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SHORT COMMUNICATION

Estimation of Coating Thickness of Polymer Coated NR Gloves

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The coating thickness of polymer coated NR gloves was estimated by using a stylus surface profile machine. During the measurement, the gloves were stretched to a suitable length, and the polymer layer which was harder than NR, cracked, exposing the NR to the surface. When the stylus was driven across the surface, the sharp-pointed end of the stylus dropped into, and came out from the cracks, generating a series of peaks that corresponded to the coating thickness of the polymer layer. The coating thickness of the polymer-coated gloves in cuff, palm, and finger regions was measured and compared. The significance of the results is discussed in relation to the way these gloves were made.

Key words: thickness; polymer; NR; gloves; coating: surface profile

The surfaces of natural rubber (NR) dipped products are tacky at the room temperature and therefore when in contact, they tend to stick together. In the case of natural rubber gloves, the surface tackiness is normally reduced by applying lubricating powder, surface chlorination, or coating it with another polymer having good lubricating properties. Currently there are many types of polymer-coated gloves, made from different coating materials, being sold in the market.

Since the performance of a polymer-coated glove, such as donning properties, may be affected by the coating thickness of the polymer, it is important for the manufacturer to know the distribution of the polymer layer on the surface of the glove. However, estimation of the coating thickness is not an easy task due to the low thickness value. While scanning electron microscopic (SEM) measurement of cross-section of samples could provide some indication on thickness of the layer the problem of compression during sectioning is often encountered. Moreover, SEM is an expensive instrument.

It is well known that materials having a low surface friction, normally have high Young's modulus and surface roughness values. Since

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the coating materials used in polymer coated gloves are much harder than natural rubber, cracks are expected to occur upon stretching of the rubber glove sample. The extension of these hard materials upon stretching is low and this makes the measurement of their thickness possible by using a surface profile machine.

MATERIALS AND METHODS

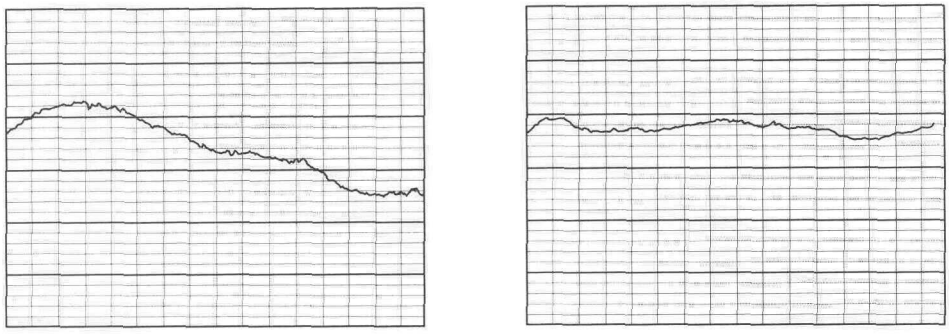
Polymer-coated gloves were either obtained from commercial samples or prepared in the laboratory according to the procedure described elsewhere[1]. Three sections of the inner layer of gloves were investigated, *i.e.* cuff, palm, and finger regions. Five pieces of rubber sample were cut from each region for measurements. Each sample was stretched in the multiple of 50%, up to 500% of its original length, and fixed on a glass surface with an adhesive tape. The surface profile of the sample was recorded with a Taylor-Hobson diamond stylus surface profile machine, Talysurf 10. After each measurement, the sample was checked under a light microscope to ensure that the coating material was not scrubbed off or damaged during the measurement. The surface profile machine was calibrated against a glass with standard roughness supplied by Taylor-Hobson. The thickness of the polymer layer was obtained from the average value of the height of 50 peaks.

RESULTS AND DISCUSSION

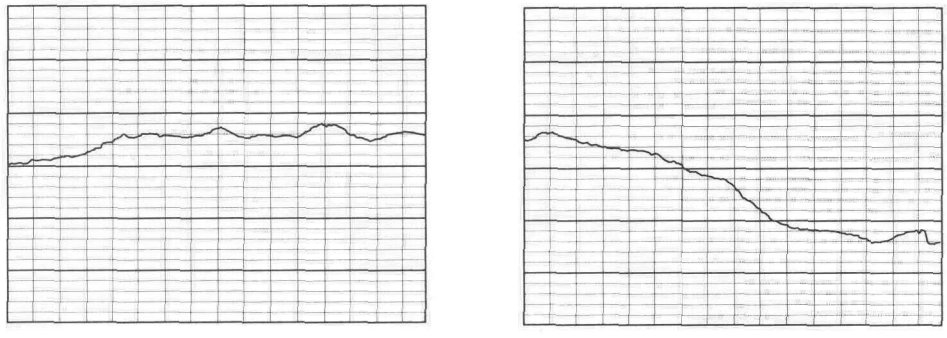
A surface texture may exhibit both roughness and waviness. Roughness is the irregularity in a surface texture, which is inherent in the production, but excluding waviness and errors of form whereas waviness is the component of a surface texture upon which roughness is superimposed.

