ADAPTIVE TEXTILES - BASIC ELEMENT OF DAILY LIFE

EFTALEA CĂRPUŞ, ANGELA DOROGAN

The National Research & Development Institute for Textiles and Leather, 16, Lucretiu Patrascanu Str. Sector 3, Bucharest, Romania, eftalea.carpus@certex.ro, angela.dorogan@certex.ro

In society there is a high interest for materials that provide a good answer to many contemporary requirements materials that "stress" the environment as little as possible. In recent years, the international scientific world focused its efforts on developing new ways for obtaining polymers, their diversification, in particular by "copying what exists in nature" and the translation of the design center of gravity to the nano – micro level. Currently, new materials are those that respond to the use requirements that are fundamentally designed to meet the demands of smart devices and are environmentally friendly. Adaptive polymers are a high interest area in terms of innovative design, structure, properties and potential application areas.

Keywords: textile, functionalities, adaptive.

OVERVIEW

In society there is a high interest for materials that provide a good answer to many contemporary requirements materials that "stress" the environment as little as possible. In recent years, the international scientific world focused its efforts on developing new ways for obtaining polymers, their diversification, in particular by "copying what exists in nature" and the translation of the design center of gravity to the nano – micro level.

Thus, the convergence in action and the multi-disciplinarity in diversity of design-research-innovation teams defined a new generation of products and related technologies, developed and / or hybrid, in all economic, social and cultural domains. All these actions enabled the development of products with functionalities that scan from passive to active and even bio-intelligent. Textile elements are worldwide recognized as a binder element and a support for nano-functionalities, arising from various fields of science such as chemistry, biology, materials science, information technology and communications etc.

Both in terms of textile components (polymers, fiber, web, strip, yarn) and also the main textile products (woven fabric, knitted fabric and clothing), these functionalities (nonspecific textile field) were attached by various methods (non-textile technologies, hybrid technologies and even textile technologies) on the fabric surface at any level, nano, micro, meso and macro.

Currently, new materials are those that respond to the use requirements that are fundamentally designed to meet the demands of smart devices and are environmentally friendly. Adaptive polymers are a high interest area in terms of innovative design, structure, properties and potential application areas.

ADAPTIVE TEXTILES IN THE CONTEXT OF ADAPTIVE POLYMERS

As smart materials, the adaptable polymers can rapidly, controllable and predictable change their own shape, under the influence of external stimuli. The amplitude, intensity or response frequency of the adaptable polymer are significantly higher compared to the energy developed / expressed by external stimuli (Galaev and Mattiasson, 1999; Hoffman and Stayton, 2004).

The adaptive textile elements/products represent the smart textile category that, after sensing for a short time - via a sensitive element - an external stimulus (default textiles), will compare / analyze information and for a preset threshold, will initiate an answer back to the emitted stimulus environment. The active element of these textiles is an adaptive polymer that is embedded into textile structure at a certain level (nano, micro, meso, and macro).

The adaptive textile elements/products are part of the generation of functionalized textiles.

ADAPTIVE POLYMER TYPES

Adaptable polymers are also called polymers that respond to stimuli by changing. The changes refer to the following levels: size, surface appearance and some features. Examples of stimulants are (Galaev and Mattiasson, 1999; Hu and Chen, 2010): pH, temperature, electric and magnetic fields, mechanical stress, enzyme substrate, agents and chemical solvents, electromagnetic radiation, sonic, biochemical agents.

A number of adaptive materials as: hydrogels-type, particles-type, surface appearance memory polymers-type, smart fiber /films-type, smart textiles-type are known. Some cyclodextrin and chitosan derivatives and copolymers are also part of adaptive materials category.

Energy that mediates the answer received by adaptive material may be: non-covalent interactions type, hydrophobic-type, coulomb forces-type, hydrogen bonding-type, van de Waals-type.

Change Surface Appearance Polymers

- If a material is under the influence of a stimulus like: heat, light, pH, it deformes, and remain in that form for a limited period of time, then returns to its original shape. The applications are numerous in terms of smart textiles, some adaptive facilities, sensors and actuators;

- If a material is subjected to a thermal stimulus, mechanical, electrical, magnetic, it will record a variation in technical parameters such as surface appearance, position, strength, friction etc.

In general, the architecture of such a polymer comprises two basic components, namely: “switch” and “network node”.

The “switch” can be represented by: various limit states, such as crystallization, amorphous, liquid-crystalline phase, supramolecular hydrogen bonds, reversible networks, nano-composite filtration networks;

Network node can be defined by: physical bonds, chemical bonds, and other polymeric bonds (Hu and Chen, 2010).

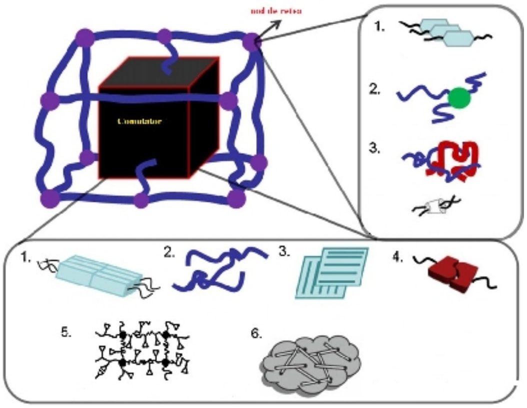

Figure 1. The drawing of the molecular structure of such polymers

Adaptive Hydrogels

- Adaptive hydrogels are polymers that swell in the presence of water and are characterized by 3D shape. The most common applications are related to the temperature and pH stimuli adaptive hydrogels.

