EFFECT OF ATH CONCENTRATION ON PHYSICAL AND MECHANICAL PROPERTIES OF VINYLESTER/ALUMIN TRIHYDRATE COMPOSITE

Rim Ouadday, Abderrahmen Kaabi, Rachid Boukhili & Aurelian Vadean
Department of Mechanical Engineering, Ecole Polytechnique de Montréal, Montréal, Canada,

Summary: Aluminum trihydrate (ATH) is mostly incorporated into polymer composite to make the flame retardant. Improving the flame retardant properties of these composites have been studied and published in the literature, but ATH effect on the mechanical strength, thermal and physical properties have not been thoroughly addressed. This investigation reports the effect of alumina thrihydrate (ATH) particles on the physical and mechanical properties of ATH filled vinyl ester casting. The bending properties, viscosity, shrinkage, exothermic peak and gel-time were explored and discussed.

INTRODUCTION

Casting made of thermoset resins (Epoxy, unsaturated Polyester, vinylester, etc.) are used as core materials for sandwich structures were high compressive properties of the core are required as for applications in civil, electric and marine engineering [1, 2]. For some applications requiring thick cores, the cure of large amount of thermoset resins lead to unacceptable exothermic temperature peaks. Non-organic fillers are added to the casting formulation to control the peak temperature and shrinkage properties as well as other physical and mechanical properties [3, 4]. Among the numerous available inorganic fillers, aluminum trihydrate (ATH) is a well-known low cost flame retarder and smoke suppressor and these aspects are well documented in the open literature [5-7]. However, the effect of ATH on the mechanical, thermal and physical properties in thermoset plastics has received less attention. This investigation reports the effect of alumina thrihydrate (ATH) particles on the physical and mechanical properties of ATH filled vinyl ester casting.

EXPERIMENTAL METHOD

- **Preparing samples**

To understand the effect of ATH concentration on the physical, thermal and mechanical properties of vinyl ester resin, five composites with different ATH fractions were prepared (10, 20, 30, 40 and 50% of total weight). The polymerization occurs in open casting mold at room temperature. The size of ATH fillers is 2 µm.

- **Physical, thermal and mechanical tests**

Viscosity: the viscosity of pure vinyl ester resin and that of ATH incorporated composite was measured during the polymerization, by Brookfield® viscometer, Model DV2T. This property is an important factor for manufacturing technique.

Exothermal: The time-temperature evolution was recorded during polymerization in mid-thickness of the sample, using thermocouples (K).

Three point bending flexural test: The samples were manufactured by specific mold adapted for bending test, in according to ASTM D790, and afterwards cut to the desired thickness.

RESULTS AND DISCUSSION

Figure 1 shows the effect of ATH fraction on viscosity of vinyl ester. The mixture viscosity is solely influenced by ATH fraction. When the ATH fraction increases from 10 to 50%, the viscosity jumps from 1.2 times higher to 47 times higher than that of vinylester (≈ 780 cPs). The relationship between filler fraction and viscosity is non-linear.

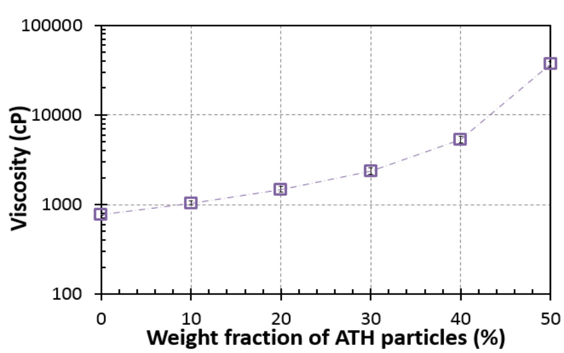

Fig.1: Effect of ATH weight fraction on dynamic viscosity of vinyl ester mixture

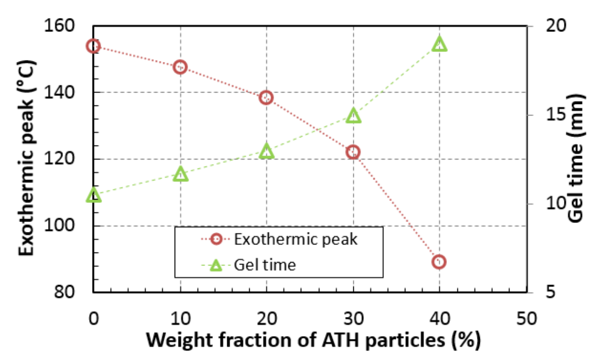

Fig.2: Effect of ATH weight fraction on Gel-time and Exothermic peak of vinyl ester

a) Corresponding author. Email: rim.ouadday@polymtl.ca.

