

## Thermal resistance and fire retardant behaviour of Poly(methyl methacrylate) / magnesium di-hydroxide (Mg(OH)<sub>2</sub>) nanocomposites

Fouad LAOUTID<sup>a</sup>, Rodolphe SONNIER<sup>b</sup>, Damien FRANCOIS<sup>a</sup>, Leila BONNAUD<sup>a</sup>, Nicolas CINAUSERO<sup>b</sup>, José-Marie LOPEZ CUESTA<sup>A</sup>, Philippe DUBOIS<sup>a</sup>

<sup>a</sup> - Center of Innovation and Research in Materials & Polymers (CIRMAP), Laboratory of Polymeric and Composite Materials (LPCM), University of Mons & Materia Nova Research Center, Place du Parc 20, 7000 Mons, Belgium  
<sup>b</sup> - Ecole des Mines d'Alès (CMGD), 6, Avenue de Clavières, 30319 Cedex, Alès, France

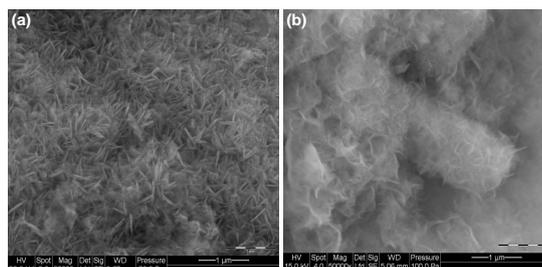
### Introduction

conventional micrometric magnesium dihydroxide (MDH) have been widely used as flame retardant additives for thermoplastics owing to its endothermic decomposition associated with water release between 300 and 400 °C [1]. However, the fire-resistant properties of MDH-filled polymers proved relevant only at high loading levels (> 50% wt.%) and the flame retardant action of MDH is not effective above 400°C. In this context, MDH nanoparticles represent an interesting alternative to the use of high loading of conventional metallic hydroxides since the incorporation of (high specific surface) nanoparticles at lower rate often leads to an enhancement of the polymer thermal stability and fire behaviour [2].

In this work, we study the interest of nanometric MDH as flame retardant agents in poly(methyl methacrylate) (PMMA) and the effect of the nanoparticle shape, either lamellar or fibrous, on both the thermal resistance and combustion behaviour of the related PMMA nanocomposites.

### Nanoparticle synthesis

MDH nanoparticles were synthesized via a sol-gel technique by the reaction of MgCl<sub>2</sub> with given alkaline solution. Different shapes can be obtained for the MDH nanoparticles depending on the nature of the alkaline solution. When NH<sub>4</sub>OH was used, lamellar MDH nanoparticles (10-20 nm in thickness and 250. 300 nm in length) were obtained while the use of NaOH favours the formation of fibrous MDH nanoparticles (ca. 20nm in a diameter and 250-300 nm in length) according to the following reactions:



### Nanocomposite processing

PMMA / MDH nanocomposites were prepared by melt blending in a Brabender internal mixer at 225 °C (10 min mixing at 50 rpm). Plates (100x100x4 mm<sup>3</sup>) for cone calorimeter testing were compression moulded at 250 °C using an Agila PE20 hydraulic press.

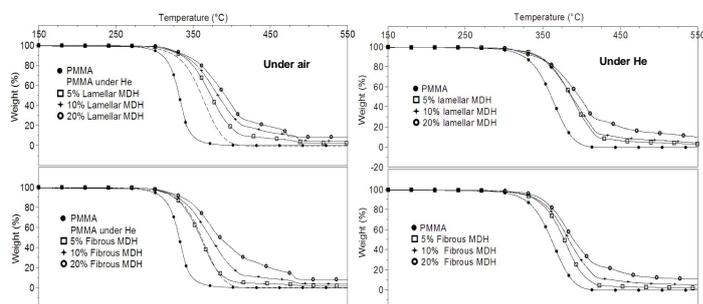
### Thermal analysis and fire testing

Thermogravimetric analysis was used to study the thermal degradation of unfilled PMMA and PMMA nanocomposites: temperature ramp from 25 to 700 °C at a heating rate of 10 °C/min using a TGA 2950 device from TA Instruments.

