a signal, evaluate the signal's intensity, and then modify its structure in reaction. The sources cited are **[6, 21, 23]**.

Natural or synthetic sources are equally viable options for the production of stimuli-responsive polymers. Naturally occurring responsive polymers such as chitosan and albumin may display responsiveness to temperature and pH. Other materials exhibiting thermoresponsive properties include methyl-cellulose and gelatin. One way to develop synthetic stimuli-responsive systems is to use a responsive polymer. Another option is to mix a polymer with a responsive compound, with the polymer serving primarily as a carrier or template for the responsive component. **[24]**

Varieties of SMART polymers and the textile industry's use of them

The applications employed in textile technology are significantly impacted by several types of SMART polymers, including shape memory polymers **[25, 26]**, intelligent/adaptive polymeric gels

[8, 13, 15, 27-41], phase change materials (PCMs) **[42-55]**, color change polymers **[56, 57]**, and self-healing polymers **[45, 58-79]**. Different SMART polymers may be utilized with certain processing methods, including finishing, spinning, or weaving. **[6, 21, 80]**.

Shape memory polymers

In addition to memorizing a permanent shape, shape memory polymers may be bent and set in a variety of temporary configurations. Restoring their previous shape, however, requires the application of certain external stimuli, such as heat, light, or a change in pH. Because of this quality, SMART textiles have several potential uses. **[25, 81, 82]**

Different shape memory polymer composites are also made for different applications. Shape memory polymers and composites of these materials have several uses in textile coatings, such as **[83]**:

- Textiles may be tested using a range of stimuli, such as light, heat, and water.
- You may start their highly customizable programming with a range of triggers using either single-step or multi-step ways.
- They have adaptable properties that are engineering-friendly and can be applied to fabric surfaces with ease.
- Their modulus is light and adjustable, making them feel almost as smooth as fabric.

Shape memory polymers' ability to restore their original shape meant that cotton fabrics treated with them came out looking wrinkle-free. Fabrics, especially cotton ones, get readily wrinkled when gently squeezed or folded because hydrogen bonds debond and slide. As seen in Figure 6, shape memory polyurethane-treated cotton fabric may immediately assume its flat, initial form when steam is introduced. Unfinished cotton fabric, however, cannot recover to a flat appearance because of its poor wrinkle resistance. Dimethyloldihydroxyethylene urea, or DMDHEU, has the for-maldehyde structure and is employed in most wrinkle-free finishing procedures now in use. **[84, 85]**

Shape memory polymer emulsion has an advantage over DMDHEU as a finishing agent since it stops the treated fabric from releasing formaldehyde. The mechanical strength and whiteness index of the fabric are unaffected by shape memory polyurethane finishing, in contrast to other wrinkle-free finishing procedures. Unlike BTCA (1,2,3,4-butane tetra-carboxylic acid), which contains polycarboxylic acid, this one does not. After being treated with shape memory polyurethane, cotton cloth gains a little more mechanical strength. Research on the durability of shape memory polyurethane emulsion has shown that it can preserve the wrinkle-free quality of fabric for hundreds of washings. **[7, 84-88]**

Shape memory polyurethane emulsion makes cotton fabrics more crease-prone and opens up new possibilities for designing visually appealing patterns on clothing. The impact of shape memory polymer on cotton fabric's ability to retain creases is seen in Figure 7. The treated cot-ton cloth and the untreated cotton fabric were first ironed into a center crease shape, as shown in Figure 7. Woven into the fabric, the treated fabric retains its crease form even after being washed in hot water (about 60 C). **[84, 85]**

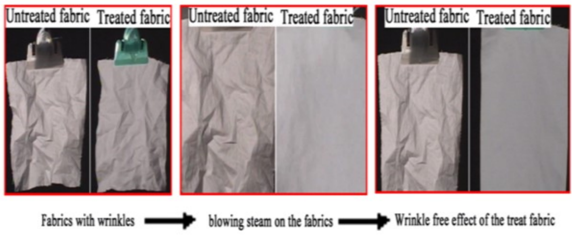

Figure 6: untreated cotton fabric and fabric treated with shape memory polyurethane.

