Self-Assembled Comb-Like Surfactant Polymers for Creation of Desirable Biomaterial Interfaces

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Abstract

We developed various comb-like surfactant polymers that could be used to modify the surface of existing biomaterials in order to improve some different desired activities, including anti-infection, blood compatibility and virus sensing. To develop anti-bacterial interfaces, a series of structurally well-defined poly(ethylene oxide)/hydrophobic C6 branched chitosan surfactant polymers that undergo surface induced self-assembly on hydrophobic biomaterial surfaces were synthesized and characterized. The surfactant polymers consist of low molecular weight (MW) chitosan backbone with hydrophilic poly(ethylene oxide) (PEO) to repel nonspecific adsorption and hydrophobic hexyl pendant groups to facilitate adsorption and proper orientation onto a hydrophobic substrate via hydrophobic interactions. The surfactant polymers were prepared with various ratios of the two side chains. The molecular composition of the surfactant polymers was determined by FT-IR and ^{1}H NMR. Surface active properties at the air–water interface were determined by Langmuir film balance measurements. The surfactant polymers with PEO/hexyl ratios of 1:3.0 and 1:14.4 were used as surface modifying agents to investigate their anti-infection properties. *E. coli* adhesion on Silastic® surface was decreased significantly by the surfactant polymer with PEO/hexyl 1:3.0. Surface growth of adherent *E. coli* was effectively suppressed by both tested surfactant polymers. The chitosan based surfactant polymers, with or without further modification with 5-formyl-2-furansulfonic acid, could improve blood compatibility of the existing biomaterial surfaces. Modification of polyethylene surfaces with the chitosan surfactant polymers resulted in a drastic decrease in platelet numbers, a decrease in the number of aggregates, and an increase in PRT time. Addition of PEO side chains to the surfactant resulted in a PEO density dependant drop in platelet numbers and increase in PRT time. These results indicate that surface modification with our negatively charged chitosan based surfactant polymers may be suitable for cardiovascular applications. Lastly, we improved virus sensitivity of a surface plasmon resonance (SPR) chip using a mixture of two comb-like dextran surfactant polymers, that are different in their dextran MW distribution and the presence of carboxylic groups. A bimodal carboxylic dextran surfactant polymer consists of poly(vinyl amine) (PVAm) backbone with carboxyl higher MW dextran, non-functionalized lower MW dextran and hydrophobic hexyl branches; while a monomodal dextran surfactant polymer is PVAm grafted with non-functionalized lower MW dextran and hexyl branches. Layer formation of non-covalently attached dextran chains with bimodal MW distributions on a surface plasmon resonance (SPR) chip was investigated from the perspective of mixed physisorption of the bimodal and monomodal surfactant polymers. Separation distances between the carboxylic longer dextran side chains within the bimodal surfactant polymer and between the whole bimodal surfactant molecules on the chip surface could be well-controlled. SPR analysis of shrimp yellow head virus using our mixed surfactant chips showed dependence on synergetic adjustment of these separation distances.

Keywords: comb-like surfactant polymers, biomaterials, SPR, anti-infection and blood compatibility