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Thermal Properties of a Glass Fiber Filled Epoxy (Sumitomo E264H)

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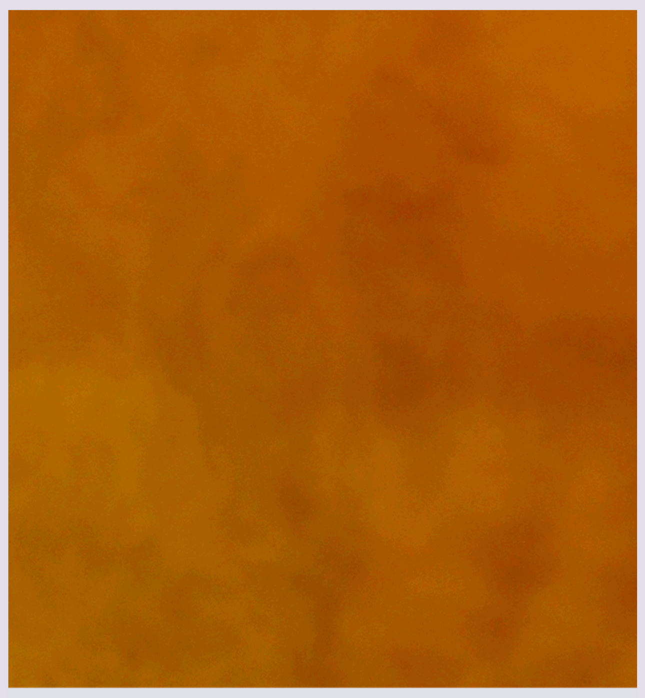
Abstract: Sumitomo E264H is a high strength, long fiber glass reinforced epoxy molding compound. We measured the thermal properties including its thermomechanical response, heat capacity, and thermal diffusivity from -50°C to 150°C. The E264H molding compound exhibits anisotropic thermal expansion behavior. After injection molding, the glass fiber does not appear to be completely homogeneously distributed in the epoxy matrix. The glass fiber in the E264H compound reduces the thermal expansion coefficient, lowers the heat capacity, and appears to "enhance" its thermal conductivity to the epoxy matrix. The thermal properties of the injection molded compound are presented in the poster.

Introduction: The thermal property of a glass-fiber composite is a crucial part of engineering integration and design. When glass fibers are added into a composite structure to enhance its mechanical performance, it can inadvertently alter its thermal properties and impact the reliability of the system. For example, increasing the volume fraction of the glass fiber in the composite will effectively reduce its thermal expansion, which in turn decreases the thermal mechanical stresses for an integrated system due to the thermal expansion mismatch between the composite and its surroundings. At the same time, the thermal conductivity of the component may increase depending on the glass fiber/epoxy ratio, the alignment and orientation of these glass fibers, and this may lead to unexpected consequences. Therefore, thermal properties were characterized, and results will be used for component qualification.

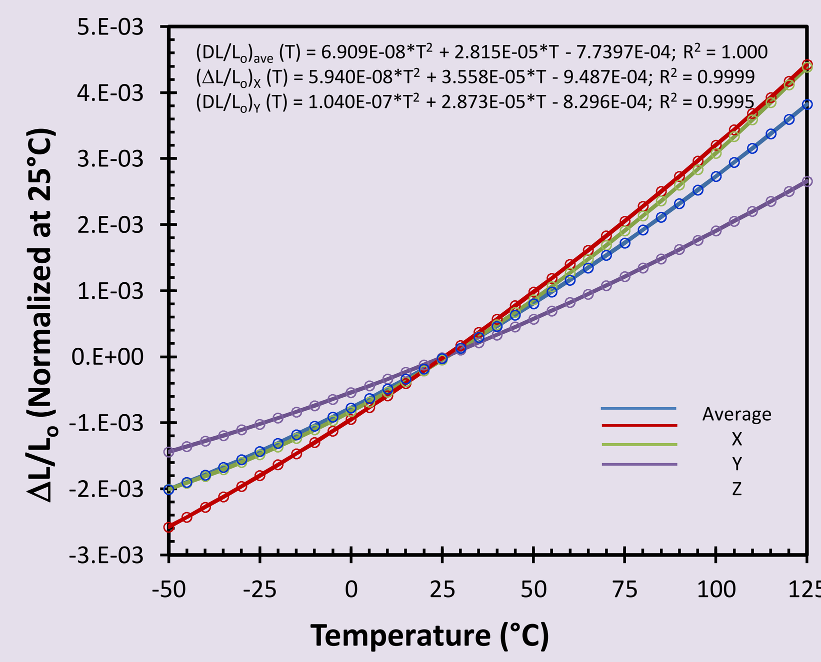
Sample Preparation:

