International Journal of
Health Systems and Medical Science

ISSN: 2833-7433
Volume 1 | No 3 | Sep-2022

Receiving New-Age Wound Treatments for Biomedical Purposes

A Goyibnazarov Ilkhom Shukhrat ugli., Yuldoshov Sherzod Abdullaevich., Sarymsakov Abdushkur Abdukhalilovich

Laboratory Chemistry and Technology of Cellulose and its Derivatives, Institute of Polymer Chemistry and Physics, Uzbekistan Academy of Sciences, Tashkent, Uzbekistan

Abstract: In this research, we studied the physicochemical features of dialdehydecarboxymethylcellulose (DCMC) samples generated by oxidizing pure sodium carboxymethylcellulose (NaCMC) samples in order to acquire novel medications for the treatment of different skin wounds and post-operative procedures. Under ideal circumstances, the mass ratios of sericin (SS) and DCMC containing 70% aldehyde groups are 1:0.2, 1:0.4, 1:0.6, 1:0.8, and 1:1. Infrared (IR) spectroscopy was used to evaluate the samples in the proportions, and the physicochemical characteristics of the samples were investigated.

Keywords: dialdehydecarboxymethylcellulose, sericin, periodate oxidation, number of aldehydes, biodegradability, imine bond.

1. Introduction. The oxidation of NaCMC macromolecules with periodate acid (HJO_4), a selective oxidizing agent, results in DCMC establishing a chemical connection with protein substances [1]. Modifications of DCMC samples with protein molecules are frequently employed in the therapy of bone tissue abnormalities [2]. Bone cell regeneration and proliferation are features of DCMC-based composites [3]. Oxidative aldehydes [4] improve the physicomechanical characteristics of natural proteins [5] and enable for regulation of biocompatibility and biodegradability [6]. Sericin is extremely important in biomedicine as a novel therapeutic drug [7]. It is utilized in medicine as a biomaterial for tissue engineering and regeneration procedures [8]. Biomaterials derived from protein substances and DCMC are frequently employed in tissue engineering for the treatment of inflamed and wounded tissues [9]. Furthermore, the effect of produced DCMC-SS composites on fibroblast cell growth [10] was investigated. Sericin comprises amino groups ($-RNH_2$) that make bonds with aldehyde groups, as well as carboxyl (-COOH) and hydroxyl (OH) functional groups with high polarity [11]. Sericin is hydrophilic because it contains 32.3% serine amino acid [12]. Compositions derived from DCMC have the virtue of dissolving in water [13]. As a result, the resulting compositions are often used in the domains of artificial skin and tissue engineering for therapy reasons [14]. When a composition was produced with DCMC, a new link was generated by creating chemical covalent bonds [15]. The number of aldehyde groups in the resulting samples was quantified chemically and confirmed using IR-spectroscopic techniques after DCMC was formed from CMC samples purified under optimum circumstances [16].

2. Method and materials

2.1 Materials.

Sodium hydroxide (NaOH) 99.0% and used to obtain Na-CMC. Ethanol with a purity of 99.08% was obtained from Ximreaktivinvest LTD. All chemicals used in this research were of analytical grade. Dialdehyde carboxymethylcellulose DCMC; Periodic acid (HJO_4) (CAS 10450-60-9); Laboratory magnetic stirrer ISO 9001:2015; Glasses dishes GOST 30407-96; Electronic balance GOST 8.453-82; Drying cabinet GOST 18663-78; Distilled water GOST 6709.

2.2 Obtaining a film of DCMC-SS

At 60°C, 0.012-0.048 g of DCMC samples are dissolved in 2 ml of distilled water. A 3.75% solution of sericin in 10 mL of water is produced. The resultant solutions are combined for 1 hour at 60°C. The resultant solution is dried in a petri dish at 37°C. The mechanical characteristics of the resulting films were investigated at temperatures ranging from 23 to 50 degrees Celsius. The effect of different temperatures on the mechanical characteristics of films was investigated.

2.3 Examination by infrared spectroscopy

Infrared spectroscopy was used to acquire spectra of CMC, DCMC, and DCMC-SS films at 25°C. The spectra have a width range of 400 cm^{-1} to 4000 cm^{-1}, with a need of 2 cm^{-1} for each point interval. Each sample was thoroughly examined and authorized as needed.

2.4 Scanning electron microscope

A 25 kV scanning Agilent Technologies 5500 microscope was used to examine the surface morphology of the DCMC-SS films.

3. The results obtained and their discussion

A 12% DCMC solution of 10 mL and a 3.75% sericin solution of 32 mL were produced. The prepared solutions were agitated for 1 hour at 60°C. The resultant solutions were put on petri plates and dried at a temperature of 37 degrees Celsius. The following graph explains the DCMC-SS derivation procedure. (fig.1).

