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Fire retardant sol-gel coated polyurethane foam: mechanism of action

S. Bellayer[1*], M. Jimenez[1], B. Prieur[1], B. Dewailly[1], A. Ramgobin[1], J. Sarazin[1], B. Revel[2], G. Tricot[3], S. Bourbigot[1]

[1]Univ. Lille, ENSCL, UMR 8207, UMET, Unité Matériaux et Transformation, F59652 Lille, France.

[2] Univ. Lille, IMMCL, 59655, Villeneuve d'Ascq, France

[3] Univ. Lille, LASIR, UMR CNRS 8516, 59655, Villeneuve d'Ascq, France

[*]Corresponding author: severine.bellayer@ensc-lille.fr / Ecole Nationale Supérieure de Chimie de Lille (ENSCL) Cité Scientifique Bât C7a Av Mendeleiev BP 90108 – 59652 VILLENEUVE D'ASCQ Cedex, France

Abstract:

This paper investigates the flame retardant (FR) mechanism of action of a flexible PU foam, flame retarded with a sol-gel coating made of a mixture of tetraethoxysilane (TEOS), methyl triethoxysilane (MTES), 3-amino propyl triethoxysilane (APTES) and diethyl phosphite (DEP) in an ethanol/water solution. To build a mechanism of action, the coating as well as the residues obtained after fire testing were analyzed using solid state nuclear magnetic resonance (NMR), rheology, thermogravimetric analyses coupled with infrared detection (TGA-FTIR), microcalorimetry of combustion (MCC), smoke box and Pyrolysis Gas chromatography coupled with mass spectrometry (Py-GCMS). The coating shows an intumescent behavior upon burning exhibiting significant expansion and bubbling. The expansion occurs in two steps: a first step around 190°C, related to the release of ethanol, and a second one around 380°C, related to the release of non-degraded DEP, ammonia and propylene during degradation of the PU matrix. The flame retardant effect occurs (i) in the condensed phase by intumescence, which yields a thermal insulating layer made of a SiO_2 and Si-O-P network mixed with orthophosphate at the surface of the PU foam, but also (ii) in the gas phase by the release of non-degraded DEP, which acts as free radical scavenger. The coating allows the protection of the underlying PU foam during burning as well as the reduction of the amount of smoke released.

Keywords: Polyurethane foam, flame retardant mechanism, sol-gel, coating.

Introduction:

Flexible polyurethane foam is a chemically complex polymeric product having a broad range of load-bearing capability and resiliency, offering comfort as a cushioning material for furniture, bedding, carpet underlay and automotive interiors. It also offers protective shock absorption performance for use in packaging and automotive applications.