Adaptive Particles

- Adaptive particles are those polymers with a spherical shape that under the action of stimuli like: light, heat, temperature, pH, chemical, occurs specific changes. They can be found in the form of powder, suspension, etc. The changes that are frequently targeted are lateral surface and the size of these nanoparticles.

ADAPTIVE TEXTILE TYPES

Adaptable polymers for textiles define groups with specific functionalities, namely: adaptive textiles for thermoregulation with memory shape change, color changing capability, luminescent, conductive.

Phase Change Materials – Materials that Change its State

Use of phase change materials for thermal energy storage has been practiced for several years. Setting the temperature according to body and environment temperature is achieved using phase change materials (PCM - bifunctional microcapsules).

There are two major application categories of phase change materials, namely, temperature control applications (consisting in maintaining an environment temperature at a constant value) and of heat or cold storage applications. Heat can be delivered or extracted from a phase change material without a major change in temperature. The materials capable to alter the state are substances that absorb or release significant amounts of energy during melting process, solidification or sublimation. These materials absorb energy during the heating process when the phase change takes place and in case of cooling process energy can be transferred to the environment while returning to the initial phase (Bajaj, 2001).

Figure 2. Drawing of the operating principle of phase change materials (Phase Change Materials Panels and Balls, 2016)

As materials for storing and reusing the latent heat, inorganic salts and mixtures of salts and paraffin can be used. The effect of thermal barrier for a fabric depends on caloric storage capacity of PCM microcapsules, their quantity and structure of the textile support. When using paraffin, the energy type is the phase change latent heat, stored heat is 200 kJ / kg and the temperature may vary in the range 5°C - 30°C.

The phase change fibers or yarns are used in manufacturing of products for sporting activities, protective equipment for home textile or medical fields.

Shape Memory Materials - Material that Store Shape

These materials are defined as materials that are able to “remember” its original shape and can return to it. The effect is due to thermal or magnetic changes (Smart Technologies for stress free AiR Travel - AST5-CT-2006-030958, 2006). The term for materials that store shape include four classes, namely: alloys (SMA), ceramics (SMC), polymers (SMP) and ferromagnetic alloys (FSMA) differentiated by material type / nature and reaction stimulus type. Those that are used in textile field are the SMP class where everything is based on two polymer properties - elasticity and plasticity. The memory effect consist of the ability of the material to resume form, before the plastic deformation, by simply changing the temperature.

The polymer matrix contains two components, one with higher melting temperature (Cook *et al*., 2005) that can turn into fiber by wet, dry or melting spinning process, or by electrospinning. The fibers can be processed in order to obtain woven, knitted, nonwoven or braided structures (Gök *et al*., 2015), with a broad potential application in the field of protective clothing and medicine (implants, sutures).

Materials Capable of Changing Color - Chameleon

The ability to reversible change the color (due to change optical properties) in according with external environment in response to application of an electric field or electromagnetic, is characteristic of these materials. In accordance with scientific literature, the electro-chromic and electro-luminescence are two directions that can cause color change. Some organic, inorganic or polymeric materials present excellent electrochromic properties. Depending on the energy of external stimulus under the chromic materials react, they are classified as is Table 1:

Table 1. Chromic materials

Framing group	External stimuli
Photochromics	light
Thermochromics	heat
Electrochromics	electricity
Piezochromics	pressure
Solvatochromic	lichid
Carsochromic	electron flux

Chromatic materials are mainly a source of inspiration for designers of clothing that can change color depending on the amount of incident light.

Luminescent Materials

Luminescence is the emission of photons (light) generated when electrons back from the state of excitation to a lower energy state.

The difference between chromic and luminescent materials is that while the first group changes color, the second group emits light (Lakowicz, 2006).

Depending on the nature of the stimulus the following luminescent materials categories can be found:

- *Photo luminescence*: external stimulus is light, we have photo luminescent organic or mineral materials; they are used in the textile industry clothing (clothing destined for activities in nightclubs), or take the safety labels used to detect imitations/fakes; Phosphorescent materials (light emission continues after the period of existence of fluorescence) can be used for protective equipment in case of poor visibility conditions.
- *Electro luminescence*: include inorganic semiconductors, polymers, and small organic molecules; electricity is external stimulus; appropriate LEDs.
- *Chemical luminescence*: chemical reaction (oxidation reaction) is external stimulus
- *Optical luminescence:* it is common in optical fibers widely used in textile sensor role in monitoring the body or environment conditions.

Materials with Conductive Properties

Electrical conductivity of textiles is a field-leading research. Clothing electrical conductive properties - “smart clothing” -uses special textiles or electronics integrated into the textile structure. For producing structures for conductive textile fibers and yarns, metal wires that contain certain levels of inorganic conductive material or conductive films can be used. As fields of use we can mention: professional health monitoring, sports and leisure activities, everyday life.

CONCLUSIONS

Currently new generation materials functionalized materials for passive, active, bio-intelligent are those that respond to the scope of use that are fundamentally designed to meet the demands of smart devices and are environmentally friendly. Adaptable polymers show an area of particular interest in terms of innovative design, the structures and the properties and potential application areas. Textiles are a viable way to introduce reliable in everyday life and in technical areas, these new generations of special polymers.

Acknowledgement

This article was made as a result of elaborate studies and partial results obtained in the project PN 16 34 02 09, in the framework of NUCLEUS, National CDI Programe.

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