Figure 1. Graphical representation of DCMC-SS film acquisition.

The mass ratio of sericin to DCMC was investigated in relation to the reaction yield. The yield of the manufactured product rose as the mass ratio grew. The outcomes are listed below (fig.2).

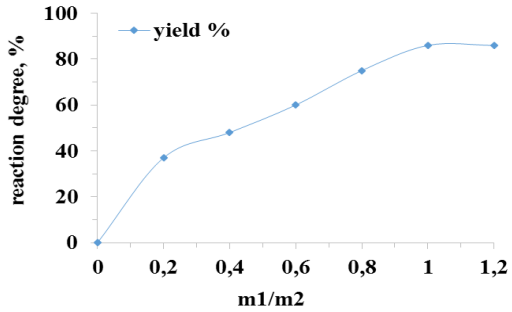

Figure 2. Dependence of increasing mass ratio on biodegradability.

Figure 2 shows that as the mass ratio grew, so did the yield of DCMC-SS complex. When the mutual mass ratio is identical, the product yield is 86%. The acquired results were validated using infrared spectroscopy (IR-spectroscopy) and scanning electron microscopy (SEM).

The functional groups in the DCMC-SS composite film were identified using the IR-spectroscopy approach. In this situation, the intensity of aldehyde groups in the 1738 cm^{-1} area of functional groups in DCMC altered. Aldehyde and amine groups combine to create a polar covalent link, known as an imine bond, which results in the formation of a composite. The intensity characteristic of the -COONa group in the DCMC and DCMC-SS composites remained unaltered during oxidation and composite production with sericin. The results ob $_{892,3}$ are shown below (fig 3).

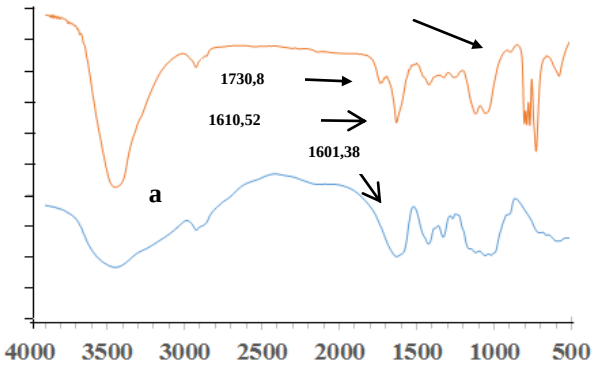

Figure 3. IR-spectroscopic results of α-DCMC, β-DCMC-SS composite film.

In the course of manufacturing the DCMC-SS composite film, it was discovered that there was no change in the intensity region of 1601 cm^{-1}, and a new intensity was produced in the area of 892 cm^{-1} as a result of inspection using the IQ-spectroscopic method. The creation of hydrogen bonds between molecules explains the new absorption intensity that results. That is, the creation of mutual hydrogen bonds with functional groups in DCMC is explained by the presence of carboxyl (COOH) and amine (NH_2) groups in sericin, which have hydrophilic qualities.

The DCMC-SS composite film's surface morphology was examined. In this example, the scanning electron microscope (SEM) was used to study the cross-composite film of SS, DCMC, and DCMC-SS, and the findings are shown below. (fig 4).

