Blunt Trauma Performance of Green Natural Rubber Composites

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Abstract: The natural rubber filled carbon black (CB) composites blunt trauma performance against 9 mm bullets of NIJ Standard-0101.04 for the effect of CB loading and number of layer is reported. Five shots for each samples with velocity of 367 ± 10 ms^{-1} and the indentation depths was measured with oil based modeling clay backing known as Roma Plastilina No. 1. The results showed that chemically modified natural rubber (CNR) filled carbon black of 50 phr recorded the lowest blunt trauma of between 4.55-6.94 mm indentation in depth.

***Keywords*:** Blunt trauma, natural rubber, carbon black, nanomaterial

INTRODUCTION

Trauma pack aims to reduce the depth of the back-face signature (BFS) and the energy transferred from personal body armour to the wearer (1-2). Nowadays, wearers insert various materials such as steel, ceramic and fabric panel behind the ballistic plate to reduce the depth of BFS but has no single solution for the reduction to the energy transferred to the body (3). The introduction of chemically modified natural rubber (CNR) filled carbon black (CB) composites reduces both the energy transfer as well as the blunt trauma defines by the BFS. CNR filled CB is also at much lower density compare to metals or ceramics. CB is widely used reinforcing fillers in numbers of rubber composites with sizes in the range of 15–300 nm (4). It considers a cheap nanomaterial which impart great properties to numerous polymers. This paper reports the trauma pack made out of NR and CNR filled CB composites to evaluate the blunt trauma performance of the compliant panel against 9 mm bullets according to the NIJ Standard-0101.04; the body armour fails, if the indentation depths of the shots is greater than 44 mm (5).

MATERIALS AND METHODS

The composites were prepared using a Haake internal mixer working at 60°C and a rotor speed of 60 rpm for 7 minutes according to ASTM D-3182 and then, subsequently compression molded at 150°C using a hot press in accordance with ASTM D 2084 [6]. Backface Signature (BFS) procedures and guidelines are given in NIJ Standard-0101.04 [5].

RESULTS AND DISCUSSION

Table 1 tabulates all acceptable level of blunt trauma which is less than 40 mm depth. Chemically modified NR (CNR) filled 50 phr CB at 6 layers exhibits the lowest blunt trauma of between 4.55 mm indentation depths. It was a decrease of blunt trauma and inceasing of energy absorption for up to

52.54 % compared to the three layers panel. Together, CNR filled 100 phr CB demostrates a low blunt trauma of 5.12–5.56 mm despite the difference in the number of layers. From the results, it is obvious that the type of matrix and CB loading play the major role in the reduction of the BFS since optimum chain mobility and rigidity improve the energy absorption whether via viscous or elastic response (1, 4). The contribution is then followed by the effect of number of layers. Fig. 1 shows the ballistic effect on the backface of CNR filled CB with unappreciable deflection mark. It is due to the nature of the elastic material that could disperse the remaining energy from the bullet impact over a wider area (1,7).

Table 1. Blunt trauma results

Panel matrix	Carbon Black (phr)	No. of Layer	Velocity (m/s)	Energy (J)	Back Face Signiture (mm)
CNR	50	3	359.6	517.7	6.94
		6	368.0	541.8	4.55
CNR	100	3	364.6	531.9	5.56
		6	369.4	546.0	5.12
NR	50	3	369.4	546.0	14.52
		6	361.2	521.9	6.49
NR	100	3	364.8	532.6	7.77
		6	368.8	542.0	5.25

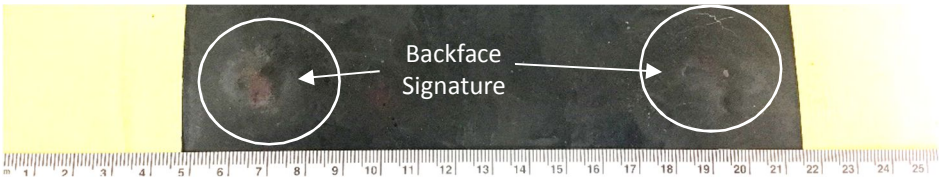

Fig. 1. Ballistic punch effect on CNR Filled Carbon Black

CONCLUSIONS

As the conclusion, the chemically modified NR (CNR) filled carbon black composites were effective in reducing the blunt trauma. The CNR filled carbon black efficiently absorbed and distributed residual impact energy from bullet during ballistic impact over a wider area. The CNR filled CB of 50 phr with six layers showed the lowest blunt trauma however the one with 100 phr CB exhibited consistently low BFS regardless the no. of layers. The significant findings open up the possibility of the material to be developed further for trauma pack.

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