고분자 표면에서의 혈소판 흡착에 대한 모델

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Platelet Adhesion Model on the Polymeric Surface

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1. Introduction

Platelet aggregation is normally induced by a polymer surface when blood interacts with an artificial organ. To investigate this phenomena as a first stage a computer model of platelet aggregation in the bulk plasma was previously suggested[1] which is activated by adenosine diphosphate (ADP). In the present study we introduce a polymer surface to the bulk model. The early events of the blood-material interaction are believed to be protein adsorption, platelet adhesion, platelet spreading and release, and then platelet aggregation by the released materials from the activated platelets. As the factors that influence the platelet adsorption on the surface of artificial organ are numerous, it is hard to categorize and analyze the factors in the blood-material interaction. We noted that two types of interaction sould be taken into account during the platelet adhesion on polymer surface; one of which is the platelet-platelet interaction (PPI) and the other is the platelet-surface interaction (PSI). It is expected that the structure and amount of the platelet aggregates on the surface depend strongly on the relative difference between PPI and PSI. In order to investigate the effect of the two interactions on platelet adsorption, we made computer simulations to obtain adsorption isotherms of platelets on the protein adsorbed polymer surface using the diffusion limited aggregation (DLA) [2].

2. Methods

We take into account the surface fibrinogen concentration as a major factor of the platelet - surface interaction. From the results of protein adsorption simulations and experiments [3], we assumed the surface fibrinogen concentration is enough to activate platelets. The polymer surface with adsorbed protein was simply modeled by a two dimensional square lattice. We let the PSI be so strong that all adhered platelets are fully spread and the radius of platelet surface bounded are is twice the radius of a normal platelet. We also assigned PSI to be very weak, where the shape of platelet was not changed. Platelets move randomly in a three dimensional space of lattice from a random position in bulk plasma until they meet a surface or adhered platelets. To see the adsorption isotherm, we do not consider the time this case. After one platelet among the initial number of platelets was tested, the next one had a motion of random walk. If one platelet goes too far away from the initial starting point, it is neglected becuase of the computational efficiency and reality. The total adhesion number of platelet was obtained after all the initial number of platelets were tested. We changed the initial number of platelets and obtained the total adhesion number of platelets again. The probability of adhesion to the surface when one platelet met a surface during random walks, was determined by PSI and the probability of sticking to the other platelets was determined by PPI. PPI was changed as the amount of adhered platelets was increased in other to consider the granule release reaction of platelet, which is followed by the platelet activation. We also performed simulations with different initial PPI's.

3. Results and Discussion

Adsorption isotherms for the different initial platelet - platelet interactions (PPi) with every 100 samples are given in Fig. 1. The effect of PPI on the total adhered number is a little positive, whereas PSI effects seem not to be significant. The structure of the adhered platelets, however, is quite different. The adhered structures of PSI = PPI = 1.0 and PSI = PPI = 0.1 are shown in Fig. 2. To see the structural characteristics more clearly, we obtained the number of platelets in the first adsorbed layer which is plotted in Fig.3. Monolayer adhered pattern is more dominant for a smaller PPI and it shows distinct tendency. As platelets with smaller PSI can wander the surface more freely, they might have

more chance to find proper seats on the surface. As a result, the adsorbed number in the first layger is larger in weak PSI than in strong PSI. However, PSI effects for a large PPI is not dominant. The average heights when the initial platelet number is let to be 5000 are shown in Table 1. Weaker PPI gives lower height. In conclusion, weak PSI shows compact and flattened adhesion pattern, while strong PPI shows loose and tall adhesion pattern.

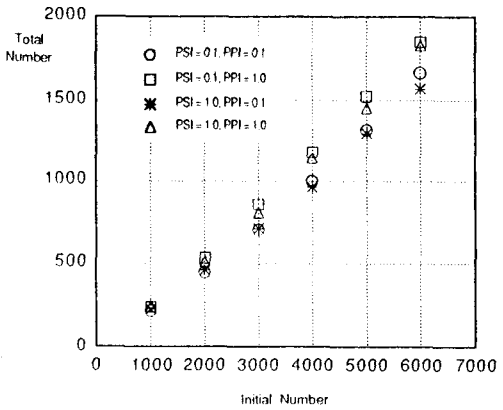

Fig.1 Total adsorbed number of platelets for different initial PPI's and PSI's when the initial platelet number is changed

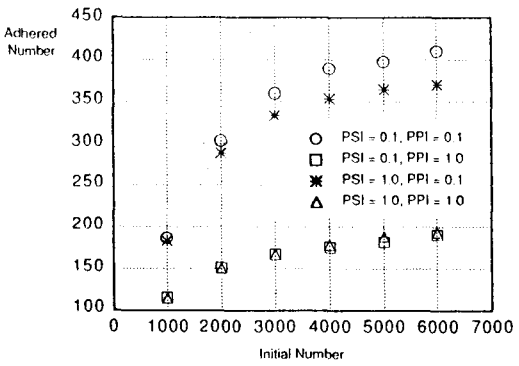

Fig.3. The adhered number of the first layer from the surface for different initial PPI's and PSI's.

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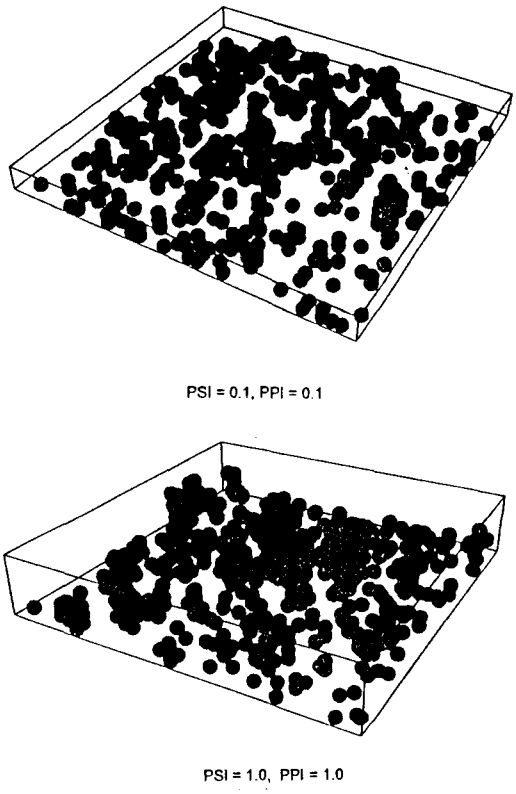

Fig.2 The typical shape of platelet adhesion at different PSI's and PPI's for the initial platelet number 6000

Tabel 1. Average height of the platelet aggregates on the surface for different PSI's and PPI's

PSI	0.1	1.0	0.1	1.0
PPI	0.1	0.1	1.0	1.0
Height	1.9278	1.9188	4.3579	4.1831