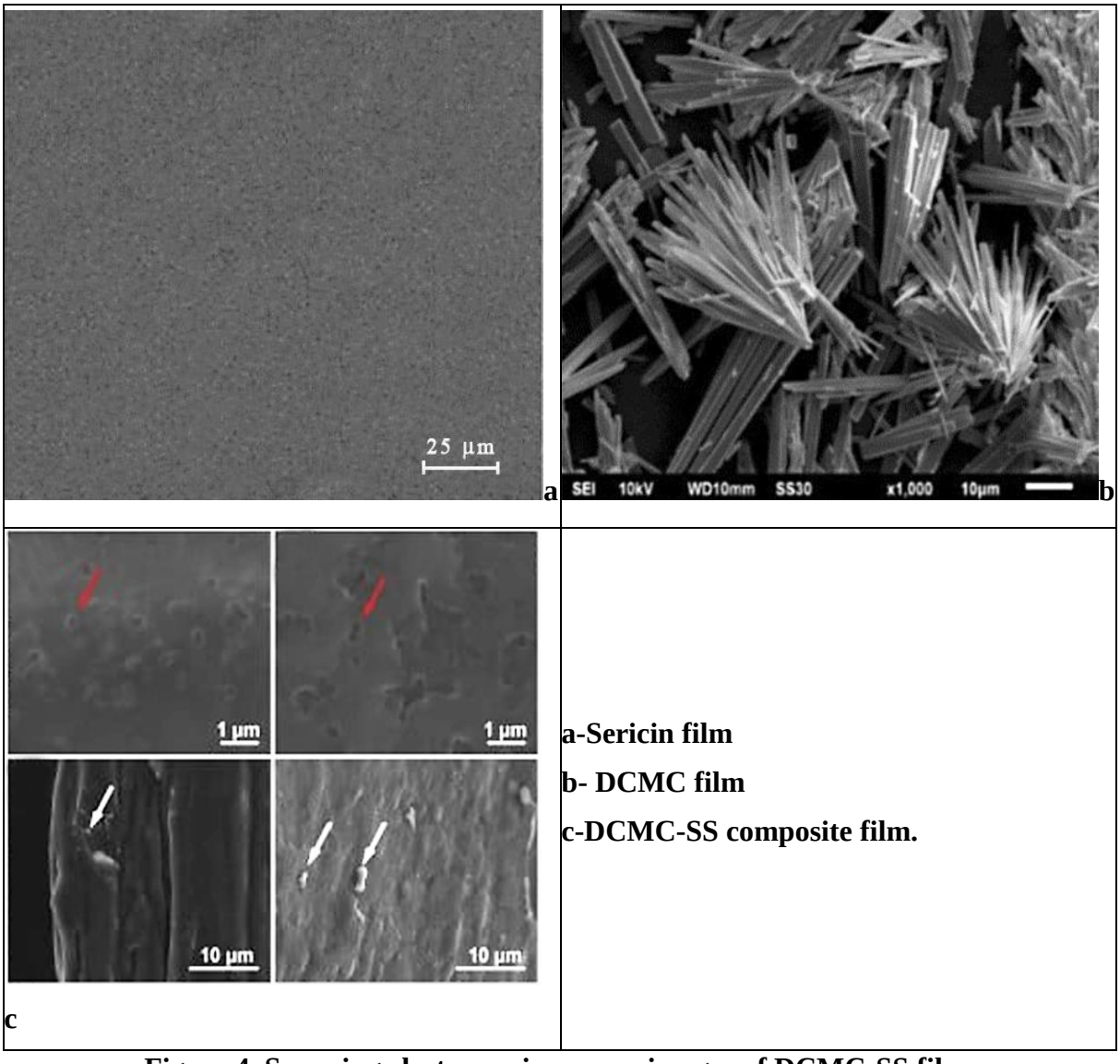

Figure 4. Scanning electron microscope images of DCMC-SS film.

SEM analysis revealed that the surface of sericin is composed of uniformly sized particles. SEM examination of DCMC samples revealed that they are made up of needle-like particles and are smaller than sericin samples. SEM examination was performed on the acquired films based on the DCMC-SS composite, and it was discovered that the particles of the obtained samples differed from those of the original samples. The disparity in shape of the acquired samples demonstrates that they constituted a composite. The dimensions of the DCMC-SS composites varied from the initial samples as well.

Because the resulting DCMC-SS composite film is biodegradable, the biodegradation time of the obtained composite was investigated. The biodegradation period of the films was examined as a function of mass and time in this example, and the findings are shown below (fig 5).

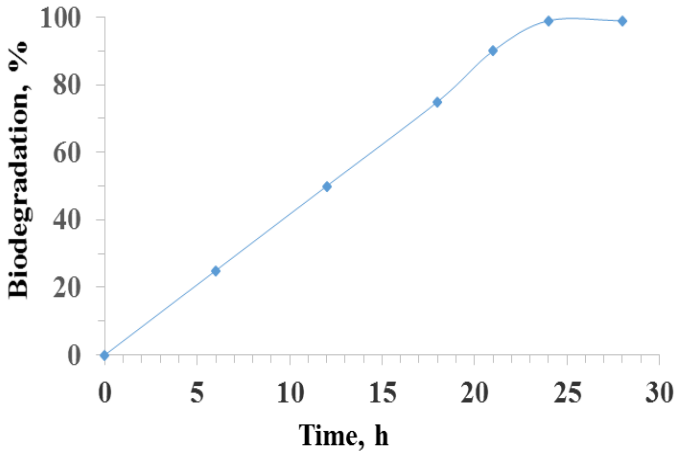

Figure 5. Time dependence of the level of biodegradation.

Biodegradable composite films are employed in different bodily wounds as a healing agent for the injured skin and to promote the formation of fibroblasts, which are skin cells. As a result, the resulting films must be absorbed by the skin as they are only used once and must be safe for the body. Because biodegradable films are only used once a day, the period of full breakdown must be equivalent to 24 hours. When the biodegradability characteristic was investigated, it was discovered that the samples were entirely dissolved in 24 hours.