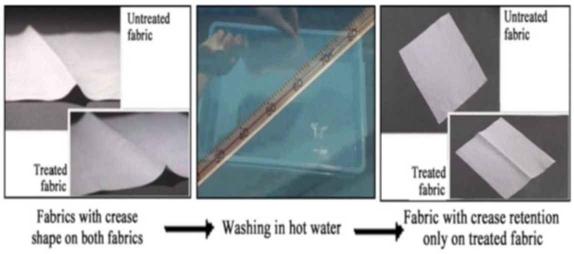

Figure 7: untreated cotton fabric and fabric treated with shape memory polyurethane

The shape memory polymer-made SMART breathable thermal and moisture-controlling garment is a hot commodity in the textile industry. For breathable fabrics made of shape memory polymers, the glass transition temperature is close to that of the human body. The degree to which shape memory polymers (polyurethane) thick sheets allow water vapour to pass through changes in relation to the wearer's core temperature. As the body temperature climbs over its glass transition point, the molecular free volume of the polyurethane thick film increases substantially, enabling the passage of heat and vapour from sweat to the environment, providing a soothing experience. When the temperature drops below the glass transition temperature of shape memory polymers (polyurethane), the molecular free volume decreases and air and water molecules are unable to flow through. Therefore, the film may help with temperature regulation. By incorporating hydrophilic segments such as dimethylpropionic acid and diol-ended poly (ethylene oxide) into shape memory polyurethane, the overall water vapour permeability of dense SMPU films may be enhanced. The creation of microfoam in shape memory polyurethanes may also significantly enhance their overall water vapour permeability. Using thermally sensitive shape memory polyurethane film as a coating, interlining, or laminating conventional tex-tiles are all viable options. **[83, 84, 89]**

In addition, Mondal and Hu used shape memory polyurethanes containing a trace quantity of multi-walled carbon nanotubes to make a cotton fabric. The water vapour permeability and UV protection of this synthetic cotton were exceptional Figure 8. **[83, 90]**

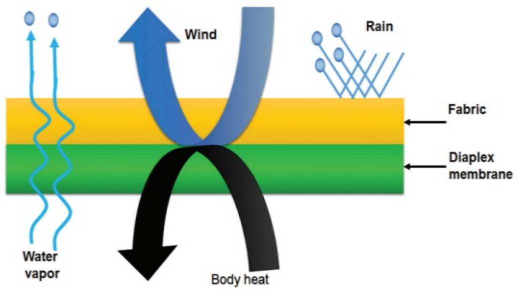

Figure 8: Structural illustration of twin layer of DiaPlex fabric

"Shape memory fibre" describes a kind of fiber that can remember its form. To return to their initial forms, shape memory fibers may be subjected to certain environmental stimuli, such as changes in temperature or pressure. The most common varieties of shape memory fibers are metals with shape memory, hydrogels with shape memory, and polymers with form memory. Due to their low density, easy manufacture, cheap cost, and high recoverable strain, shape memory polymers perform better than shape memory metals. There has been a recent uptick in the study of shape memory fibers. **[91]**

Fibers and textiles with form memory properties may be made using shape memory polymers. Shape memory polyurethanes, thermoplastic polynorbornenes, polystyrene-poly(1,4-butadiene) copolymers, polyethylene terephthalate-polyethylene oxide copolymers, polyethylene/nylone-6-graft copolymers, poly(vinyl chloride), polyethylene-poly(vinyl chloride) copolymers, and polyethylene are all examples of polymers that can exhibit shape memory effects through post-spinning. Electric spinning, melt, wet, or dry spinning are all viable options for producing the versatile fibers. **[21, 92]**

