UNIVERSITI TEKNOLOGI MARA

# DEVELOPMENT OF BODY ARMOUR SYSTEMS UTILISING NATURAL RUBBER COATED FABRICS

MOHD ROZI AHMAD

Thesis submitted in fulfillment of the requirements
for the degree of
**Doctor of Philosophy**

**Faculty of Applied Sciences**

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## Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as reference work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

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|---|---|
| Name of Candidate | Mohd Rozi Ahmad |
| Candidate's ID No. | 2004188455 |
| Programme | Doctor of Philosophy |
| Faculty | Applied Sciences |
| Thesis Title | Development of Body Armour Systems utilising Natural Rubber Coated Fabrics |

Signature of Candidate .....

Date 31 JULY 2008

# ABSTRACT

This research explores the application of natural rubber latex as a thin coating matrix on high strength fabrics for ballistic impact and stab resistance applications. Pre-vulcanised natural rubber latices were used to coat ballistic fabrics mainly by the single dipping method. It was found that natural rubber latex changes the frictional aspects among the yarns in the coated fabrics. The natural rubber latex film was able to bind the yarns, restrict mobility and share in resisting the load applied to the fabric. In particular, an increase in friction was evident from the higher yarn pull-out and puncture resistance of the natural rubber latex coated fabrics in comparison with neat (uncoated) fabrics. In the ballistic impact tests, utilising several natural rubber latex coated fabrics in a fabric system increases the ballistic limit as high as 21% in comparison with all-neat fabric systems. The single dip-coating technique gave higher ballistic limit values than all-neat and other types of coating techniques. Stitching of fabrics and hybrid fabric systems were effective in enhancing ballistic impact resistance of fabric systems. In subsequent tests, as high as 46% in blunt trauma reduction was achieved using fewer layers of the coated fabrics in the fabric systems. The main deformation modes were small deflection and peeling-off of the natural rubber latex film at the impact point. Neat fabrics failed mainly through broken yarns, yarn pull-out, and yarn stretching. In addition, crease marks and high deflection are visible on lower thread density fabrics. Further investigations showed that with natural rubber latices, ordinary ballistic fabrics can be engineered for stab resistance purposes. Hard solid particles of silicon carbide are effective in increasing penetration resistance with natural rubber latex as the binder to adhere the particles on the fabric's surface. Incorporating several layers of the coated fabrics enhanced the stab resistance of fabric systems with less number of fabric layers. As a conclusion, the natural rubber latex-coated fabrics were effective in absorbing the impact energy and reducing blunt trauma. The coated fabrics are recommended to be used in blunt trauma panels and positioned at the rear of a fabric system.

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