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Regenerated Milk Fiber: An Approach towards Green Textiles

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Introduction

Natural protein fibres like silk and wool express remarkable properties and are useful for various purposes. However, silk and wool fibres are produced in limited quantities and besides this, these fibres are uneasy about dissolving, modifying, or manipulating to achieve explicit properties for specific applications. Hence, with a perception to emulate natural silk and wool fibres an effort is made out to dissolve proteins and regenerate the proteins into fibres (man-made protein fibres) using various ways. In this light, a man-made protein fibre was produced by dissolving the casein protein from milk in diluted alkali and extruding these solutions through a spinneret into an acid-formaldehyde coagulating bath. Regenerated protein fibres also called azlons are man-made fibres produced from either animal or vegetable non-fibrous proteins which have been reconfigured to take up a fibrous form to emulate the major protein fibres and their characteristics. Blood, castor oil seeds, collagen, egg white, fish albumen, hair, casein from milk, soya beans, sunflower seeds, peanuts, zein from corn (maize) etc., are some sources for regenerated protein fibres. For international ecological textiles, milk fibre has received oeko-tex standard 100 green certifications. Micro-zinc ions are embedded in the fibre during the wet spinning process, which uses a special spinning solvent. After drying and treatment, zinc oxide is formed, making the fibre durable and bacteriostatic. Most casein fibres are produced as a staple, tow, or top.

Casein

Casein is the fundamental protein found in the milk of bovine animals which accounts for approx. 80% of the protein content of cow's milk. It is responsible for the white, opaque appearance of milk in which it is combined with calcium and phosphorus as clusters of casein molecules, called 'micelles' [1]. Casein fibre was developed in the 1930s in Italy and America to emulate wool fibre. Aralac, Lanital, Merinova are all different brands for the fibre manufactured from casein.

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The production process of casein fibre

Casein protein is extracted by acidifying the milk. The casein protein then coagulates and forms a curd that is washed, dried, and then powdered to a fine consistency. In a solution of caustic soda, casein is dissolved. The mixture is filtered and deaerated after being left to ripen until it achieves the proper viscosity. The casein polymers are spun by the wet spinning technique. Here, the spinning solution is extruded via spinnerets into a coagulating bath containing water, sulphuric acid, glucose and some hardening agent. Then the casein polymer coagulates and forms continuous filaments, which are later collected as tow. The casein filaments are later cut into preferred lengths to blend with other fibres like wool, cotton, viscose, etc. to produce a final product (Figure 2).

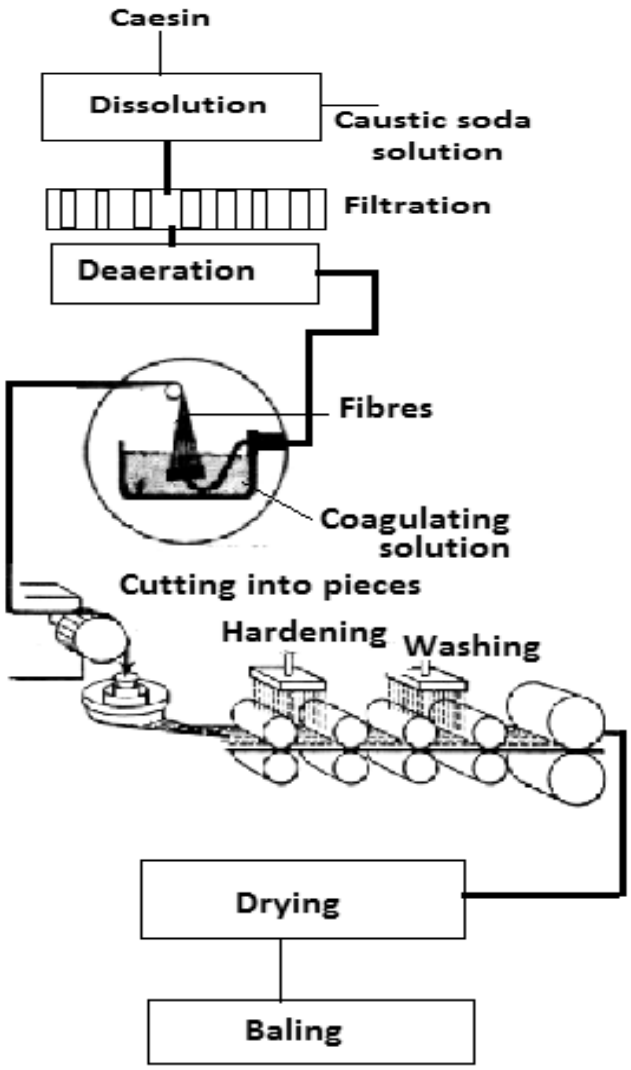

Figure 1. Flow chart of milk fiber manufacturing [2]

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Physical and chemical properties of milk fibre

Casein is chemically very alike in chemical composition to protein in wool as shown in Table 1 [3]. Even though wool and casein fibres are chemically very similar, they can be easily distinguished physically as wool fibres possess scales whereas regenerated casein fibres lack them. Casein fibres contain less quantity of sulphur compared to wool fibres, which explains the fewer or no disulphide bonds in the fibre structure, further corroborate by the reduced fibre strength and lesser resistance to chemicals than the wool fibres (Table 2). The major amino acids in casein are leucine (19%), glutamic acid (22%), proline (11%) and lysine (8%) [4].

