Journal of Physical Chemistry and Functional Materials

Home Page of Journal: https://dergipark.org.tr/jphcfum

A study on Optical Applications of Silk Fibroin Biomaterial

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ABSTRACT

Silk fibroin (SF) is a natural substitute used in biological medicine for its good biocompatibility and biodegradability. Compared to other easily degradable (biodegradable) materials, they exhibit excellent properties, such as excellent mechanical properties, optical properties and electrical insulation, which are advantageous in the development of materials made from silk bromine, flexible electronics. In here, optoelectronic parameters such as optical band gap, transmittance, dielectric constant and conductivity components of the silk fibroin solution were obtained and were discussed for biomaterial applications.

ARTICLE INFO

Keywords:
Silk,
silk fibroin,
biopolymer,
optoelectronic parameters,
optical band gap

Submitted: 20-May-2020,
Accepted: 12-June-2020
ISSN: 2651-3080

1. Introduction

Silk (S) is a natural semi-crystalline biopolymer [1]. Fibroin (F) protein is the main structural component of silkworm cocoon fiber. Silk fibroin (SF) is a natural protein polymer [2]. Bombyx mori silk consists of two types of protein, fibroin and sericin [1]. In recent years, silk fibroin (SF) has been extensively studied in many biomedical applications thanks to its excellent biocompatibility, biodegradability, minimal inflammatory effect and superior mechanical properties. They are used in different fields, especially in biological applications, medicine and structural mechanics. Although SF has been used in biomedical applications for centuries, it is still widely used today as technological material. SF offers great potential for use in medically relevant applications due to a lack of immune response and high biocompatibility [3-7].

In this manuscript, the fibroin silk solution, which is made of 100% fibroin protein was used. Optoelectronic parameters (e.g., optical band gap, transmittance, dielectric constant and conductivity components) of the silk fibroin solution were obtained and were discussed for biomaterial applications. Several SF structures have been reported as seen in Fig. 1 [8].

2. Results and Discussion

The optical properties of a material can be investigated by measuring UV spectra. The absorbance (Abs) and transmittance (T) spectra of SF were recorded. Figure 2 shows the Abs spectra of SF material. Figure 2a emphasizes that the Abs spectra of SF are dominant and exhibit maximum peaks (275 nm) in the NUV region.

To investigate the optical behaviors of the SF protein polymer-solution, the transmittance (T) measurement was taken. The plot of the T vs. wavelength (λ) of the SF is shown in Figure 2b. The T values of SF predominate in the visible region and increase very sharply in the range of about 290-320 nm.

Absorption band edge and optical band gap are important parameters in bio devices and biomaterial-based applications. To obtain the absorption band edge of the SF protein polymer solution, the dT/dλ curve vs. λ was plotted (Fig. 3a). The absorption band edge of the SF protein polymer was found to be 3.982 eV. The optical band gap can be estimated from the Tauc relation and from the $(\alpha h\nu)^2$ plot vs. photon energy (E) as seen in Figure 3b. The optical band gap of the SF protein polymer was found to be 3.974 eV. This optical band gap is compatible with the absorption band edge value.

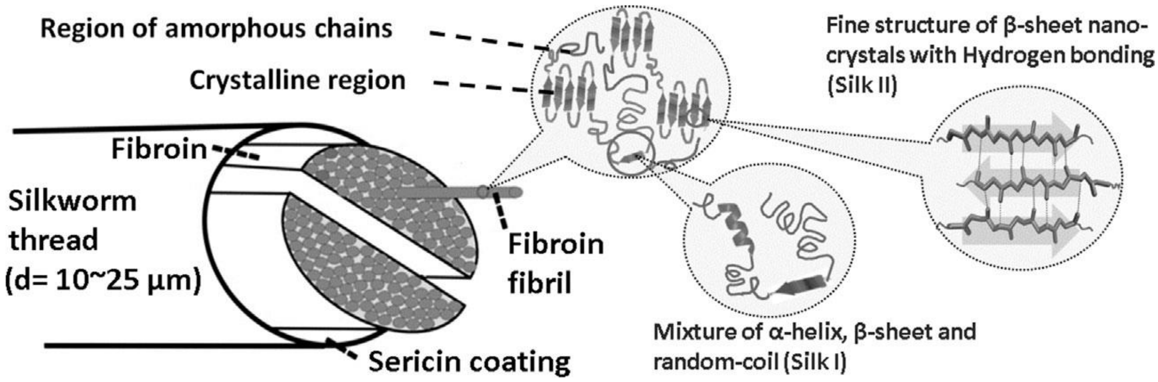

Fig. 1. Schematic representation of the deduced SF structure [7,8].

