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Structure And Properties of Thick Layer Polymer Materials

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Annotation: Thin polymeric materials are generally understood to be flat, film-like or paper-like non-woven materials with a thickness of nanometers to millimeters, and these materials are widely used in practice. Today, such materials include polymer films, natural and synthetic fibers.

Key words:Polymer, polyethylene film, silk cocoon, fibroin, fiber, fibrillar, nanoparticles, composites, nanocomposites

In the practical application of polymers, the role of flat materials, in which the thin thickness of the base is in the nano and micro ranges, is incomparably large, and they can be one or more layers [1]. Typically, layers are formed from the same or different materials, and each of these layers performs a specific functional function.

Examples of single-layer groups are polyethylene films [2], and multi-layers are silk cocoons (Figure 1). The basis of silk cocoon is fibroin fibers as a thin non-woven material, the surface of which is covered with layers of sericin and wax-oil [3]. The cocoon is a multi-layered material with a thickness of about 1 mm, which can be mechanically divided into flat layers of different thicknesses.

a b

Figure 1. Single-layer PE film (a) and multi-layer silk cocoon (b)

The film is in the range of the average relative mass of the polyethylene (PE) molecule obtained [4]. In view of its monomer linkage, they are connected to each other by covalent bonds. Given that the monomer link is a molecular mass, then the number of monomers in a polyethylene molecule is in the range. Due to the absence of eyebrow bonds between the monomer links, they twist very easily relative to each other and the length of the thermodynamic segment is 1.6 nm [5]. Therefore, the polyethylene molecule has a basic flexibility and forms lamellar (flat, plate-like) layered structures of individual polyethylene molecules with orderly thickness (L) from a few nanometers to microns and separated by firing chains (Fig. 2).

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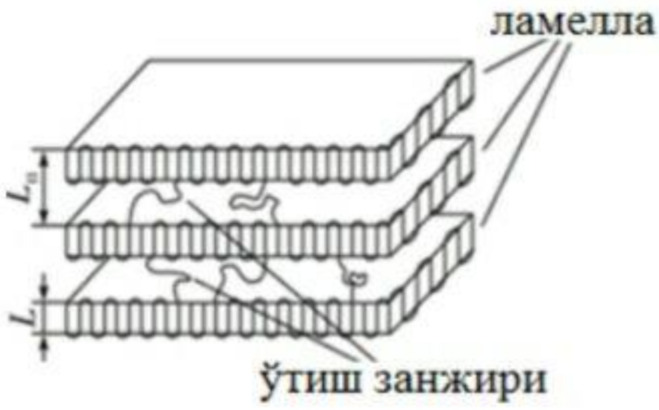
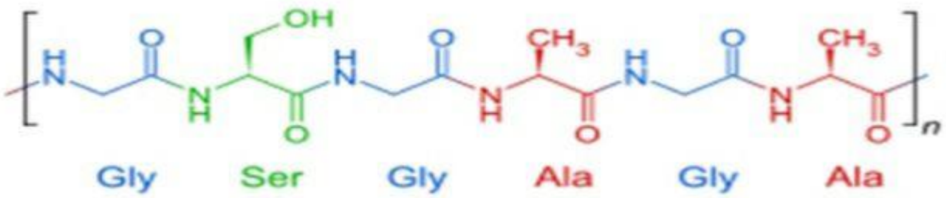


Figure 2. schematic view of the microtography of the polyethylene single crystal (b)

If the film is stretched mechanically, the physical state of the lamellar layers may change, or they may bend in the direction of elongation, or the lamellar layers may disintegrate and become oriented, forming fibrillar crystals. The mechanical elongation force transmitted by such lamellar fibrillar shoots can be controlled by the action of ambient heat [5]. In the lamellar state, the film is transparent and optically isotropic, while in the fibrillar state, the transparency is partially lost at the base and becomes optically anisotropic.

In contrast, although the silk cocoon is round in shape, in fact it is a flat thin material and its thickness does not exceed 1 mm [6]. It contains fibrillar protein - fibroin-based microfibers (thickness 7-10 microns) that are continuously folded into an octagonal shape to form a flat irregularity, which makes up 70-75% of the cocoon. The surface of fibroin fibers is coated with a globular protein - sericin, and the amount of sericin is 25-30%. The surface may also contain 3-5% of wax-oil and minerals. Fibroin fibers are separated by washing sericin and wax-oil and minerals in water-soda solvents at high temperatures () [8]. The fibroin molecule consists of a sequence of amino acid residues that are joined together by peptide bonds, to be more precise,



Its chemical formula is equal to the average molecular mass of the elementary link and the length of the -spiral segment is around 100-150 nm. The supermolecular structure of fibroin molecules in silk fiber is in the fibrillar-shaped amorphous-crystalline state (Fig. 3). In this case, the -shape, ie the proportion of the crystalline part is 40-70%, which ensures the strength of the fiber, while the non-crystallized - amorphous part gives the fiber high elasticity [7].

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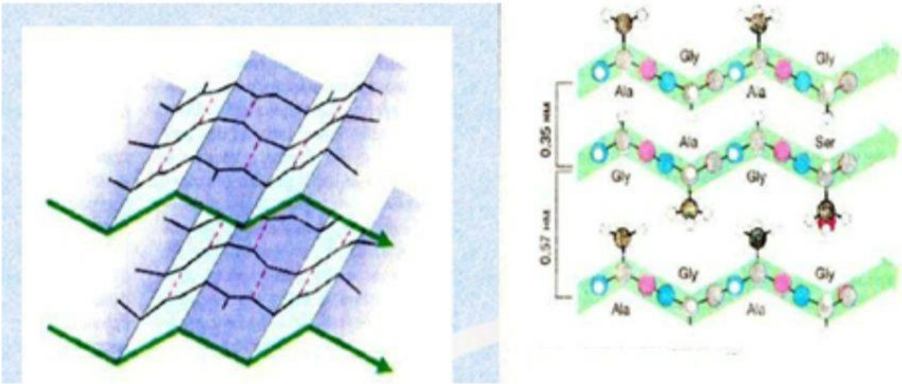

Figure 3. Fibrillar structure of the fibroin molecule

Approximately 30% of natural silk cocoon is recycled into fiber waste, and the basis of this waste is a valuable fibroin biopolymer, which requires the processing of various raw materials and products as an urgent task. In processing, first of all, it is necessary to separate fibroin fibers from wastes while maintaining the native state, to prepare fibroin solutions by dissolving the fibers without destruction and to form from them the formation of materials of different structure and properties [7,9].

Conclusion

Although a number of scientific studies have been carried out on the production of powders, sorbents, films, fibers, nanoparticles, composites, nanocomposites, coatings, as well as thin-layer materials from fibroin solutions, there is still a lot of research to be done. The task of creating methods and technologies remains one of the current scientific research tasks.

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