An assortment of natural, regenerated, or synthetic fibers may be used to create shape memory yarns, or shape memory polymer fibers can be used in isolation. Mixed yarns may include core spun, friction, and decorative yarns. Textiles also include threads manufactured from shape memory polymer fibers as well as conventional natural or synthetic fibers. Form memory fabrics come in a variety of weaves, knits, braids, and even nonwoven varieties. When heated to a temperature over the shape memory switch threshold, the aforementioned fibers, yarns, and fabrics may rapidly return to their original form, regardless of how deformed or wrinkled they initially were **[21, 93]**

Shape memory polymer fibers are used to produce self-adaptive fabrics that can easily alter their architectures in response to changes in ambient temperature. Fabric structures define the shape memory effect (SME) that a fiber may take on after being integrated into textiles, which can include a number of changes, such as bending, shrinking, and thickness expansion, although it is usually thought of as a change in length. The garments crafted from shape memory polymer fibers may be tailored to the individual's measurements (see Figure 9). Clothing constructed with shape memory polymer fibers has a reduced vertical tension stress compared to clothing constructed from elastic fibers, as shown by vertical pressure tests.

This is because the shape memory polymer fibers may temporarily take on various shapes, reducing the pressure that users may feel. The shape memory polymer fibers' form fixity allows the garment constructed of these fibers to stretch and conform to the wearer's body without causing any unnecessary discomfort. The garment's construction applies pressure to the wearer since the Spandex fibers in the fabric are very supple. The enhanced comfort level of textiles made with shape memory polymer fibers makes them ideal for use in intimate apparel and low-pressure socks. References. **[80, 83, 94]**

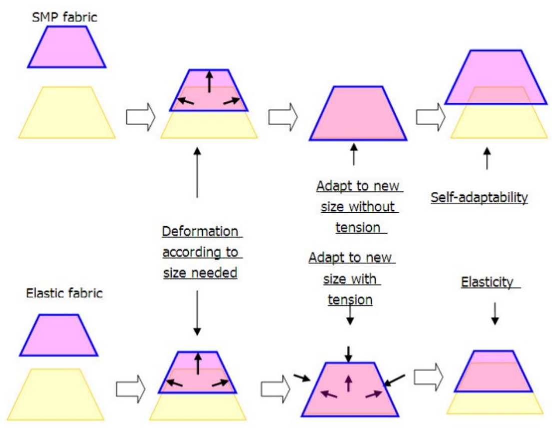

Figure 9: shape memory polyurethane fabric, garment fits different wearer's figure without tension

smart/adaptive polymeric material

It is difficult to categorize polymer gels as a specific kind of material, despite gel's widespread usage and accessibility. Gels are substances that may be thought of as being on the boundary between solids and liquids. It is a diluted matrix that contains fluid and is cross-linked; in steady state, it does not show any flow. One way to cross-link these systems is to fill their pores with an extender (medium), which may be anything from water (hydrogel) or oil (oil-gel) to air (aerogel). Figure 10 shows the equilibrium position between osmotic forces and the expansion capacity of polymer chains, which causes the gel network to swell. The molecular weight of the material may grow by a factor of 10 to 20 due to the polymer's elongation, which gives it a considerable capacity to inflate and a moderate ability to absorb. It should be noted that gel may expand but not dissolve. This swelling ability is due to hydrophilic functional groups attached to the polymeric chains, while the resistance to dissolution is caused by the cross-links between the chains of polymer. Because of this, gel is often considered an ideal medium for absorbing substances with a wide range of potential uses. **[95]**

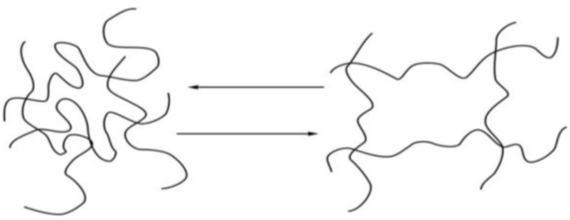

Figure 10: Gel equilibrium.

