# Experimental Measurement of Thermophysical Properties of Al2O3-Ethylene Glycol Nanofluid

Giovanni A. Longo [C, S]
*University of Padova, Dept. of Management and Engineering, Vicenza, Italy*
*tony@gest.unipd.it*

Claudio Zilio
*Università degli Studi di Padova, Dipartimento di Fisica Tecnica, Padova, Italy*

The nanofluids are suspensions of solid nanoparticles with sizes typically of 1-100 nm in traditional liquid such as water, glycol and oil. These solid-liquid composites are very stable and show a great enhancement in thermal conductivity and convective heat transfer with respect to traditional liquids and therefore they seem to be the "cooling medium of the future". Nanofluids have been investigated recently to quantify the heat exchange performance, to identify the specific transport mechanisms and critical parameters and to develop specific production, management and measurement techniques. The experimental investigations include metallic nano-particles (Cu, Al, Au and Ag), oxide nano-particles (CuO, $Al_2O_3$, $TiO_2$ and $SiO_2$) and carbon nanotubes (CNTs) in traditional liquids such as water, glycol and oil with a wide range of nano-particle volume fraction and size. The experimental work carried out till now was not sufficiently systematic to collect a sound amount of coherent and unambiguous data with respect to methodology and results. However the experimental evidences show the possibility to apply successfully nanofluids as transport medium in several systems and processes. The experimental studies available in the up-to-date open literature on thermophysical and transport properties of nanofluids are focused mainly on the measurement of thermal conductivity and heat transfer coefficient, but the sets of data are quite widespread and cover the thermal range close to or above ambient temperature. Therefore there is a specific need for a sound amount of new experimental data including viscosity and pressure drop measurements in order to assess the capability of nanofluids as thermal medium, particularly at medium-low temperature range, between ambient temperature and ice-point. The aim of this paper is to measure the thermal conductivity and the dynamic viscosity of $Al_2O_3$-Ethylene Glycol nanofluid with a declared 10 nm average particle size and a nanoparticle volume fraction ranging from 1 to 3% in the temperature range from 0 to 50°C. The nanoparticles show a great tendency to agglomerate into clusters: the average cluster size measured by a DLS apparatus Malvern Zetasizer Nano ZS is around 105 nm, 10 time the declared average size of the dispersed nanoparticles. The thermal conductivity measurement were performed by using a Transient Hot Disk TPS 2500S apparatus instrumented with the 7577 probe (2.001 mm in radius) having a maximum uncertainty (k= 2) within $\pm$ 5.0%. The dynamic viscosity measurement and the rheological analysis were carried out by a rotating disc type rheometer Haake Mars II instrumented with a double cones probe (60 mm in diameter) having a maximum uncertainty (k=2) within $\pm$ 5.0%. The experimental results were reported in term of absolute values and enhancement ratio with respect to the base fluid (water) at the same temperature. $Al_2O_3$-Ethylene Glycol nanofluid shows a thermal conductivity enhancement ratio from 9 to 29% which increases with nano-particle volume fraction and temperature. $Al_2O_3$- Ethylene Glycol nanofluid exhibits a Newtonian behaviour in all the ranges of temperature and nanoparticle volume fraction. The dynamic viscosity of Al2O3-water nanofluid increases for increasing nanoparticle volume fraction. The experimental measurements were also compared both with available measurements carried out by different researchers and classical computational models for thermophysical properties of suspensions such as Maxwell's correlation for thermal conductivity and Einstein's formula for dynamic viscosity. All the classical models show weak ability to capture the experimental data and the discrepancy with measurement increases for increasing nanoparticle volume fraction.