論文 / 著書情報
Article / Book Information

題目(和文)	ゴムフィルムへの微粒子付着におけるメニスカス形成および微粒子沈降
Title(English)	Microsphere Adhesion on Rubber Films Accompanied by Meniscus Formation and Sedimentation
著者(和文)	三島翔子
Author(English)	Shoko Mishima
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第11451号, 授与年月日:2020年3月26日, 学位の種別:課程博士, 審査員:扇澤 敏明,鞠谷 雄士,安藤 慎治,淺井 茂雄,松本 英俊
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第11451号, Conferred date:2020/3/26, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	材料 系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of （ 工学 ）
学生氏名： Student's Name	三島 翔子	指導教員（主）： Academic Supervisor(main)	扇澤 敏明
		指導教員（副）： Academic Supervisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The microsphere adhesion on rubber film to clarify the adhesion phenomena of pressure sensitive adhesives (PSAs) was investigated from the point of view of interface development. To discuss the factor of adhesion phenomena, we have to independently consider the effects from an adhesive, adherend, and interface.

In Chapter 2, formation of an interfacial area between a microsphere and *cis*-1,4-polybutadiene (BR) were investigated. A BR meniscus formed on the sphere surfaces when the film thickness was less than the diameters of the spheres. Additionally, the attractive forces acting on the spheres in the direction of the BR films were examined via atomic force microscopy (AFM). When the rubber film thickness much greater than the diameters of the microspheres, sedimentation of the spheres was observed. The resting time dependence of sedimentation ratio were nearly identical for spheres with various surface free energy, γ, and these sedimentation behavior was independent to the sphere type. Sedimentation eventually ceased when the angle between the tangential line of the sphere and the rubber surface became equal to the equilibrium contact angle determined by Young's equation. The sedimentation velocity was greatly dependent on the sphere diameter. Interestingly however, the plots in time dependence of sedimentation ratio was able to be superposed on one another by shifting the data along the time axis. This results implied that the sphere size affects the velocity but not the overall behavior. The same sedimentation phenomena were studied with crosslinked BR films. In contrast to the experiments performed using various types of spheres, the sedimentation behavior varied with crosslinking time of BR. The results of these studies indicate that the sedimentation behavior mainly depends on the physical properties of the rubbers used, although the physical properties of the spheres are in determining their final depth.

In Chapter 3, we investigate the adhesion of microspheres onto rubber films to clarify the dominant factor in the adhesion process with using the various rubber films. The rubber meniscus formation and sphere sedimentation were observed for the system of $\gamma_{sphere} < \gamma_{rubber}$. We then assumed the factor is the resultant tension on a tangential line of a sphere. This force allowed the fluid material to spread on a spherical material, forming a meniscus, even for incompatible systems, such as a poly(tetrafluoroethylene) ball–water system. The microsphere sedimentation was strongly dependent to the rubber type, and the sedimentation behavior could not be explained only by the surface free energy of rubber film and meniscus force. We demonstrated that there was a strong correlation between the sedimentation behavior and creep behavior, whereby the wetting process in the adhesion was strongly dominated by the viscoelasticity of the bulk rubber (adhesive) via creep.

In Chapter 4, the key of tack generation was investigated from the point of view of spontaneous wetting behavior and the adhesion behavior when the load applied on PSA surface during attachment. The 10 wt% tackified BR showed better tackiness for rolling ball tack test, however the spontaneous wetting behavior, such as the rubber meniscus formation and microsphere sedimentation were not promoted by tackifier addition. Additionally, 30 and 50 wt% tackified BR did not show tackiness. According to the surface free energy and Fourier transform infrared spectroscopy (FT-IR) measurements, the surface enrichment of tackifier were observed. This results imply that the high amount of tackifier in near surface decreases the rubber deformability. On the contrary, an AFM force–sample displacement measurement revealed that the rubber contained 10 wt% of tackifier showed general effectiveness of tackifier addition such as easy to deform during attachment and long elongation during detachment when the load applied during the probe indentation. On the basis of the results, the rubber surface deformation by applying the external load is indicated to be necessary for tack generation.

In Chapter 5, the relationship between surface morphology (phase separation in surface layer) and tack generation was discussed. We first observed the cross section of tackified BR films via transmission electron microscope (TEM) because the surface enrichments of tackified rubber films were observed in Chapter 4. The surface layers formed for all blends, and the phase separation in surface layer was also observed via AFM. This surface morphology kept forming even after the rubber film was annealed at 50 and 100 °C, which temperature was higher enough to the glass transition temperature of tackifier. Interestingly, the force curve at matrix showed good adhesive property, such as using the colloidal prove in Chapter 4, when the rubber surface indented more than surface layer thickness. The originally silicon wafer interface also showed the same adhesive behavior as the surface matrix. These results imply that the phase separation and surface roughness are not important for tack generation.