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Effect of controlled pH and concentrations of copper sulphate and silver nitrate solutions during nanoparticles synthesis towards modifying compressor oil yield stress and lubricity for improved refrigeration

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Abstract

Vapour compression systems are designed to use refrigerants and lubricants for smooth performance. However, recent advances in nanoparticles research have led to the use of Cu and Ag-nanoparticles (AgNPs and CuNPs) as compressor fluid modifiers. In this study, several concentrations of $AgNO_3$ and $CuSO_4$ solutions were adopted in synthesizing nanoparticles for use in a compressor oil. The optimum Coefficient of Performance and cooling effect of the system were observed at optimum concentrations of 0.08 and 1.6 M for the Ag- and CuNP- lubricating oils, respectively, thus giving better cooling effects than the ordinary Copeland 46B oil. At optimum conditions, the weakly acidic CuNP-oil performed better than the weakly alkaline AgNP-oil with cooling temperatures of −8 and 2.3 °C, respectively. Equilibrium concentrations for both particulate oils were found to be 0.08 and 2.7 M at the same yield stress of 2 lb./100 ft^2, while the lubricities of the oils ranged from 0.119–0.154, 0.134–0.155 and 0.156–0.180 for the CuNP-, AgNP- and Copeland 46B oils, respectively. Since lower lubricities are indicative of better lubrication, it then implies that the CuNP-oils gave the best lubricities. An increase in the motor speed gave a corresponding increase in the torque generated as well as, the lubricity coefficients and lubricities of all the oils. Enthalpy changes ranged from 70.3–520 Jg/mol for the 1.1–2.1 M CuNP-oils, although, it was very high (4523.5 Jg/mol) for the 2.7 M CuNP-oil which may be due to the superficial distribution of copper as well as its large surface area to charge ratio at the oil surface, thus making it a better conductor of heat relative to the AgNP-oils. For the AgNp-oils, the enthalpy changes were very small i.e. from −1.012 – 1.2957 Jg/mol whereas, it was 523 Jg/mol for the Copeland oil. Furthermore, the least power consumption was obtained for the CuNP-oils.

Keywords Coefficient of performance · Nanoparticles · Optimum concentration · pH, Vapour compression system · Yield stress

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1 Introduction

Energy conservation in a refrigeration system helps to sustain the salvage value of its compressor for efficient air conditioning, preservation and chilling of drinks/food items. Refrigeration is a process that causes heat to be released from low to higher temperature systems in an enclosed space [1]. The household refrigerator uses Copeland R46B as lubricant with R-134a as refrigerant. In its refrigeration cycle, one way to improve its compressor performance is by direct dispersion of nanoparticles in its compressor oil which in turn reduces the risks associated with erosion and friction of its moving parts