European Journal of Emerging Technology and Discoveries
ISSN (E): 2938-3617
Volume 4, Issue 4, April - 2026

STUDY OF THE SIZE AND DISTRIBUTION OF SILK FIBROIN MICRO- AND NANOPARTICLES BY DYNAMIC LIGHT SCATTERING

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Abstract
In recent years, particular attention has been paid to studying the physical properties of biopolymers at the nanoscale. In particular, one of the pressing issues is the formation of functionally active micro- and nanoparticles and composite materials based on them. Therefore, the production of bioeffective, surface-active polymeric materials suitable for various purposes, the determination of their structure and properties, and the exploration of practical applications are important scientific challenges in the field of polymer physics.

Keywords: Hydrolysis, deformation, silkworm Bombox mori, diketopiperazines, peptide.

Introduction

Hydrolysis of silk waste and uncondensed cocoon fibers is preceded by hydrolysis and denaturation of the three-dimensional protein structure, which facilitates the cleavage of peptide bonds [1-3]. It is known that not all peptide bonds are easily cleaved; the most stable are those formed by leucine, isoleucine, and valine. Furthermore, secondary products, particularly diketopiperazines with new three-dimensional structures, can be formed during hydrolysis [4-7].

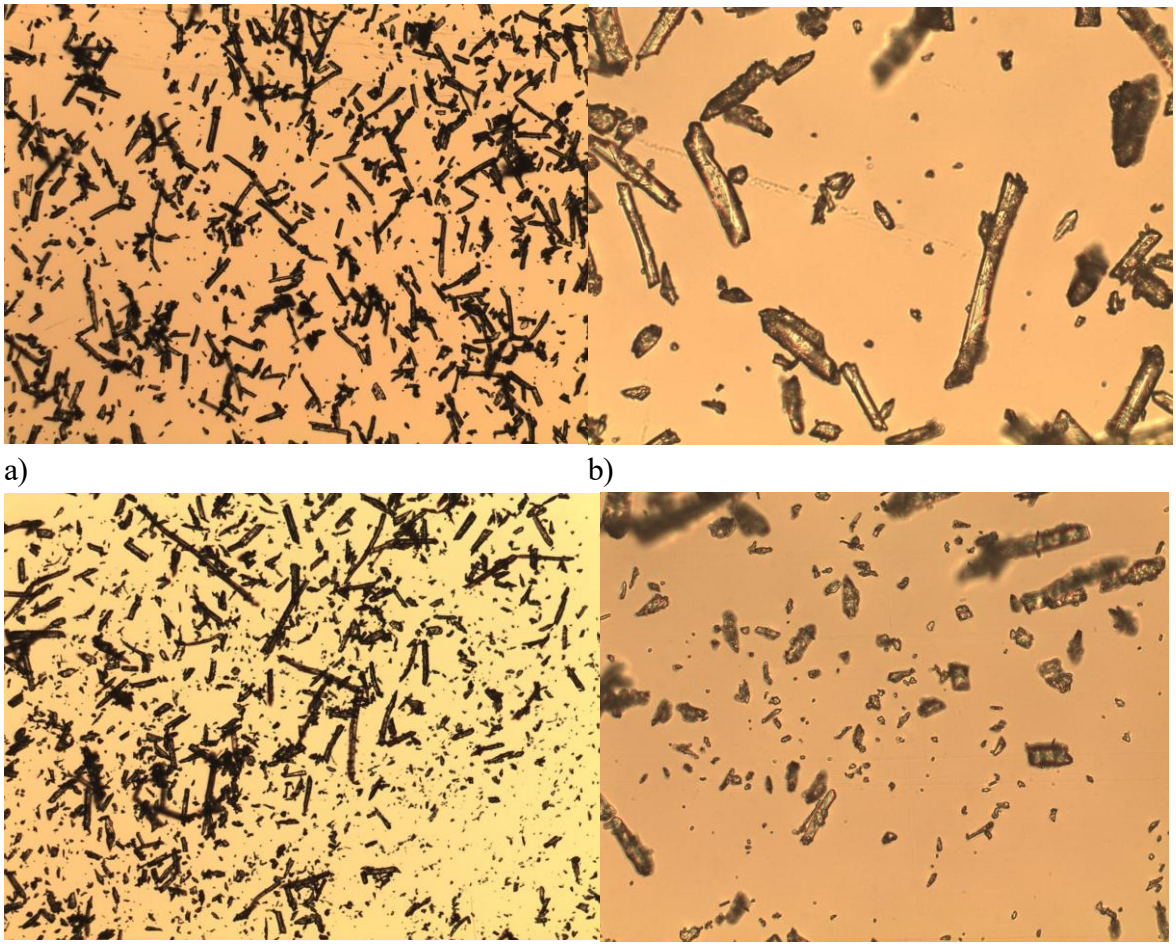
Results and Analysis

Fibroin micro- and nanoparticles obtained by hydrolysis can be used without further processing. However, the dependence of the composition and characteristics of the resulting fibroin micro- and nanoparticles on hydrolysis conditions remains unclear. The key properties of the hydrolyzed product, which determine its use in medicine and cosmetology, depend on the specified parameters (including solubility and bioactivity).

