Graphene Oxide Nanocoatings Produce Flame Resistant Flexible Polyurethane Foams

Lorenza Maddalena
Federico Carosio, Julio Gomez, Guido Saracco, Alberto Fina

Politecnico di Torino, sede di Alessandria , Viale Teresa Michel 5, Alessandria, Italy

lorenza.maddalena@polito.it

Polyurethane Foam (PU) are the first item to be ignited in fires as they can burn quickly and release toxic gasses. The traditional way of flame-retarding polymer foams is mainly based on halogenated additives that have been found to pose severe environmental and health threats and are thus being progressively banned from the market. This produced a urgent need for the substitution of traditional solutions with more effective and sustainable alternatives. Here, the Layer by layer (LbL) has been used as a versatile tool able to penetrate inside the foam and homogeneously coat every available surface with a nanostructured coating based on Graphene Oxide (GO) as flexible high aspect ratio nanoparticle. GO nanoparticle with different aspect ratio were also considered.
The LbL growth of the GO coupled with natural or synthetic polyelectrolytes was monitored with FT-IR spectroscopy [1]. The effects of ionic strength and pH on LbL growth conditions were also evaluated. Scanning Electron Microscopies confirm that the these GO based LbL coatings produce a compact exoskeleton on the PU internal structure where GO are assembled in a "brick and mortar" fashion.
Flammability tests in horizontal configuration demonstrated the complete suppression of the melt dripping phenomenon and self-extinguishing behaviour for foams treated at high ionic strength. Unexpectedly, by cone calorimetry some of the treated foams showed no ignition at all when exposed heat flux typical of developing fires (35 kW/m^2). In addition, flame penetration tests demonstrated that LbL-treated PU foams are able to withstand an impinging flame and to maintain and excellent thermal insulation, with a gradient of about 570°C/cm, comparable in performance to a commercial silica aerogel[2]. The prepared materials represent a an industrially scalable and high performing solution capable of greatly improving fire safety in buildings and transports.

References

[1] L. Maddalena, F. Carosio, J. Gomez, G. Saracco, A. Fina, Polymer Degradation and Stability, 152 (2018), 1-9.
[2] F. Carosio, L. Maddalena, J. Gomez, G. Saracco, A. Fina, Advanced Material Interfaces, 5 (2018), 1801288.

Figures

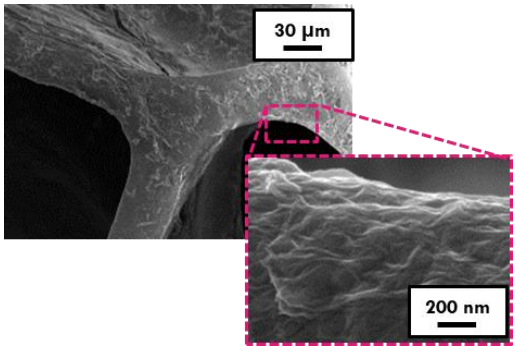

Figure 1: SEM micrograph of 3 BL treated PU foam and detail of the flexible nature of GO nanoparticles

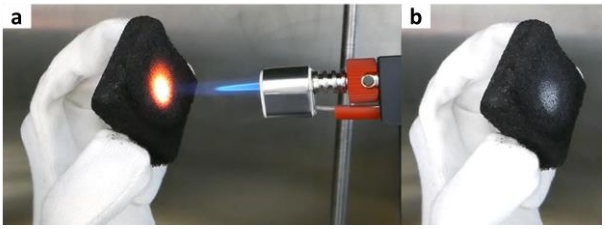

Figure 2: Flame resistant foam during (a) and after (b) the application of a 750°C flame.