PEGylated and peptide-functionalized supramolecular metal-phenolic network coatings for enhanced performance of cardiovascular grafts.

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Abstract

Cardiovascular devices like catheters, stents, heart valves, and vascular grafts are essential in medical treatments but often cause adverse biological responses, including blood clotting, smooth muscle cell growth, poor re-endothelialization, and inflammation. To address these challenges, a ferric ion and tannic acid (FT) based metal-phenolic network coating was optimized through PEGylation and peptide conjugation for application on blood-contacting substrates. A catechol-conjugated 4-arm poly(ethylene glycol) [P-NHcat]$_4$ was synthesized and incorporated into the FT coating (FT-[P-NHcat]$_4$) using layer-by-layer dip coating techniques to improve its

biomedical potential. The surface of the supramolecular coating was further functionalized with YIGSR peptide to promote selective endothelial cell adhesion. Chemical, spectroscopic, structural, and colorimetric analyses confirmed the successful synthesis of [P-NHcat]$_4$ and the uniform, stable application of FT-[P-NHcat]$_4$ coating on a substrate surface. *In vitro* and *ex vivo* vascular perfusion assays demonstrated that the PEGylated and peptide-functionalized coating exhibited improved hemocompatibility, enhanced resistance to platelet adhesion, protein repulsion, and antibacterial properties, resulting in reduced thrombus formation. *In vivo* subcutaneous implantation of FT-[P-NHcat]$_4$-coated substrates in Sprague-Dawley (SD) rats demonstrated resistance to protein adsorption, prevention of blood cell adhesion, and reduced inflammation. These combined properties suggest that designed PEGylated and peptide-functionalized supramolecular coating could improve the long-term patency of cardiovascular grafts.

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