Co-assembly, spatio-temporal control, and morphogenesis of a hybrid peptide/protein system.


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Introduction

The ability to modulate peptide/protein interactions by self-assembly in real time and guide their hierarchical assembly into functional macrostructures would represent a major break-through in material science. Here we report a robust hybrid peptide/protein system that enables the possibility to direct molecular self-assembly at multiple scales with spatial and temporal control by shifting protein conformation (collapsed to open conformation) due to protein-peptide interaction.

Methods

A self-assembling peptide (PA) drop is added within an elastin-like protein (ELP) solution on a hydrophobic surface. The ELP-PA combination spontaneously forms dynamic macrotubular structures. Structures obtained and molecular interaction are being characterised by Small Angle X-ray Scattering, Zeta Potential, TOF-SIMS, Scanning and Transmission Electron Microscopy. Functionality of the system has been studied by co-culture of vascular endothelial cells and adipose-derived stem cells on the structures.

Results

PA/ELP structures emerge from the possibility to open ELP molecules by the PA through a series of molecular interactions (Fig. 1a), generating a distinctive multi-layer architecture at the nanoscale (Fig. 1b) and consequently producing the remarkable dynamic behaviour of the material. This behaviour involves the capacity to be manipulated in real time, self-organize into complex macroscale geometries with nanoscale order (Fig. 1c-e), grow, controllably disassemble, adhere and seal, and self-heal (Fig. 1d). Tubes exhibit elasticity, strength, and support the growth of multiple cell types (Fig1. 1f).
Figure 1. a) Proposed interaction between ELP and PA resulting in the opening of ELP. b) SEM images of multi-layered structures. c-e) Directed self-organization into tubular networks and merging of multiple structures.

Discussion

The system reported here is able to generate hybrid multifunctional tubular structures by directed self-assembly without the use of predefined moulds. This material may provide a novel nanofabrication platform for developing a new kind of hybrid peptide/protein materials of unprecedented complexity and functionality beyond vascular tissue engineering applications.

Keywords: Co-assembly, functional, hybrid biomaterial, morphogenesis