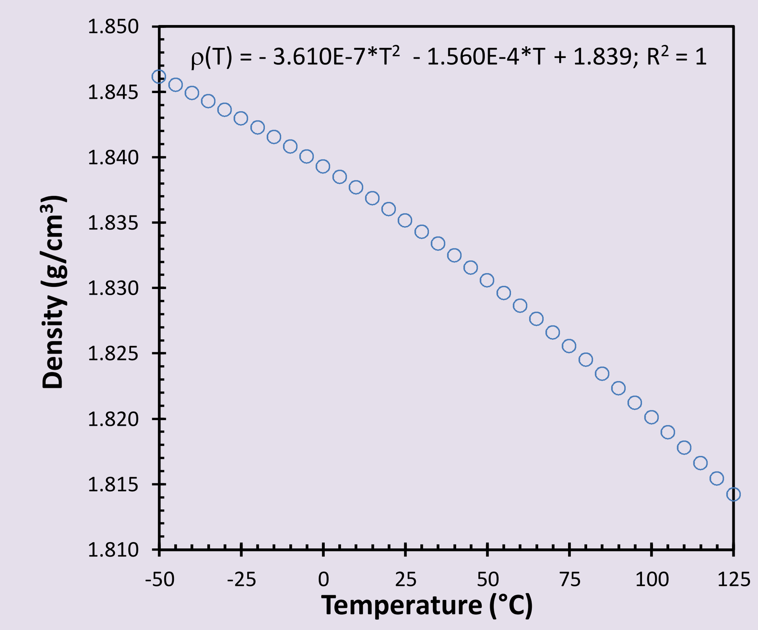
There is a slight difference in sample appearance (or visible inhomogeneity). Specimens from different locations and orientations were prepared for the measurement.



Geometric Density (ρ):

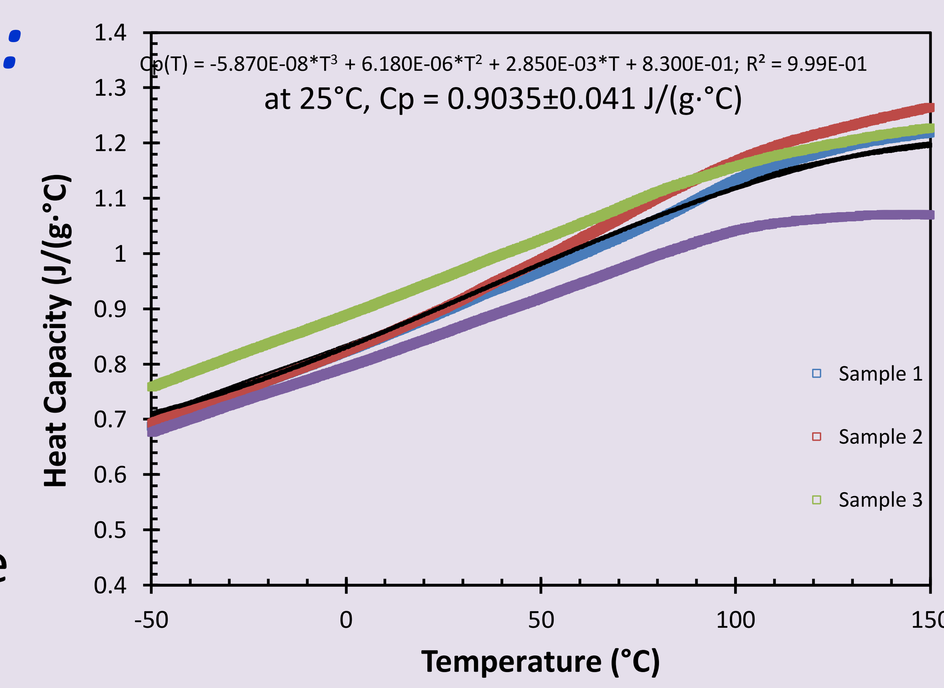
Because of the anisotropic nature of the specimen, bulk density was directly calculated from the average linear thermal expansion data.