The fire behaviour was tested by cone calorimeter (Fire Testing Technology) (35 kW/m<sup>2</sup>).

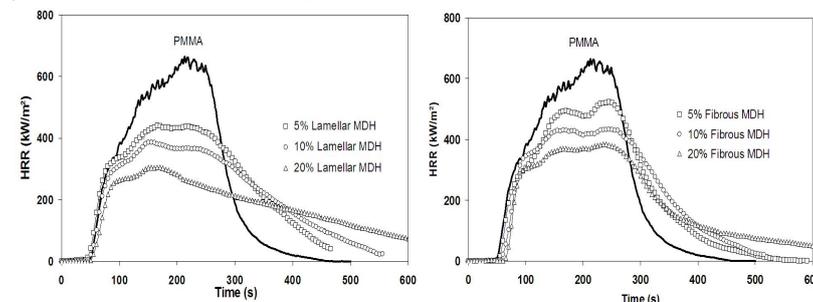
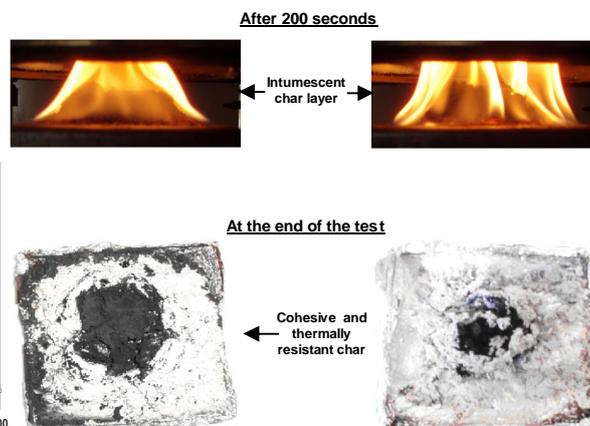
### Thermal resistance

- Both type of MDH nanoparticles increase significantly the thermal resistance of the PMMA matrix, either in air or inert (under He) atm sphere.
- The thermal degradation of the nanocomposite occurs at significantly higher temperature when the loading in MDH nanoparticles rate is increased.
- The enhancement level is much more important when lamellar MDH is concerned
- MDH nanoparticles modify the thermal degradation pathway of PMMA and lead to the formation of a char (see hereunder).



### Fire behaviour during cone calorimeter test

- Overall decrease of the peak of heat release rate (pHRR) for all compositions depending on the filler content.
- The HRR reduction is more marked when lamellar MDH nanoparticles are used
- Formation of an intumescent char layer with both types of MDH nanoparticles
- At the end of the test, the char formed after combustion of compositions containing lamellar MDH nanoparticles appears more cohesive and more thermally resistant.



### Conclusion

MDH nanoparticles and more specifically lamellar type of MDH nanoparticles appear to be a very promising new flame retardants for polymers as illustrated here for PMMA matrix.

### Acknowledgments

LCPM-Materianova authors would like to thank the Région Wallonne and the European Union (FEDER, FSE) for financial support in the frame of INTERREG IV: NAVARE project; Fonds structurels européens 2007-2013. FEDER Convergence and EU Seventh Framework Programme FP7. They are also much indebted to the Belgian Federal Government Office of Science Policy (SSTC-PAI 6/27) for general support.

### References

- 1 - F. Laoutid, P. Gaudon, J.-M. Taulemesse, J.M. Lopez Cuesta, J.I. Velasco, A. Piechaczyk, *Polymer Degradation and Stability*, 91 (2006) 3074-3082
- 2 - F. Laoutid, L. Bonnaud, M. Alexandre, J.-M. Lopez-Cuesta, Ph. Dubois, *Materials Science and Engineering R*, 63 (2009) 100. 125