The physical properties of casein fibres compared with other natural protein fibres like silk and wool are depicted in Table 2. The tenacity of casein fibre (0.8-1.1 g/den), density (1.30 gm/cm^3), and moisture regain (14%) properties are almost similar to the properties of silk and wool fibre. Casein fibres have good resistance to acids whereas bad resistance to alkalis and ultraviolet rays.

Table 1-Chemical composition of casein and wool fibres

Elements	Casein fibre	Wool fibre
Carbon (%)	53.0	49.2
Hydrogen (%)	7.50	7.6
Oxygen (%)	23.0	23.7
Nitrogen (%)	15.0	15.9
Sulphur (%)	0.70	3.6
Phosphorous (%)	0.80	-

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Table 2 – Comparative properties of casein, silk and wool fibres

Properties	Casein	Silk	Wool
Tenacity (g/den)	0.8-1.1	1-1.5	1.5-2.0
Elongation (%)	15	25-45	25-40
Density (gm/cm^3)	1.30	1.34-1.38	1.33
Moisture regain (%)	14	11.0	14-16
Acid resistance	Good	Excellent	Excellent
Alkali resistance	Bad	Good	Bad
Resistance to moth/fungus	Resistance to fungus but not to moth	Resistance to fungus but not to moth	Resistance to fungus but not to moth
U.V resistance	Bad	Bad	Bad

Microscopically casein fibres, longitudinally (Fig. 2a), look uniform, smooth and almost featureless, having faint striations and some surface graininess. In the cross-section view (Fig. 2b), they are almost circular. Additionally, delustrants showed up as small specks in the casein fibres and made the fibre look dulled [5].

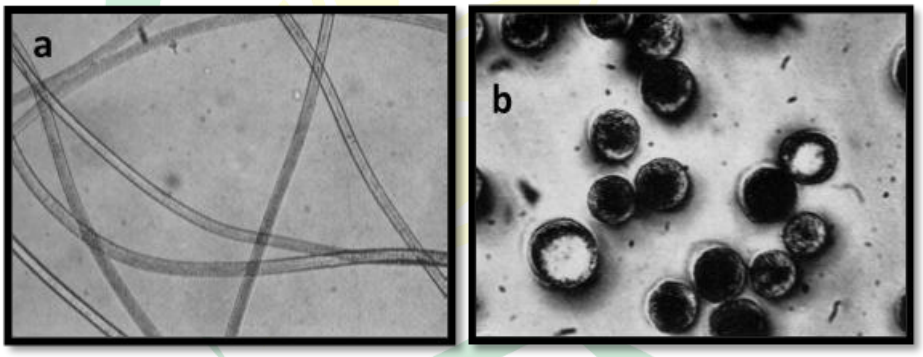

Fig. 2- Longitudinal (a) and cross sectional (b) view of casein fibre

Benefits of Milk Protein Fiber:

At present, casein fibres are eco-friendly, high strength and much finer as compared to man-made fibres. Some of the gains of having milk fibre are as listed below [6]:

- Graft polymerization technique makes it totally environmentally friendly.
- It can be regarded as a “Green Product” as no formaldehyde is present in the final product.
- Milk protein fibre is made from milk casein instead of fresh milk. The varieties of acid, reactive or cationic dyes could be used for their colouration.

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- Casein fibre has a pH of 6.8 which is that of human skin. Hence, the final products made will be much more compatible with human skin.
- As casein fibres are bio-degradable, they can be explored in medical textiles as an aid in wounds, surgical sutures, etc.
- These fibres are more comfortable, with excellent air permeability and water transport properties.

The major uses of casein fibres

The regenerated milk fibres have multifunction applications in various textile fields. The major application of this fibre in making sustainable garment products like T-Shirts, undergarments, sportswear, ladies' outerwear, sweaters, children's garments, eye mask, socks and hats, and in other technical textiles applications such as home textiles, automobile industry, medical textiles, hygienic diaphragms, etc. [6].

Conclusion

In light of sustainability and eco-friendly manufacturing, textile industries have begun to use alternatives for synthetic materials. They are either investigating new natural materials, recycling industrial or agro-waste, or, in some circumstances minimizing the usage of synthetics and chemicals. Casein fibres are regenerated protein fibres derived from milk. Environmentally friendly methods of processing casein fibres have been developed recently. Due to its excellent moisture absorption and smooth texture, casein fibre has a variety of properties that make it extremely useful in sports technology. In addition, casein fibre is said to have a built-in antimicrobial action. This creates a plethora of brand-new opportunities for the medical industry. Due to its low environmental impact, casein fibre utilization is anticipated to rise in the near future.

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