There are several forms of polymeric gels that may be classified according to their origin, the solvent medium in which they expand, and the type of crosslinking that occurs during gelation. When biological molecules like proteins, polysaccharides, etc., are cooled, they usually form polymeric gels, which make up the vast bulk of naturally occurring gels. [29, 33, 96, 97] These naturally occurring gels are created by physical crosslinking, namely by hydrogen bonds. These gels may be made from a variety of components, including gelatin, starch, agar, carrageenan, pec-tin, and more. A hydrogel is a kind of gel that can absorb and retain large quantities of water due to its hydrophilic chains. Organogels, in contrast, are a special kind of gel that expands more rapidly in organic solvents. When a gas phase replaces the liquid mercury in a gel, the result is called an aerogel. A different kind of gel called xerogel is made by removing all swelling media; the result is an open network. **[98]**

A novel hydrogel, developed by Liu and Fan36, has molecular inclusion function, sensitivity to pH and temperature, and is composed of poly (isopropyl acrylamide-co-maleic anhydride -cyclodextrin). This novel hydrogel was synthesized by means of free radical polymerization in an aqueous solution. A reactive monomer containing vinyl carboxylic acid functional groups was synthesized by reacting -CD with maleic anhydride (MAH) in N, N-dimethylformamide (DMF) at 80°C. The poly (NIPAAm-coMAH-CD) was formed by copolymerizing the monomer with NIPAAm. The equilibrium swelling ratio of the hydro-gel clearly increased as the pH increased. At a certain pH, the equi-librium swelling ratio rose with rising temperature, but it dropped precipitously near the temperature at which the phase change occurred. The temperature/pH dual-sensitive hydrogel has several possible applications in the field of smart textiles. Grafting temperature-pH dual-sensitive hydrogel onto the surface of fiber or cloth makes it environmentally responsive. It is believed that the fragrance molecules in -CD may be made to release their aroma in a sustainable manner by adjusting the pH or temperature. Novel deodorant fabrics could be made by incorporating fragrance molecules into the -CD. **[99]**

Hydrogel, a supple material made of temperature-sensitive polymers, may find use in the textile sector. To regulate the water-repellent properties of the Smart Skin TM inner layer of wetsuit fabric, Midé Technology Corpo-ration (USA) used the hydrogel, a thermoresponsive polymer. At a transition temperature that depends on the relative concentrations of the copolymer components, the volume of this thermosensitive layer—which is mostly a co-polymer of hydrophilic and hydrophobic components—changes quickly. Almost identical to the gel's transition temperature is the internal temperature of the suit. The diver might use the suit as a kind of protection when diving. As the diver becomes hot, the gel contracts, letting more water through the wetsuit to keep them cool. When the internal temperature of the suit drops below the transition temperatures of the gel, Smart Skin TM expands to reduce water flow and slow down the rate of heat loss. Although the two suits provide almost comparable protection in warm water, the optimal Smart Skin TM pattern provided a substantial 70% increase in protection in cold water compared to a normal suit. Because of the difficulty in removing the adsorbed ions—essential for a reversible transition—a freshwater gel would not function well in saltwater. There is a clear transition temperature for salt-water gels, even if they may expand in freshwater. The reversal of the process is made easy by the absence of ions. Midé estimates that the United States comprises between seventeen and twenty-five percent of the world's wetsuit industry, with a value ranging between seventeen and two hundred and twenty million dollars. **[100]**

