



SEM image of blood cells deposited on the surface of polysaccharide nanosheet overlapping the Polypropylene fibrous mesh (colord)

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■ RESEARCH TOPIC

Development of Flexible and Robust Nanosheets: A Major Progress in Biomedical engineering

■ Reference

1)Fujie T.,Matsunami N., Kinoshita M., Okamura Y., Saito A., Takeoka S., "Adhesive, Flexible and Robust Polysaccharide Nanosheet Integrated for Tissue-Defect Repair", *Adv. Funct. Mater.*, 2009

■ Key words

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Development of Flexible and Robust Nanosheets: A Major Progress in Biomedical Engineering

Nanotechnology, which has gained popularity in the field of IT, is currently being used in the area of bioengineering for various medical applications. A good example of the use of nanotechnology is the development of biomaterials such as cell sheets and artificial bones. Dr. Toshinori Fujie, who is a Research Associate at the Graduate School of Advanced Science and Engineering, Faculty of Science and Engineering, has succeeded in developing nanosheets from natural polysaccharides. This is a major achievement in the field of biomedical engineering, and “nano-adhesive plasters” developed using nanotechnology can be used for the treatment of injuries and in surgical procedures.

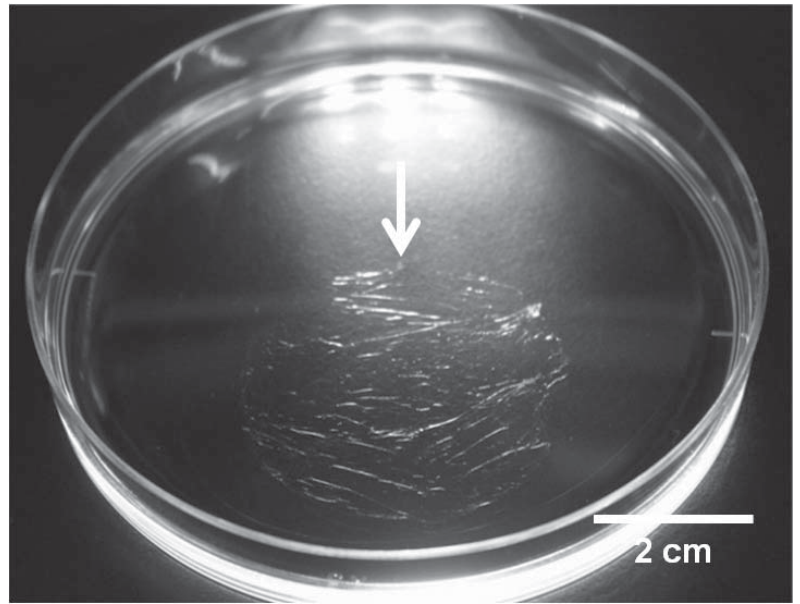
Fujie is currently working as a Research Associate in Professor Shinji Takeoka’s laboratory, which is engaged in the research and development of artificial blood and drug delivery systems made from bio (macro)molecules such as amino acids and sugars. As a part of this project, Fujie has been involved in the development of blood-platelet-like carriers (sheet-shaped carriers); his research was based on the development of platelet substitutes using nanoparticles. On the basis of his research findings, he has successfully fabricated ultrathin nanosheets of chitosan and sodium alginate. Chitosan and other polysaccharides are already being widely used as food additives and in wound dressings, and they are well known to be biocompatible. The nanosheets developed by Fujie are in the form of squares whose sides are several centimeters long; the thickness of these nanosheets is of the order of a few dozen nanometers. These nanosheets remain stable in water for more than six months and are metabolized within a certain period of time when attached to the surface of organs inside the human body. Owing to this property, these nanosheets can be used for treating external as well as internal injuries.

Sheet-shaped carriers have a larger surface area and are more flexible than spherical carriers. Fujie and his team have also succeeded in multilayering of chitosan and alginate and reducing each of these layers to single molecular size. In this manner, they could increase the stability of the nanosheets and make them at least ten times more flexible than individual thin membranes made from the same materials. Fujie says “the sheets are not only flexible; they are really robust. This is because we multilayered alternate layers of chitosan, which has a positive electric charge, and alginate, which has a negative electric charge, in an aqueous solution and were able to interact with the macromolecules electrostatically.” (Note: It has been shown that similar strong and flexible nanosheets can be made from macromolecules other than water-soluble macromolecules like polysaccharides, if there exists intermolecular force between the macromolecule chains.) The researchers also demonstrated that the nanosheets were sufficiently robust for use in the treatment of lung pleural defect, a condition in which a part of the lung was torn and air leaks out, and in the treatment of perforative peritonitis, a condition in which there was a hole in the intestines or other parts of the digestive tract.

Fujie proceeds to state that “these nanosheets can also overlap, internally and on their surfaces, substances such as drugs that carry electric charges similar to those carried by chitosan and alginate.” He adds that it has been experimentally demonstrated that these nanosheets can retain substances internally and on their surface; in these experiments, particles with a diameter of $2\mu\text{m}$ are found to be easily overlapped in the nanosheets, and hence, the inclusion of crystalline and magnetic particles and living cells is also expected. It is necessary to confirm that no adverse side effects occur when these nanosheets are degraded, absorbed, and metabolized inside the human body; however, Fujie believes that the development of square nanosheets whose sides are several hundred meters long is possible in the near future.

Dr. Fujie insists that “materials science research is pointless if it does not lead to applications.” There are no existing reports on the use of nanosheets in living organisms; hence, Fujie is carrying out further studies on improving the functionality of the nanosheets with the aim of increasing their biomedical applicability.

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A free-standing polysaccharide nanosheet floating in a buffer solution.

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