**Improvement of thermal conductivity in graphene reinforced cyanate ester resin**

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The advantages of composites such as light weight, corrosion resistance and easy processing make them a good material in several applications, in particular in aerospace sector. There is a big interest to increase thermal conductivity of polymer based material to be used in light weight high performance thermal management systems. In particular cyanate ester resins have been touted as potential material for structural aerospace applications. These matrices have outstanding physical properties such as low water absorption and outgassing, excellent mechanical properties, dimensional and thermal stability, low ionic contaminant concentration, good dielectric properties, and have the benefit of being single component materials.

The thermal conductivity of polymers has been traditionally improved by the addition of thermally conductive fillers. High filler content is usually needed to achieve the required thermal conductivities that leads to a significant increase of the weight of the composite and represents a significant processing challenge. Carbon based filler appear to be the best candidates when lightweight is required. Nevertheless the results obtained up to now with carbon nanotubes (CNTs) are relatively low compared with expectations, According to the bibliography [1] cyanate ester composites with MWNT content up to 25% wt exhibit a slight increase of the conductivity from 0.2 $Wm^{-1}K^{-1}$ to 0,4 $Wm^{-1}K$.

In the past few years an important progress has been made in the developing of graphene based composites. Graphene possesses similar mechanical properties as CNT but has superior electrical and thermal properties. In this work two types of graphene have been incorporated into a cyanate ester resin LTM123 provided by ACG Company to enhance its thermal properties and have been compared with two ceramic fillers, micro and nanoBN. These fillers were added gradually to a fixed amount of cyanate ester resin up to its maximum acceptable load. Sample thermal conductivity was measured by Hot Disk sensors TPS 2500 S and associated software at room temperature.

The best results have been achieved with a 14% wt of graphene GR122, the thermal conductivity of the resin has been increased from 0.2 $Wm^{-1}K^{-1}$ to 1 $Wm^{-1}K^{-1}$ whereas the same concentration of graphene SG8 only increases the conductivity up to 0,4 $Wm^{-1}K^{-1}$. Significant differences have been also found in their processability and dispersability in the resin as consequence of the different quality of the graphene as it can be observed in the SEM images.

The results show that graphene are more efficient filler materials for increasing the thermal conductivity of cyanate resin than conventionally used fillers.

**References**

[1] Vincent Calard, Celeste Pereira, Antonio Vavouliotis, Stefan Forero, Laurent Pambaguian, Fellicitas Hepp, Proceedings "3rd Vienna International Conference on Nano-Technology" (2009)

| Filler reference | Filler load in samples (%wt) | Thermal conductivity W/Km | Improvement (%) |
|---|---|---|---|
| - | **0** | 0,2 | |
| nanoBN (BN nanopowder (PLASMACHEM)) | **26.2** | 0,4 | 100 |
| microBN (S12- ESK) | **12.6** | 0,5 | 150 |
| Graphene Avanzare SG8 | **14** | 0,4 | 100 |
| (AIGMO-179) Graphene Avanzare GR122 | **5.5** | 0,5 | 150 |
| (AIGMO-179) Graphene Avanzare GR122 | **14** | **1** | **400** |

**Table 1.** *Thermal conductivity values of different fillers reinforced cyanate ester resin*

**Figures**

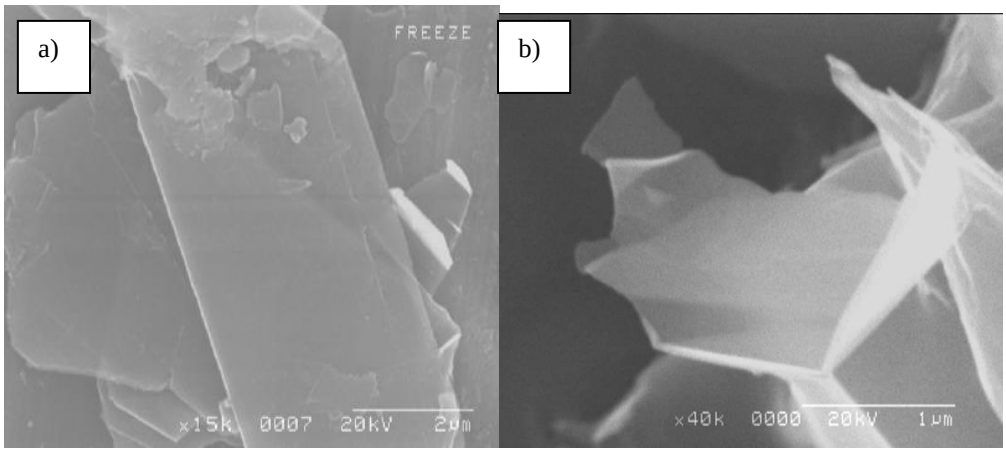


**Figure 1.** *SEM images of graphene Avanzare ( a) SG8 and (b) GR122 (courtesy of Avanzare)*

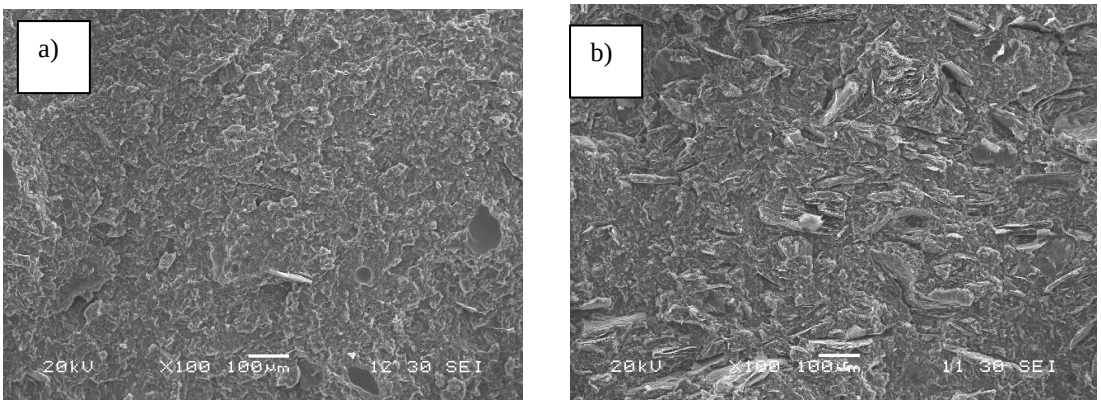


**Figure 2.** *SEM images of nanocomposite 14% wt Graphene Avanzare ( a) SG8 and (b) GR122 in cyanate ester*