Heat Capacity (C_p):

The heat capacity was determined by a differential scanning calorimetry (DSC) technique from -75°C to 180°C. The DSC was calibrated with a sapphire standard.



Thermal Conductivity:

The thermal conductivity was calculated using the product of the thermal diffusivity (α), specific heat (C_p), and bulk density (ρ) by,

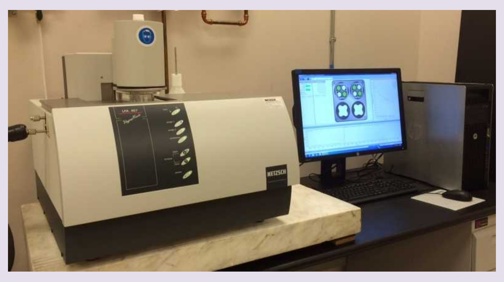
$$\lambda(T) = a(T) \bullet Cp(T) \bullet \rho(T)$$

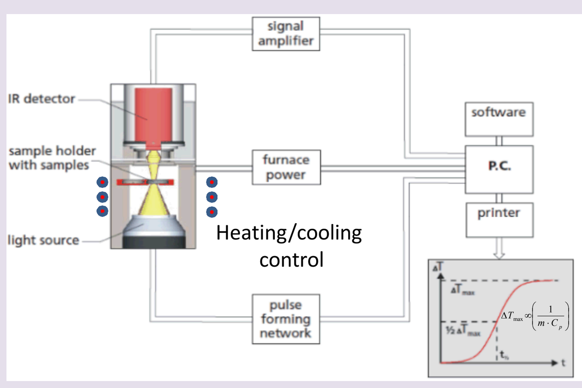
Thermal Diffusivity (α):

Based on the heat transfer equation:

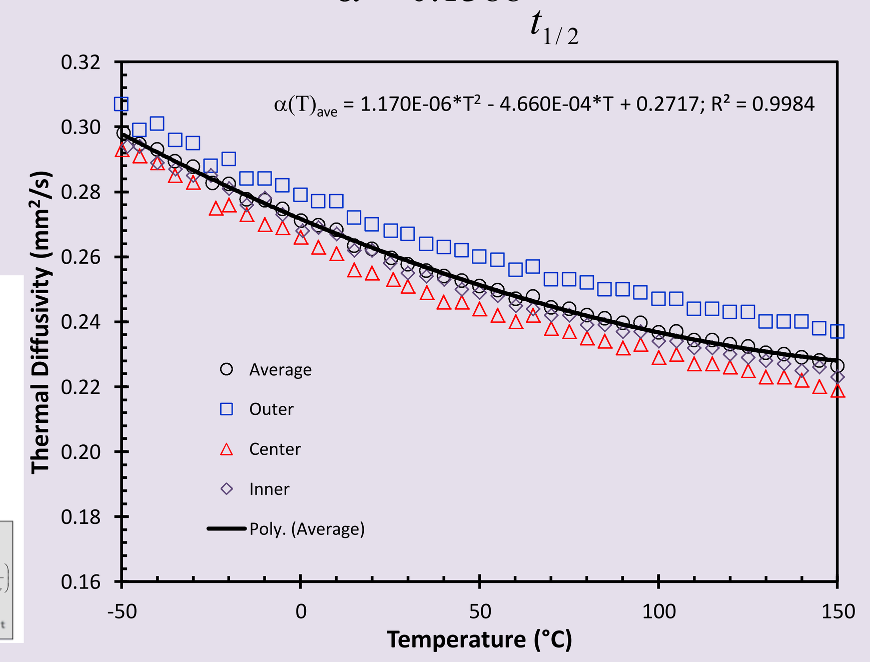
$$\frac{\partial T}{\partial t} = \alpha \nabla^2 T$$

