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Topic of the Speech:
Solvent-Welding Fabrication of Silk Nanofibrous Aerogels for Environmental Applications

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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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Solvent-Welding Fabrication of Silk Nanofibrous Aerogels for Environmental Applications

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ABSTRACT

Aerogels have attracted attention due to the outstanding characteristics such as ultra-high surface area, ultra-low thermal conductivity, and ultra-low volume density. Presently, aerogels prepared from silicon dioxide, clay, graphene, carbon nanotubes, etc., have been widely studied and successfully commercialized, but aerogels made from biodegradable natural materials are gaining more interest due to their properties like sustainability, non-toxicity and facile modification of surfaces, etc. However, except for the problems existed in the inorganic aerogels, such as high energy needed for supercritical drying, toxic solvents and high temperature used during preparation, etc., natural materials also encounter challenges of relatively low mechanical strength as well as the use of toxic crosslinkers. Therefore, it is highly desired to fabricate aerogels from a mechanically robust natural material using green, low energy consuming and easy-to-manipulate approaches.

A method was recently developed in our lab to fabricate light, water-insoluble silk fibroin nanofibrous aerogels (SNFAs) through solvent welding of lyophilized silk nano-fibrous 3D networks at the junction points, while converting silk structures from random-coils to β-sheets (water insoluble). Silk nanofibers were obtained via electrospinning, cut into fragments, unidirectionally dispersed in water by stirring and then lyophilized into a porous, water-soluble scaffold. Aromatic alcohols, especially phenethyl alcohol (PEA), were used to fumigate the lyophilized scaffolds, resulting in mechanically robust, water insoluble, highly porous SNFAs. PEA vapor treatment was a better approach than solvent infusion to retain volume, density, and mechanical strength of the SNFAs. The mechanical properties of highly orientated SNFAs were superior to randomly distributed fibers. The SNFAs had a low density (3.5 mg/cm3), high hydrophobicity (140.9°), and a porous surface morphology on the individual nanofibers, resulting in high efficiency and selectivity for absorbing particulate matter (PM) and oils. Compared with commonly used inorganic aerogels, the SNFAs developed in this study are biocompatible, easily functionalized, environmentally friendly and low-cost, therefore, with potential for air and water purification, biosensors, drug delivery and tissue engineering.

In conclusion, SNFAs with ultra-low density and hydrophobicity was fabricated in this study by using electrospun silk nanofibers and PEA solvent welding. PEA was found for the first time to have optimal silk β-sheet structure-inducing capability and diffusivity in silk material matrices. The SNF-containing solution was dried by lyophilization, which should facilitate large scale production in the future. The strong welding and β-sheet structure formation of intersected SNFs, as well as the unidirectional orientation of SNFs, account for the excellent material properties of the SNFAs. The SNFAs developed in the study showed promising applications in air purification for PM 2.5 absorption, and water treatment for residual oil adsorption and separation.