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Effects of EB-Irradiation on Temperature Dependent Peeling Resistance of Laminated Sheet of High Strength PP and Bio-adaptable PDMS

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ABSTRACT

The effects of homogeneous low voltage electron beam irradiation (HLEBI) on the adhesive force of peeling resistance of laminated sheets of bio-adaptable polydimethylsiloxane (PDMS) with transparency and high strength polypropylene (PP) without glue but with sterilization were investigated. It was concluded that HLEBI was probably a useful tool for quickly lamination of PDMS and PP.

1. INTRODUCTION

Composite polymers have been prepared for biomedical applications by laminating them with heating and glue. However, these methods often degrade

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the adhesive strength and chemical properties, thereby affecting human health. Development of rapid adhesion without heating and glue would solve this problems. Since polydimethylsiloxane (PDMS) exhibits high transparency and bio-adaptability, this structural polymer can be mainly applied to contact lens. In addition, since it also shows self-adhesive, it can be expected to apply to rapping the bio-medical sensors.

Since polypropylene (PP) exhibits high wear resistance as well as high strength and fracture toughness, it can be applied to artificial lunge. However, it is difficult to glue without problems induced by quick-drying glue and heat adhesion. To solve the problem, the development of rapid and safe adhesion method between PDMS to PP sheets has been expected to allow many biomedical applications.

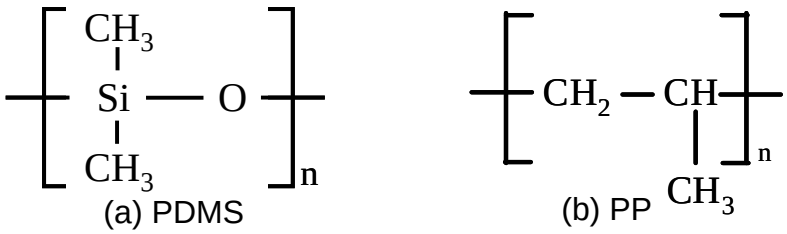
The treatment time of homogeneous low voltage electron beam irradiation (HLEBI)-sterilization is a few seconds, although sterilizing with ultraviolet light irradiation requires a few hours. Thus, HLEBI is expected to be an excellent tool for not only gluing different polymers, but also sterilizing them for biomedical applications, simultaneously.

Therefore, this study has been investigated the effects of HLEBI on the adhesive force of peeling resistance of laminated PDMS/PP without glue but with sterilization.

2. EXPERIMENTAL PROCEDURE

2-1. Sample preparation and homogeneous irradiation of electron beam

Fig. 1 shows constitutional formula of PDMS and PP. Composites sheets were constructed with PDMS (10 mm x 40 mm x 0.075 mm, DOW CORNING TORAY SILPOT 184 W/C, Dow Corning Toray Co. Ltd., Japan) and PP (10 mm x 40 mm x 0.030 mm, Clear Pack No.13, P-WORK Co. Ltd., Japan).



(a) PDMS (b) PP

Fig. 1 Constitutional formula of PDMS (a) and PP (b).

Both stainless steel springs and 0.015 mm thick nylon6 supporting film, which was loaded by the compressive stress (0.080 MPa) at interface, reproducibly connected each polymer surface. As shown in Fig.2, samples were set on the stainless spring and urethane sheets. They were compressed under 0.080 MPa by nylon6 film with 15 μm.

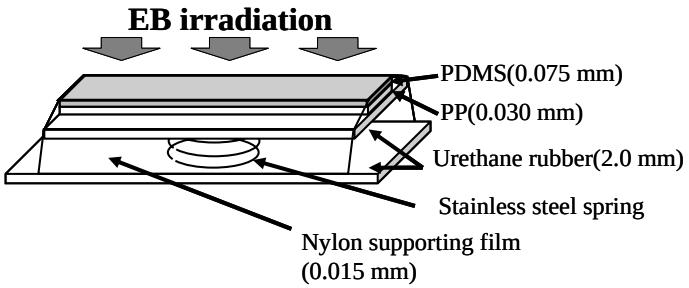


Fig. 2 Schematic diagram of composites loaded to 0.08 MPa during irradiation.