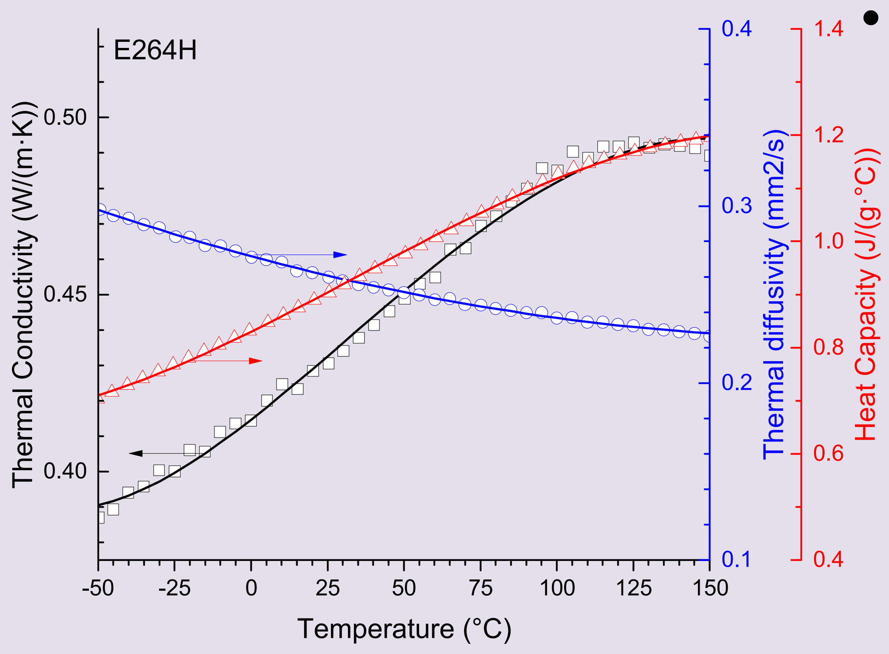
The thermal diffusivity is the measure of thermal inertia i.e., the ability to conduct thermal energy relative to its ability to store thermal energy.





$$\alpha = 0.1388 \frac{L^2}{t_{1/2}}$$





Summary:

- The *averaged* thermal properties of E264H compound are
  - Density (1.835 g/cm^3 at 25°C) – error ~ 3.60%

    $\rho(T)$ = - 3.610E-07*T^2 - 1.560E-04*T + 1.839
  - Heat capacity (0.9035 J/(g·°C) at 25°C) – error ~ 3.20%

    $Cp(T)$ = -5.870E-08*T^3. + 6.180E-06*T^2 + 2.850E-03*T + 8.300E-01
  - Thermal diffusivity (0.2597 mm^2/s at 25°C) -error~ 2.88%

    $\alpha(T)_{ave}$ = 1.170E-06*T^2 – 4.660E-04*T + 2.717E-01
  - Thermal conductivity (0.4306 W/(m·K) at 25°C) error~ 9.68%

    $\lambda(T)$ = -2.544E-08*T^3 + 2.834E-06*T^2 + 6.639E-04*T + 0.4143

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