Conclusion

IR-spectroscopic and SEM procedures were used to obtain DCMC-SS composite films. The likelihood of building a composite with sericin was discovered to rise as the number of aldehydes increased. The feasibility of producing hydrogels from DCMC-SS composites and their use in a variety of applications has been demonstrated. The films made from the DCMC-SS composites that we synthesized are designed for the medical profession and can be employed in the treatment of scarless wounds.

References

1. Zheng T., Yu X., Pilla S. Mechanical and moisture sensitivity of fully bio-based dialdehyde carboxymethyl cellulose cross-linked soy protein isolate films. Carbohydrate Polymers. 2017. vol. 157. pp. 1333–1340.
2. Cook S.D., Salkeld S.L., Patron L.P. Bone defect healing with an osteogenic protein-1 device combined with carboxymethylcellulose. Journal of Biomedical Materials Research Part B, Applied Biomaterials. 2010. vol. 75B(1). pp. 137–145.
3. Huang W., Ebrahimi D., Dinjaski N., Tarakanova A., Buehler M.J., Wong J.Y., Kaplan D.L Synergistic integration of experimental and simulation approaches for the de novo design of silk-based materials. Accounts of Chemical Research. 2017. vol. 50(4). pp. 866–876.
4. Calvini P., Gorassini A., Luciano G., Franceschi E. FTIR and WAXS analysis of periodate oxycellulose: Evidence for a cluster mechanism of oxidation. Vibrational Spectroscopy. 2006. vol. 40(2). pp. 177–183.

5. Karahaliloglu Z., Kilicay E., Denkbas E.B. Antibacterial chitosan/silk sericin 3D porous scaffolds as a wound dressing material. Artificial Cells, Nanomedicine, and Biotechnology. 2016. pp. 1–14.
6. Kundu S.C., Dash B.C., Dash R., Kaplan D.L. Natural protective glue protein, sericin bioengineered by silkworms: Potential for biomedical and biotechnological applications. Progress in Polymer Science. 2008. vol. 33(10). pp. 998–1012.
7. Lee C.H., Singla A., & Lee Y. (2001). Biomedical applications of collagen. Interna-tional Journal of Pharmaceutics, 221, 1–22.
8. Lawrence B.D., Marchant J.K., Pindrus M.A., Omenetto F.G., Kaplan D.L. Silk film biomaterials for cornea tissue engineering. Biomaterials. 2009. vol. 30(7). pp. 1299–1308.
9. Lamboni L., Gauthier M., Yang G., Wang Q. Silk sericin: A versatile material for tissue engineering and drug delivery. Biotechnology Advances 2015. vol. 33(8). pp. 1855–1867.
10. Mu C., Liu F., Cheng Q., Li H., Wu B., Zhang G., et al.. Collagen cryogelcross-inked by dialdehyde starch. Macromolecular Materials and Engineering. 2010. vol. 295. pp. 100–107.
11. Peng Wanga., Huawei Hea., Rui Caia., Gang Taob., Meirong Yangb., Hua Zuod., Ahmad Umare., Yejing Wang Cross-linking of dialdehyde carboxymethyl cellulose with silk sericin to reinforce sericin film for potential biomedical application. Carbohydrate Polymers. 2019. vol. 212 pp. 403–411. https://doi.org/10.1016/j.carbpol.2019.02.069
12. Xue R., Liu Y., Zhang Q., Liang C., Qin H., Liu P., Wei Y. Shape changes and interaction mechanism of Escherichia coli cells treated with sericin and use of a sericin-based hydrogel for wound healing. Applied and Environmental Microbiology. 2016. vol. 82(15). pp. 4663–4672.
13. Yoo C.K., Jeon J.Y., Kim Y.J., Kim S.G., Hwang K.G. Cell attachment and proliferation of osteoblast-like MG63 cells on silk fibroin membrane for guided bone regeneration. Maxillofacial Plastic and Reconstructive Surgery. 2016. vol. 38(1). pp. 17.
14. Yang Y., Bteich J., Li S.D. Current update of a carboxymethylcellulose-PEG conjugate platform for delivery of insoluble cytotoxic agents to tumors. The AAPS Journal. 2017. vol. 19(2). pp. 386–396.
15. Zhang X., Khan M. M., Yamamoto T., Tsukada M., Morikawa H. Fabrication of silk sericin nanofibers from a silk sericin-hope cocoon with electrospinning method. International Journal of Biological Macromolecules. 2012. vol. 50(2). pp. 337–347.
16. Ғойибназаров И.Ш., Йўлдошов Ш.А., Саримсоқов А.А Натрийкарбоксиме тилцеллюлоза асосида диалдегидкарбоксиметилцеллюлоза синтез қилиш. комплекс бирикмалар кимёси ва аналитик кимё фанларининг долзарб муаммолари” республика илмий-амалий конференцияси. 2022. № 2 б-426-427.