IMPROUVED PERFORMANCE OF POLYUREA COMPOSITES REINFORCED WITH CARBON NANOTUBES

Răzvan Petre [a,*], Nicoleta Petrea [a], Ginghină Raluca [a], Teodora Zecheru [a], Simona Maria Sandu [a], Mihaela Mureşan [a], Florentina Neaţu [b], Marcel Ionescu [c]

[a] *Scientific Research Centre for CBRN Defense and Ecology, Bucharest, 041309, Romania*

[b] *National Institute of Materials Physics, Măgurele, 077125, Romania*

[c] *EUROPLASTIC SRL, Bucharest, 061334, Romania*

**Corresponding author: 0040213322115, E-mail: petre.razvan@gmail.com*

Abstract: In the recent years the fibre-reinforced polymer materials have been used successfully in a wide range of applications where can significantly improve the characteristics of protection. The fibres are mainly responsible for the performance changing (strength and stiffness properties) and can expand the usefulness of the polymeric matrix. In defence field the fibre-reinforced polymer materials can be used to mitigate dynamic stress, chemical protection, etc.

Keywords: polyurea, carbon nanotubes.

1. Introduction

Fibre-reinforced composite materials (FRCMs) have gained recognition in the recent years and are commonly used wherever high strength-to-weight ratio is required. FRCMs tend to be used in the manufacture of high-performance products that need to be lightweight and also very strong, such as: aerospace industry components, boat hulls, competition motorbikes and racing car frames, etc.

FRCMs are made from three or more constituent materials with radically different chemical and physical properties, that when combined, create a material with noticeably advanced characteristics, different from the individual components. The individual components remain separate and distinct within the finished structure.

In this respect we studied the possibility of using FRCMs in military applications as reducing blunt trauma for ballistic protection equipments.

2. Experimental

The key constituents that have been taken into account for obtaining FRCMs were: polyurea and functionalized multi-wall carbon nanotubes as reinforcing fibres.

Polyurea is created by the chemical reaction (polyaddition) between a di-isocyanate (NCO-R-NCO) and a polyamine (NH_2-R-NH_2), without the aid of an additional cross linker.

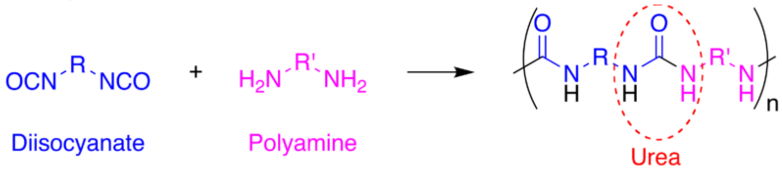

Figure 1. General reaction for forming a polyurea chain

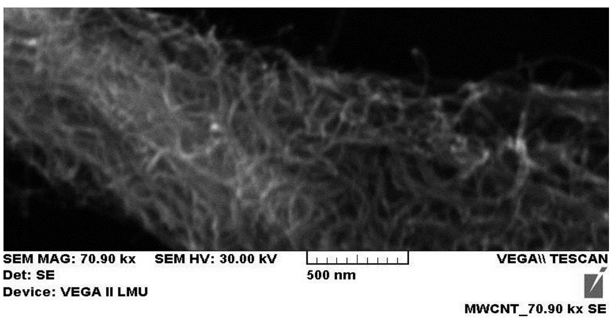

Figure 2. SEM image of multi-wall carbon nanotubes

The reinforcing of a polymeric matrix with high strength and modulus fibres utilizes the viscoelastic displacement of the matrix under stress to transfer the load to the fibre; this result in a high strength, high modulus composite material. The aim of the combination is to produce a two phase material in which the primary phase, that determines stiffness, is in the form of fibres and is well dispersed and bonded and protected by a secondary phase, the polymeric matrix.

Different percentage of reinforcement fibres and different thickness were expressly used for customizable applications of FRCMs, for the following purposes: improving ballistic protection of existing equipments; reducing blunt trauma for protection equipments; additional shield for armoured transport vehicles.

3. Results and discussion

Determination of ballistic protection characteristics were made for a ballistic protection plate made of 10 mm thick kevlar which was covered with 3.1 mm thick layer of FRCMs. The ballistic plate was initially tested without FRCMs and the results were not satisfactory.

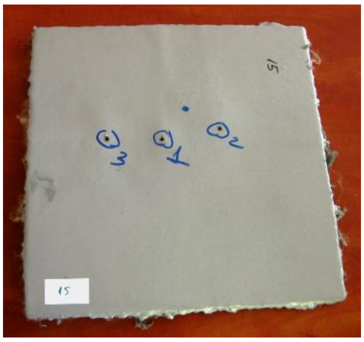

Figure 3. Ballistic protection plate front side (strike face after firing)

Figure 4. Ballistic protection plate rear side (after firing)

The experimental test program aimed to check the ballistic resistance (penetration resistance) and blunt trauma for .44 Magnum bullets under standard conditions.

Table 1. Ballistic protection plate performances

No	Ammunition	Distance [m]	Angle of shooting [^{0}]	Speed [m/s]	Results
1.	.44 Magnum SJHP bullets	5	0	426	Not penetrated
2.				427	Not penetrated
3.				426	Not penetrated

4. Conclusions

The progress beyond the state of the art consists in producing of FRCMs with excellent mechanical resistance. Different types of reinforcement fibres and different thickness can be expressly used for specialised applications of FRCMs, for the following purposes:

- Improving ballistic protection of existing equipments;
- Reducing blunt trauma for protection equipments
- Additional shield for armoured transport vehicles.

FRCMs have exceptional mechanical characteristics, appropriate for dynamic stress mitigation and, in addition, present durability and resistance to the external factors. The presented determinations have confirmed a substantial improvement in the equipment protection capability.

Acknowledgments

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References

1. Joshi, M., Jauhari, S.; Journal of Materials Engineering and Performance, 21, no. 7, p. 1346, 2012;
2. V. CHOUDHARY, A. GUPTA – *Polymer /Carbon Nanotube Nanocomposites, Carbon Nanotubes - Polymer Nanocomposites*, Dr. Siva Yellampalli (Ed.), ISBN: 978-953-307-498-6, InTech, pp. 66-90, 2011.