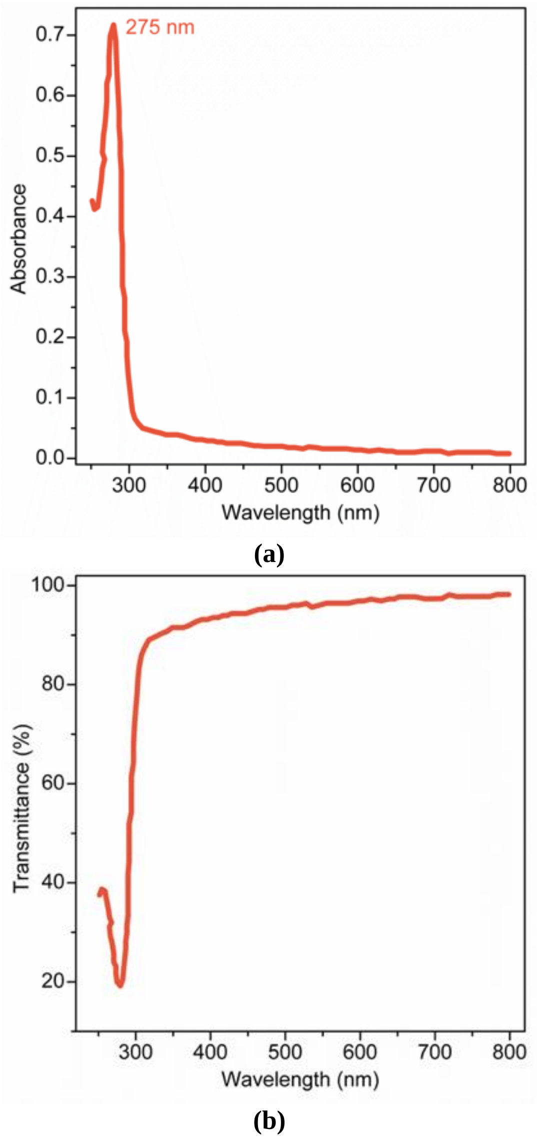

Fig. 2. The **a)** absorbance **b)** transmittance spectra of the Silk Fibron solution.

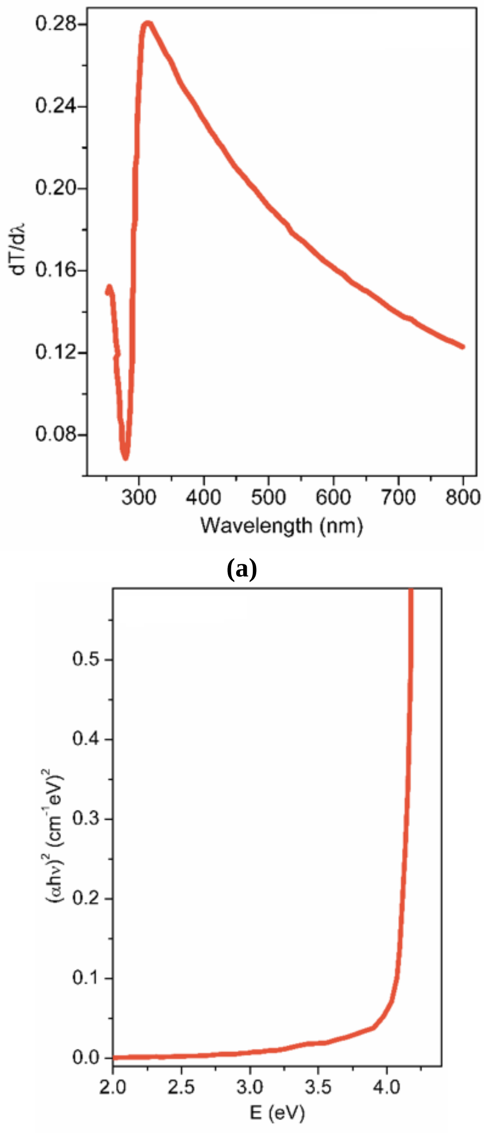

Fig. 3. The **a)** dT/dλ curve vs. λ **b)** $(\alpha h\nu)^2$ curve vs. photon energy (E) of the SF.

The optical conductance (σ_{op}) and electrical conductance (σ_{elec}) of the SF protein were obtained from the related equations [9]. Fig. 4. shows the σ_{op} and σ_{elec} curves vs. E of the SF material. The maximum σ_{op} (about $3.10x10^{10}$ S) and σ_{elec} (about 280 S) values of the SF protein polymer were observed.

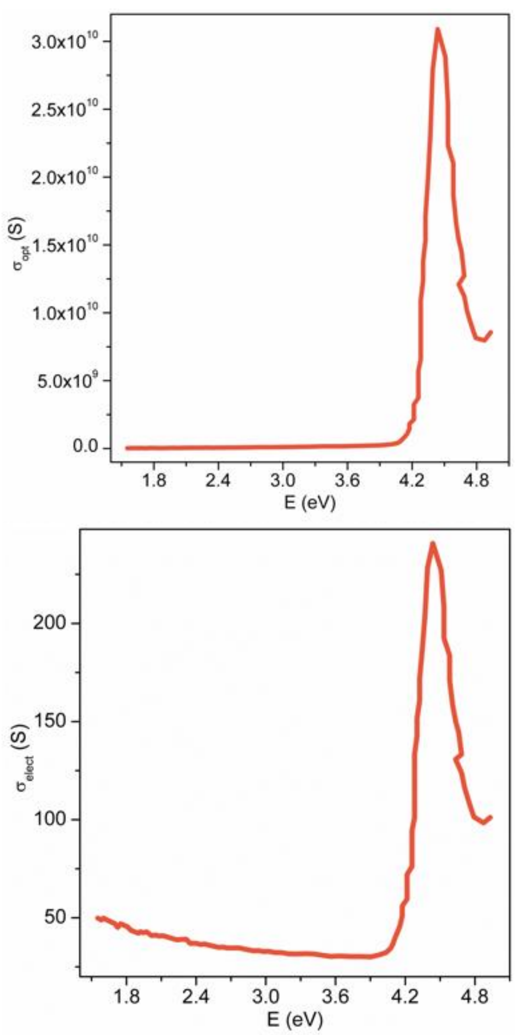

Fig. 4. The σ_{op} and σ_{elec} curves vs. E of the SF material.

3. CONCLUSION

We investigated the optoelectronic properties of silk fibroin solution for biomaterial applications. The silk fibroin is a suitable material for biomaterial devices. Because the absorption band edge and optical band gap values of silk fibroin material are ideal for these devices. We also compared the optical and electrical conductivities of the silk fibroin. We have determined photon energies where their conductivity is highest and lowest. The silk fibroin is ideal for bio-devices in the 4 eV band.

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