Figure 1 shows the surface profile of an unstretched and stretched, uncoated textured natural rubber gloves. For the unstretched sample, the surface exhibits low level of roughness as well as waviness. As the sample was stretched to a higher elongation level, the surface roughness and waviness were further lowered due to flattening effect of stretching of the rubber.

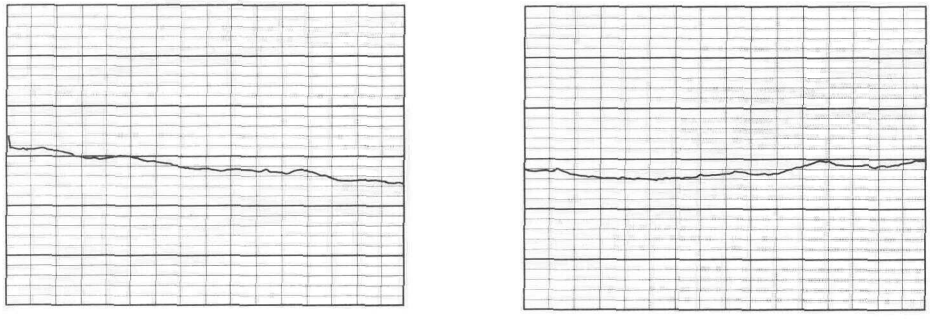
Figure 2 indicates the surface profile of an unstretched and stretched polymer coated glove. The unstretched rubber showed surface waviness, due to the textured surface on the outside surface of the glove and the surface roughness is low. In this case, the distance between the peaks of two waves was 1.6 mm, *Figure 2(a)*. Observation under a light microscope revealed that the spacing between two irregularities could be as high as 1.8 mm. As the glove was stretched, the crack profile of the coated polymer could be clearly observed. As the elongation level increased, the intensity of the peak was found to increase. This was due to the fact that at low elongation level, the cracks generated were not large enough to allow the sharp-pointed stylus to reach the rubber underneath the coated polymer, *Figures 2(b)* and *2(c)*. When the rubber was stretched further, the size of the cracks increased and eventually the stylus could reach the base, *Figure 2(d)*. The average peak height value gives an average value for the thickness of the coated polymer. Further elongation of the rubber would not change much of this value. However, it would reach a stage when the adhesion of the polymer to the rubber surface became very much weakened. At this point, the polymer layer was found scrubbed off by the stylus when it is driven across the surface and therefore no significant peaks were observed as shown in *Figure 2(e)*. Since there are many factors that govern the adhesion strength of a polymer to the rubber



(a) (b)