Since peeling force was not detected at the interface between the nylon6 supporting film and the jig in the composites, it was easy to remove the supporting film after irradiation. The sample at the outer surface of the nylon6 film was homogeneously irradiated by an electron-curtain processor (Type CB175/15/180L, Energy Science Inc., Woburn, MA, Iwasaki Electric Group Co., Ltd., Tokyo). The samples were homogeneously irradiated with an electron beam. The samples are treated by HLEBI at room temperature (298 K), high temperature (358 K) and LN_2 temperature (77 K).

2-2. T-peeling test

Composite samples were prepared for the T-peeling test to evaluate the influence of HLEBI on the adhesive force ($^{o}F_{p}$) of peeling resistance. The peeling force and its peeling distance were obtained by the peeling test, which was performed by using a micro load tensile tester (F-S Master-1K-2N, IMADA Co. Ltd., Japan) with a strain rate of 10 mm/ min.

3. RESULTS & DISCUSSION

Although the large adhesive force of peeling resistance has never been measured before irradiation, the laminated sheets constructed with PP and PDMS has been prepared before and after HLEBI. HLEBI homogeneously laminates the PP with the PDMS films at their interface. Fig. 3 shows the relationships between

mean adhesive force of peeling resistance ($^{o}F_{p}$) and peeling probability (P_{p}) of PTFE-PDMS laminated sheets irradiated at 0.13 MGy under high (358 K), low (77 K) and room temperatures (298 K). All $^{o}F_{p}$ values of PTFE-PDMS laminated sheets at room temperature (298 K) are always higher than that at other temperatures.

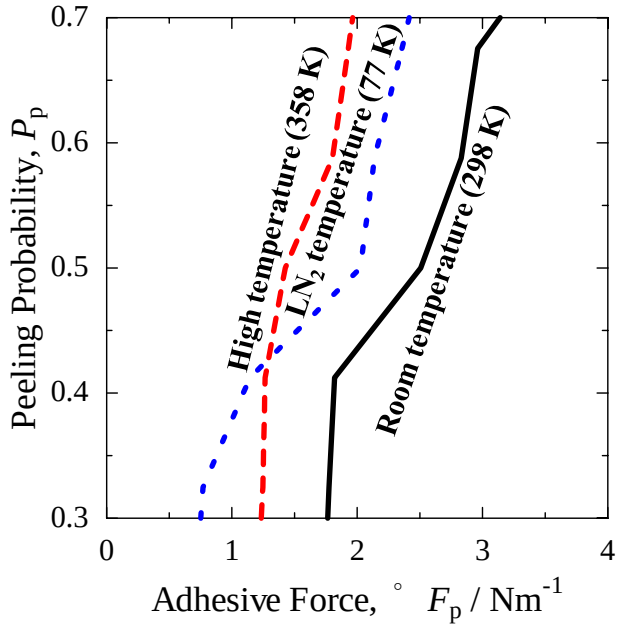


Fig.3 Relationships between mean adhesive force of peeling resistance ($^{o}F_{p}$) and peeling probability (P_{p}) of PTFE-PDMS laminated sheets irradiated at 0.13 MGy under high (358 K), low (77 K) and room temperatures (298 K).

The density of the dangling bonds was measured by means of electron spin resonance (ESR) spectrometer (JES-FA200, JEOL Ltd., Tokyo) to obtain more precise information on atomic-scale structural changes in the polymers. Although ESR signals could not be detected in the untreated sample, ESR signals, indicating dangling bonds, have been observed in PP samples irradiated. On the other hand, ESR signals cannot be detected in the PDMS samples before and after irradiation.

CONCLUSION

The effects of homogeneous low voltage electron beam irradiation (HLEBI) on the adhesive force of peeling resistance of laminated sheets of bio-adaptable polydimethylsiloxane (PDMS) with transparency and high strength

polypropylene (PP) without glue but with sterilization were investigated. All ${}^{o}F_{p}$ values of PTFE-PDMS laminated sheets at room temperature (298 K) are always higher than that at other temperatures. It was concluded that HLEBI was probably a useful tool for quickly lamination of PDMS and PP.

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