



**CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY**

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Project Title Controlling Properties of Composite Materials Using Nanoparticles	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The purpose of my experiment is to learn about the properties of composite materials and how nanoparticles effect their properties. The property I am studying is the coefficient of thermal expansion. Based on research, I hypothesized that the coefficient of thermal expansion (CTE) of a composite material is based on the volume ratio of the filler (in my case aluminum) to the matrix (in my case an epoxy). I also hypothesized that if the filler particle size is reduced to a few micrometers or less (nanoparticles) then the influence of the filler is enhanced.</p> <p>Methods/Materials I used a Michelson interferometer to measure the coefficient of expansion of composites with various volume ratios and particle sizes. The Michelson interferometer can measure very small changes in distance using interference properties of light. The composite material was placed behind one of the mirrors of the interferometer and heated by a small resistor. As the composite expanded it pushed the mirror forward and the amount of expansion was measured by counting the number of fringes displayed by the interferometer. This process was repeated for three volume ratios and three different filler sizes.</p> <p>Results My hypothesis was verified. At constant volume ratio, the CTE of the composite material changed with particle size and the effect of the filler was enhanced. For aluminum to epoxy volume ratio of 0.20 the composite CTE went from the value of 636 ppm for 20 μm partivles to 590 ppm and 459 ppm for 4 μm and 50 nm particles respectively. Similar results were obtained for a volume ratio of 0.4 where the CTE was reduced from 501 ppm to 455 ppm for 20 μm and 4 μm particles respectively.</p> <p>Conclusions/Discussion The effect of the filler on the composite was enhanced when the particle size was reduced because of an increase in the relative volume of the inter-phase layer in the composite. The interphase layer is a thin layer of epoxy that surrounds the filler particles and has properties between that of the matrix and the filler even though it is chemically identical to the matrix. The interphase layer properties are different than the bulk matrix becasue they are attached to the filler particles and are constrained by the filler particle molecules.</p>	
Summary Statement My project demonstrates that that the effect of filler particles on the coefficient of thermal expansion (CTE) of a composite material is enhanced when the filler partices become nanoparticles	
Help Received Father helped with identifying project, getting equipment for experiment and collecting data	