Investigation of interaction between the dynamic polymer surfaces and collagen molecules

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Introduction: Interaction between the solid surface and the proteins involves with many biological phenomena such as cell-material interaction or plaque formation. Investigation of protein-surafce is important in the aspect that the controlling the bioloigcal behavior by altering the surface characteristics. For the same reason, the collagen-surface interaction is being actively investigated.[1,2] Such interaction is important in the aspect that this is relaed to the function in the body. That is, the collagen surrounding the matrial forms interface with the materials surface which lead to either healing response or capsulation. However, not much information on these phenomena has been reported. In this study, we tried to establish the interaction between the collagen molecules and surface, especillay focusing on the dynamicity (mobility) of the surface, so as to predict how biorecognition process occurs in vivo. For this, we synthesized polyrotaxanes possessing α-CDs threaded onto PEG backbone. With this polymer, we observed how the surface topography, surface chemistry, and surface property actually affect the adsorption of collagen molecules during fibrillization.

Materials & Methods: The QCM-D sensor with gold electrode was coated with poly[2-methacryloyloxyethyl-phosphorylcholine (MPC)-*co*- butyl methacrylate (BMA)] (PMB), poly(ethylene glycol-*b*-PMB) (PEG-PMB), poly(rotaxane-*b*-PMB) (PRX-PMB), and methylated poly(rotaxane-*b*-PMB) (OMePRX-PMB),and poly(iso-butyl methacrylate) (PBMA). For the control, gold substate and poly(BMA) was coated on the QCM-D sensor with gold electrode. Each electrode was set in the QCM-D before flowing collagen aqueous solution with NaCl 0.9wt% into the chamber so as to induce fibrillogenesis.[3] The frequency change (Δf) and the dissipation change (ΔD) was measured at 37°C for 1 hour. Atomic froce microscope (AFM) was used for the observation of the surface before and after the collagen adsorption. In order to observe the living body response to the mobile polymer, the cell desk coated with the polymer described above was coated and sterlized before implanting into the rat. After 2 and 12 weeks, the healing response was investigated.

Results & Discussion: The collagen starts fibrillize in physiological condition within 10 minutes. Since the fibrillization occurs mainly in solution than on the surface, the formation of the collagen fibrils by the adsorbed collagen molecules is low. The adsorption of the collagen molecules is thought to due to the hydrophobic nature of the surface, where the hydrophobic part of the collagen interact with the surface.[2] QCM-D data showed that Δf was high for PBMA and OMePRX-PMB implying that the interaction between the PBMA and OMePRX-PMB, and the collagen is high. But the difference was shown when the induced energy dissipation per coupled unit mass (ΔD/Δf) of the adsorbed collagen was calculated. The higher ΔD/Δf shown by OMePRX-PMB. This is thought to due to the mobility of the OMePRX-PMB where the mobility parameter was the highest among the samples.[4] This also indicates that the adsorbed collagen moelcules are relatively weakly interacting with the surface of OMePRX-PMB. In the case of PMB, PEG, and PRX-PMB, the amount of adsorbed collagen was low, due to its hydrophilic nature. The image of AFM shows clear image of formation of fibril on the surface is much faster for the OMePRX-PMB than to that of the PBMA. This is thought to due to the weak interaction of the collagen molecules to the surface. Furthermore, we could observe the alignment of the collagen fibrisl within 1 hour of adsorption in the case of OMePRX-PMB. The schematic images of collagen-surface interaction is shown in Fig. 1.

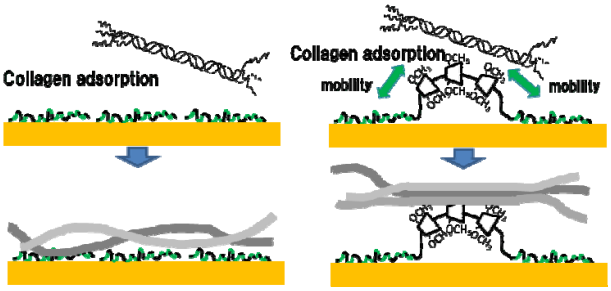

Fig 1. The schematic image of the collagen adsorption on immobile (left) and mobile (right) surface.

When the mobile polymer was implanted into the kliving body, it sshowed that the healing process has taken much fatser compared to other samples, indicating that the mobility is important.

Conclusion: By preparing a polymer loop structure with mobile methylated α-CDs threaded onto PEG backbone, we tried to define the role of dynamicity of the polymer surface to the collagen adsorption and fibrillogenesis. The surface mobility is an important parameter that controls the collagen adsorption and fibrillogenesis. Such property is thought to bring the fast healing process *in vivo*.

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