Topic of the Speech:
Living Silk-Based Hydrogels with Microalgae for Environmental Applications

Professor Xiaoqin Wang
Soochow University
China

Professor Xiaoqin Wang obtained his Bachelor's degree in the Microbiology Department of Shandong University, China, in 1991. After graduation, he joined Harbin Medical Group as a R&D engineer until 1995 when he continued his education for his Master's degree in Peking Union Medical College, China, on molecular biology and gene engineering. He went to the University of Groningen, the Netherlands, in 1998 joining Prof. George Robillard's group to start his PhD study on biochemistry and protein science. After his graduation in 2004, he worked shortly in a biotech company in the Netherlands, and then went to the United States to join Prof. David Kaplan's group at Tufts University for his postdoc training on biomedical engineering using biodegradable materials, mainly silk fibroin protein purified from silkworm cocoons.

During this period, Prof. Wang's primary research mission was to understand how cells, ranging from mammalian cells to prokaryotic cells, interact with biomaterial scaffolds, and how the material processing and functionalization may impact on the structure, mechanical properties, biocompatibility and degradation of the scaffolds. Another research area that Prof. Wang focused on was the controlled release and stabilization of bioactive molecules ranging from small molecules to macromolecules from biomaterial carriers, such as nano- and microparticles, hydrogels, etc. Prof. Wang was appointed as a research assistant professor of Tufts University in 2011. In 2012, Dr. Wang was appointed as a distinguished professor at Soochow University, China and established a Soochow-Tufts joint lab to promote collaborative research between Soochow and Tufts University on silk biomaterials.

So far, Prof. Wang has published over 60 peer-reviewed articles and more than 30 US and Chinese patents, most of which are on silk biomaterials for tissue engineering and drug delivery, and has served as a reviewer for the top scientific journals and the key speakers for several international conferences. In addition to his academic achievements, Prof. Wang is also actively engaged in the commercialization of research results. In 2009, during his postdoc training at Tufts University, he co-founded a biotech company, Ekteino Laboratory, together with Prof David Kaplan and served as a consultant for the product development. In 2013, he co-founded another Tufts spin-off company, Cocoon Biotech Inc., and served as the vice president of R&D until 2016. Prof. Wang is also the founder and president of Simatech Inc., a startup company located in Suzhou, with a focus on silk-based biomedical applications.

ABSTRACT SUBMISSION
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Living Silk-Based Hydrogels with Microalgae for Environmental Applications

Yuhang Fu[1], Siwei Zhao[2], Zhaozhu Zheng[1], Gang Li[1], Xiaoqin Wang[1*], David Kaplan[2]
[1] *National Engineering Laboratory for Modern Silk, Soochow University, Suzhou, 215123, P.R. China*
[2] *Department of Biomedical Engineering, Tufts University, Medford, Massachusetts 02155, United States*
[*]Presenter's email: wangxiaoqin@suda.edu.cn

ABSTRACT

Silk fibroin hydrogel can be prepared at ambient conditions using either physical cues, such as ultrasonication (shear force) that can induce physical crosslinking between fibroin molecules, or chemical cues, such as H_2O_2-horseradish peroxidase (HRP) reaction that can induce silk crosslinking. These features, together with robust mechanical properties, safety and biocompatibility, tunable degradation, and green sourcing, make silk hydrogels an ideal scaffold to host and support cell proliferation and differentiation for tissue engineering and drug delivery applications. The purpose of the research is to expand the application of silk fibroin hydrogels from biomedicine to environmental protection, to address air pollution and carbon emission problems the world faces today. Microalgae are a large group of unicellular organisms that are capable of photosynthesis, and they are commonly used in biomass production to convert sunlight and carbon dioxide to biofuels, hydrogen and oxygen gas, as well as in wastewater treatment to remove metals and organic pollutants. In practice, microalgae are preferred in immobilized formats in these systems instead of being cultivated as suspensions so that the population and function of microalgae can be maintained for long periods of time, cellular products can be more easily collected and the liberation of microalgae into the surrounding environment can be limited. In this study, two marine microalgal strains, Platymonas sp., and Chlorella sp., were cultivated, harvested and mixed with silk fibroin solution that had been either probe-sonicated or supplemented with H_2O_2 and HRP. The mixtures were incubated in molds or in syringes in a 3D printer at 37°C until the solution gelled. The microalgae-embedded hydrogel structures with specific dimensions and shapes were obtained and further incubated in a sealed container with a continuous supply of culture medium and carbon dioxide gas. Alginate hydrogels, commonly used for microalgae immobilization, was used as a control. The results showed that cell density (10^5-10^7 cell/mL) and gel concentration (6-7% w/v) were critical in maintaining microalgae alive and photosynthetically active, while the gel structure remained intact for more than 90 days, during which oxygen was replenished and carbon dioxide was reduced in the air or water environment. The hydrogel could be fabricated into thin membranes (~1 mm), which was separated from the culture medium by a semi-permeable membrane and thus kept hydrated. The hydrogel could also be injected through a 3D printing nozzle under water, forming desired shapes. In contrast, the structure of the alginate hydrogel was challenging to maintain due to the softness of the gel. The efficiency of oxygen generation of the microalgae embedded in silk hydrogels was approximately 6 times higher than that of the same amount of microalgae cultivated in suspension. In conclusion, functional microalgal silk hydrogels were successfully achieved and the data suggest potential applications of these living biomaterials in air purification and waste/polluted water treatment towards green, healthier indoor and outdoor environments.