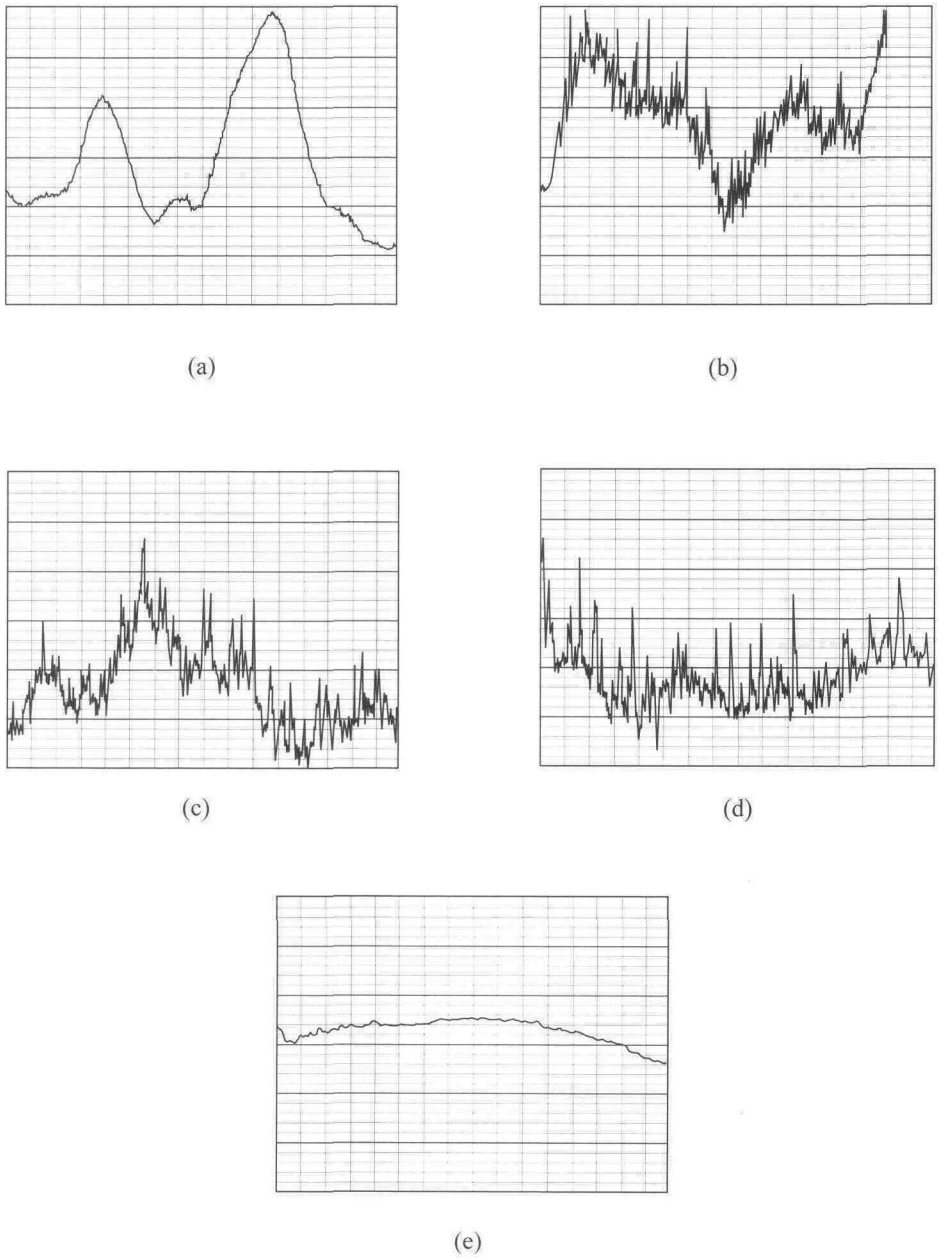
(c) (d)



(e) (f)

(Scale: Vertical 1: 2000 or 1 smallest scale = 1 μm; Horizontal 1: 20 or 1 smallest scale = 0.25 mm.)

Figure 1. Surface profile of untreated natural rubber glove stretched to different levels: (a) 0%; (b) 100%; (c) 200%; (d) 300%; (e) 400%, and (f) 500%.



(Scale: Vertical 1: 2000 or 1 smallest scale = 1 μm; Horizontal 1: 20 or 1 smallest scale = 0.25 mm.)

Figure 2. Surface profile of polymer-coated glove stretched to different levels: (a) 0%; (b) 100%; (c) 200%; (d) 300%; and (e) 400%.

TABLE 1. THICKNESS OF COATING MATERIAL ON POLYMER COATED GLOVE

Sample region	Thickness of coating material (μm[a])			
	Polymer-coated glove (Present work)[b]	Commercial polymer-coated glove, A[b]	Commercial polymer-coated glove, B	Commercial polymer-coated glove, C
Cuff	5.4 (0.17)	3.1 (0.22)	1.3 (0.14)	0.3 (0.07)
Palm	2.8 (0.21)	3.7 (0.27)	3.4 (0.19)	0.4 (0.09)
Finger	2.4 (0.23)	5.1 (0.29)	4.6 (0.23)	0.7 (0.10)

[a] Average of five measurements; [b] Textured surface
Thickness of the glove sample in mm is given in parentheses.

surface, such as thickness, hardness, polarity and surface treatment of the rubber before coating was made, it is necessary to measure the peak height at different elongation levels.

Four different types of polymer-coated gloves were examined in the present study. The average thickness values of these gloves at three different regions are shown in *Table 1*. It was observed that for glove prepared in the laboratory where the former was inverted after coating, with its finger region facing upward during drying in the oven; the thickness of coating material was highest in the cuff region and lowest in the finger region. This is because the coating material tends to flow down to the cuff region during drying. Commercial polymer-coated glove production, on the other hand, normally involves the rotation of the formers in tilted position after dipping, with the finger facing downward during drying. This produces the coating aving thickness in the increasing order of cuff < palm < finger regions. This distribution was also observed in the case of glove thickness. The variation, in this case, is due to the difference in the amount of coagulant in the respective region on the former, resulting in the flow of coagulant from cuff to finger regions while the former was being removed from the coagulant dipping tank. In the case of coating materials, a similar trend was also observed, indicating that the process of coating involved a similar on-line dipping process.

CONCLUSION

The coating thickness of the NR gloves coated with hard polymers could be estimated by stretching the gloves to a suitable level and scanning the surface with a stylus profile machine. However, when the gloves were over-stretched, the adhesion of the polymer to the rubber surface became very much weakened and therefore the polymer layer could be scrubbed off by the stylus when driven across the surface of the gloves.

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