As can be seen from the figure, alkaline hydrolysis of fibroin at a 1:6 ratio at 180°C for 120 minutes produces fibroin microparticles measuring 35-40 μm.

Microscopic examination revealed that the original natural silk fibroin sample is a long, thin fiber with bright fluorescence in polarized light, indicating its anisotropy. After hydrolysis in NaOH, the fibers are strongly reduced: rod-shaped particles of varying thickness are observed, resulting in transverse separation of the natural silk enzyme during hydrolysis. These particles glow brightly in polarized light. With increasing alkaline hydrolysis time in a 1:5 module (15

minutes, 180°C), fibroin acquires micro- and nanosized amorphous particles. The particle size distribution through a 008 mesh is 95%. It is virtually insoluble in water, and the bulk density is 650-750 kg/m³. Dynamic light scattering (DLS) studies were conducted on dispersed fibroin particles obtained by alkaline hydrolysis.



a) b)

c) d)

Microscopic image of fibroin obtained by alkaline hydrolysis.

The experiments showed that the particle size ranges from nano- to micro-sized, and the polymodal particle distribution depends on the state of their extraction.

As shown in Figures A and B, silk fibroin micro- and nanoparticles are formed as a result of hydrolysis depending on the alkali concentration and hydrolysis time. At a modulus ratio of 1:6, a hydrolysis time of 120 minutes, and a temperature of 180°C, the proportion of particles is 2% 68 nm, 78% 416 nm, and 20% 240 μm. At a modulus ratio of 1:5, a hydrolysis time of 150 minutes, and a temperature of 180°C, the proportion of particles is 7% 80 nm, 13% 406 nm, and 80% 18 μm.