Creating a functional textile-based material for topical skin application included attaching a thermos-responsive hydrogel to one side of an absorbent nonwoven fabric. A thermos-responsive hydrogel was readily and rapidly produced by chemically coupling poly(ethylene glycol) and poly(-caprolactone) using hexamethylene diisocyanate (HMDI). The molecular blueprint of the as-prepared triblock copolymer hy-drogel was provided by 1H NMR and FTIR studies. The hydrogel showed great promise as a drug-controlled release material, and its sol-gel transition behavior was temperature-induced. At around 34 °C, it became a moisture management system, allowing for the unidirectional flow of fluids (sweat, blood, etc.) from the hydrophobic hydrogel-coated side of the fabric to the uncoated side. It was shown that the textile materials coated with thermos-responsive hydrogel could maintain a clean, breathable, and pleasant atmosphere for a long time. This suggests that they have great promise for long-term skin treatment. Structure, surface morphology, in vitro drug release behavior, and unidirectional water transport mechanism of the thermos-responsive hydrogel were studied in detail. The successful development of functional textile composites would pave the way for the production of other functional materials based on textiles or polymers, which might find value in real-world scenarios. **[101]**

Summary

Polymers, a type of natural polymer, have been present on Earth since ancient times and are essential for various forms of life. Synthetic polymers emerged in the early 20th century and are modern materials with limitless possibilities for building various polymers through chemical reactions. They are used in various areas of human endeavor, including everyday items like clothing, shoes, furniture, electrical and electronic appliances, packaging, utensils, automobile parts, coatings, paints, adhesives, tires, and more.

Polymers are the most adaptable of all materials, covering a wide range of mechanical qualities from soft gels to strong fibers. Their properties are determined by the way molecules repeat and interact with one another in their lengthy chains. Semi-synthetic polymers are created by altering natural polymers, such as cellulose acetate.

SMART polymers, such as shape memory polymers, intelligent/adaptive polymeric gels, phase change materials (PCMs), color change polymers, and self-healing polymers, significantly impact the textile industry. Shape memory polymers can memorize a permanent shape and can be deformed and fixed in temporary configurations. They can be used to create fibers and fabrics that can easily regain their original shape when heated over the shape memory switch temperature.

Gel is another type of material that exists between a solid and a liquid state of matter and can be cross-linked through physical or chemical connections. Polymeric gels can be divided into distinct types based on their origin, solvent medium, and crosslinking involved during gelation.

Poly (isopropyl acrylamide-co-maleic anhydride-cyclodextrin) is a new hydrogel developed by Liu and Fan36 that exhibits pH and temperature sensitivity and molecular inclusion function. Thermos-responsive polymer hydrogel has potential use in the textile industry, controlling the permeability of wetsuit fabric (Smart Skin TM) and maintaining a clean, breathable, and pleasant environment over an extended period.

Funds

No fund

Conflict of Interest

The authors declared no competing interests in the publication of this article

Acknowledgment

The authors are gratefully grateful to acknowledge the National research Centre.

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دراسة عن البوليمرات التقليدية والذكية، مع التركيز على استخداماتها الجديدة في صناعة النسيج

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المستخلص .

يتضمن هذا الاستعراض المعلومات الأساسية حول البوليمرات والبوليمرات الذكية، وهي مواد يمكن أن تحدث تغييرات ملحوظة في خصائصها الفيزيائية أو الكيميائية مع التحفيز البيئي. يمكن تقسيم البوليمرات الذكية إلى العديد من الأنواع مثل البوليمرات المتغيرة اللون، وبوليمرات شفاء الرف، وبوليمرات ذاكرة الشكل، وهلام البوليمر الذكي. من خلال دمج البوليمرات الذكية في المنسوجات، يمكن إضافة وظائف جديدة إليها. لتحسين أو إنشاء قدرات ذكية للمنسوجات، تم تطبيق البوليمرات الذكية، مثل الهلاميات الحرارية والحساسة لدرجة الحموضة، والبوليمرات الحرارية والرطوبة والضوء، على المنسوجات. تتم مناقشة تطبيقات البوليمرات الذكية في صناعات المنسوجات والملابس.

الكلمات المفتاحية: البوليمرات، البوليمرات الذكية، المواد المستجيبة للمحفزات، بوليمرات الذاكرة الشكلية، هلام البوليمر الذكي، النسيج الذكي