Biologically Derived Nano-Scaffolds from Sundew Adhesive for Tissue Engineering

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Statement of Purpose: The goal of this research is to explore biologically derived nano-scaffolds from Sundew (*Drosera capensis*) for tissue engineering. Naturally occurring nano-scaffolds that were observed and collected from the Sundew adhesive have been proposed as promising biological materials. It has demonstrated promising capability to capture neuron-like cells, osteoblasts and endothelial cells for wound healing. Another merit of the Sundew scaffold is its structural stability during the cell growth, although it has been proved to be exclusively composed with polysaccharides. Using atomic force microscope (AFM), we also noticed that the nano-fiber like scaffold contains spherical nanoparticles. As is well-known, polysaccharides are prone to form nano-sized structures in aqueous solution; however, the mechanism for these polysaccharides to form nano-fiber like network through self-assembly is still not clear. Although previous studies have indicated that the polysaccharides in Sundew adhesive were mainly consisted with arabinose, xylose, galactose, mannose, and glucuronic acid with a ratio of 8:1:10:18:17, the exact chemical structures of the nano-scaffolds have not been elucidated. On the other hand, the contribution of these nano-fiber like scaffold to the Sundew adhesive and the significance to the physiological function of Sundew growth should be elucidated, through which bio-inspired nano-scaffolds may be created. All the above questions have been investigated in this study.

Methods: Sundew (*D. capensis*) was obtained from Black Jungle, Turners Falls, MA and cultured in a plant incubator at 28 °C with a 16:8 photoperiod. High-speed camera was employed to visualize the elastic adhesive secreted by the plant. The adhesive was collected and characterized using a MFP-3D AFM (Asylum Research, Santa Barbara, CA). Nanoparticles were isolated by sonication and filtration. MTT test was performed to analyze the cytotoxicity of Sundew nano-scaffold. X-ray photoelectron spectroscopic (XPS) study was performed to analyze the chemical composition of the polysaccharides contained in the Sundew adhesive.
Results: Different from traditional structural adhesives, the Sundew adhesive is a type of pressure-sensitive glue as shown in **Fig. 1**. The degree of the bond is determined by the amount of pressure applied to the surface. No other factors, such as solvent, water, or heat are required to activate this adhesive. Pressure sensitive adhesive was broadly employed as hydrogel used for controlled drug release and delivery. Here we used this biologically-derived pressure sensitive adhesive as tissue scaffold that can be easily controlled or modulated by mechanical forces. Spherical nanoparticles with an average diameter around 90 nm were obtained from the adhesive after

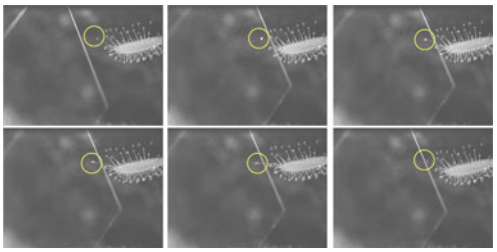

Fig. 1 High speed camera images of Sundew adhesive.

sonication and filtration (**Fig. 2**), indicating the self-assembly process of the polysaccharides contained in the adhesive. The schematic drawing of **Fig. 2** reflected the morphological changes of Sundew nano-scaffold while stress was applied on the nano-fiber. The structurally unstable multilateral scaffold was easy to deform and stretch along the direction of mechanical forces. The elasticity of the adhesive secreted by Sundew was attributed to the morphological changes of the nano-scaffold. This unique property makes the Sundew nano-scaffold a promising candidate as soft-tissue matrices that can be controlled by an external mechanical modulation. Further XPS study indicated that nitrogen was contained in the Sundew adhesive, suggesting the presence of amino

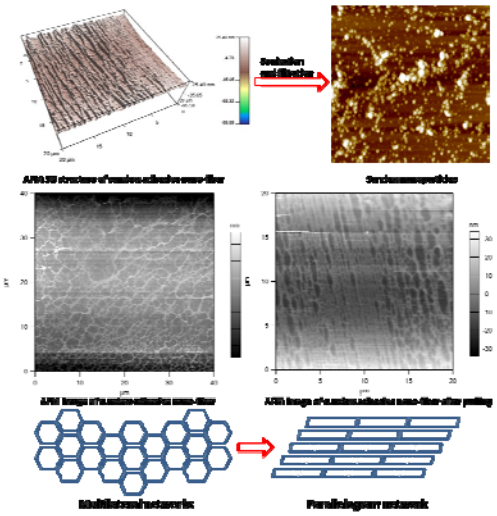

Fig. 2 Nano-scaffold and elastic adhesive.

groups in the polysaccharides. This scaffold showed well cyto-compatibility to small muscle cells and 3T3 cell lines while testing by MTT.

Conclusions: Here we introduced a biologically derived nano-scaffold from Sundew adhesive. The structure of this scaffold is sensitive to external forces, which is an advantage for controlled cell growth. This scaffold showed enhanced cell binding property and well cyto-compatibility, which is crucial for tissue engineering.