The Figure 2.a reveals that ATH fraction changes two parameters at least: the temperature at exothermic-peak and gel-time. Indeed, when ATH fraction increases, the reaction is delayed and the exotherm-peak temperature decreases. This effect is mainly due to the decreasing of resin quantity in sample, and secondly by the thermal effect of fillers which act as local micro-heat sink. Consequently ATH particles restrict the speed of polymerization reaction progress.

Vinyl ester has a volume shrink close to 5.7%. Figure 3 shows the effect of ATH particles on volume shrinkage ratio of vinyl ester resin. When filler concentration increases from 10 to 50%, the volume shrinkage falls from 4.1% to 0.75%. This effect can be explained by two reasons: the first is related to the decreasing of temperature gradient during polymerization and the second is explained by the lower coefficient of thermal expansion (CTE) of ATH.
The VE/ATH composites present a brittle behavior, which is characterized by rupture without any noticeable prior change in the rate of elongation, figure 4. However, the ATH particles contribute on improvement of rigidity of the material. Figure 5 shows the effect of ATH fraction on flexural properties of ATH-VE composites. When the ATH fraction increases, flexural modulus increases, but the ultimate flexural strength and maximum strain decline.

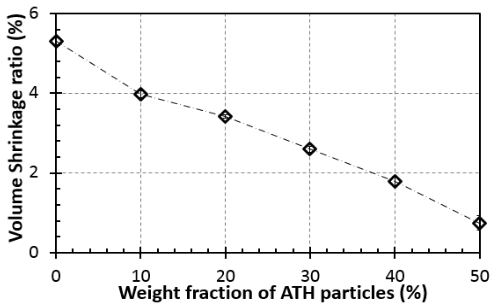

Fig.3: Effect of ATH weight fraction on volume shrinkage ration of Vinyl ester composites

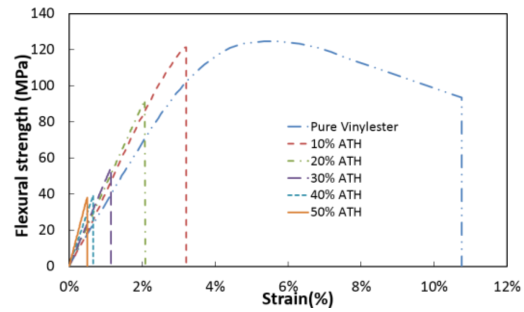

Fig.4: Effect of ATH weight fraction on flexural behaviors of Vinyl ester composites

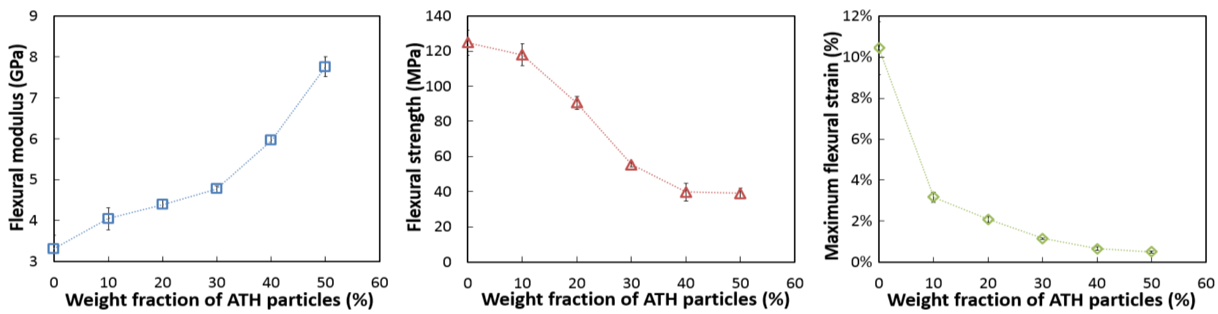

Fig.5: Effect of ATH weight fraction on flexural modulus, ultimate strength and maximum strain

CONCLUSION

According to all the results of this experimental study, ATH fillers affect the mechanical and physical properties of vinyl ester matrix composites. ATH increases viscosity, retards polymerization reaction, and decreases exothermic temperature. Furthermore, ultimate bending strength and the maximum flexural strain decrease when ATH concentration increases. While the flexural modulus increases proportionally to the ATH concentration. This research has shown that if the incorporation of ATH fillers improves composite flame performance, as demonstrated in the literature, this is can be associate to significant processability difficulties and substantial mechanical performance modifications.

References

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