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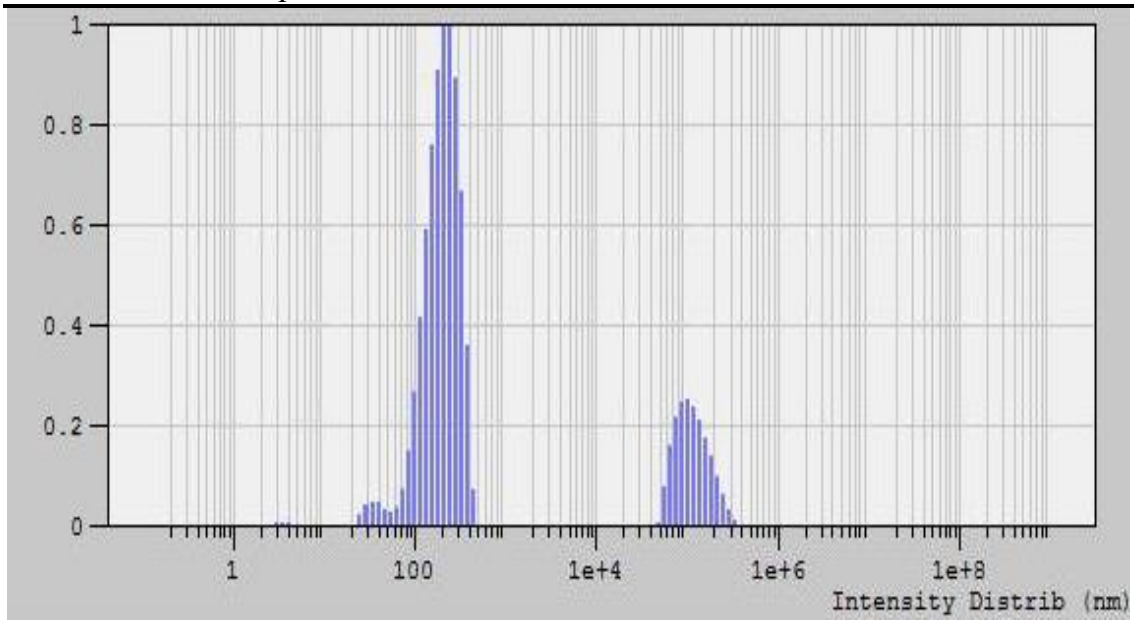
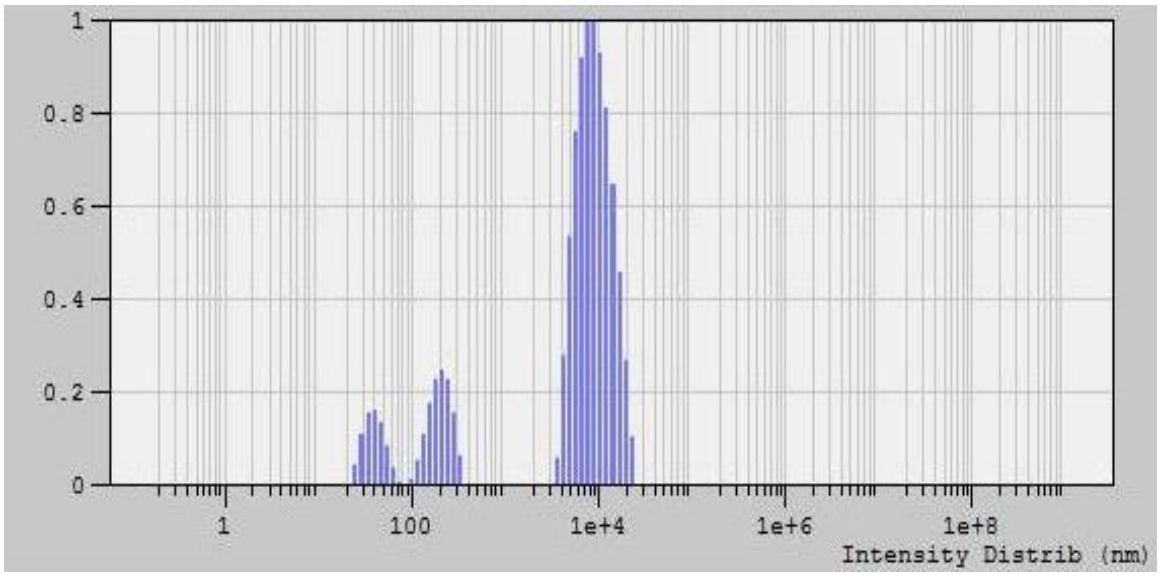


A)



B)

Distribution of fibroin particles obtained under different conditions of alkaline hydrolysis: A – nanoparticles; B – microparticles.

Conclusion

1. Optimal hydrolysis conditions for producing microdispersed and nanoparticle silk fibroin were determined;
2. The size and distribution of micro- and nanoparticles of silk fibroin were assessed, and the dependence of hydrolysis process parameters on the structure and properties of materials based on them was studied.

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