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Performance augmentation of retrofitted sustainable R1234yf in R134a air conditioning system using Al_2O_3–SiO_2 hybrid nanolubricant

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Abstract
Low global warming potential hydrofluoroolefin-1234yf (R1234yf) is an alternative green refrigerant for the automotive air conditioning (AAC) system to replace the existing R134a refrigerant. However, the low energy efficiency of the AAC system using R1234yf has been a significant obstacle to its wider use. This paper describes using Al_2O_3–SiO_2/DEC PAG nanolubricant to enhance the performance of the AAC-R1234yf system. The hybrid nanolubricant was created by a two-step preparation process. The experiment was undertaken at volume concentrations up to 0.05% and under various operating conditions. The stability test shows that the hybrid nanolubricant remained in superior stability after 6 months, with minimum particle aggregation and sedimentation. The AAC-Al_2O_3–SiO_2/DEC PAG system achieved the best performance at 0.03% volume concentration with an average increment of 12.01%. This outcome was contributed by the increase of the AAC evaporator's heat absorb value by 2.8% and the reduction of the compressor work with an average decrease of 7.7%. In conclusion, a 0.03% volume concentration of Al_2O_3–SiO_2/DEC PAG nanolubricant in the AAC compressor was recommended for optimum system performance and energy saving.

Keywords R1234yf · Hybrid nanolubricant · Double-end-capped polyalkylene glycol · Compressor work · Coefficient of performance

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List of symbols

AAC	Automotive air conditioning
AAC-Al_2O_3–SiO_2/DEC PAG	AAC-R1234yf system with Al_2O_3–SiO_2/DEC PAG hybrid nanolubricants
AAC-DEC PAG	AAC-R1234yf system with DEC PAG lubricants
AAC-R1234yf	AAC system with R1234yf refrigerant
AAC-R134a	AAC system with R134a refrigerant
ASHRAE	American society of heating, refrigerating and air conditioning engineers
COP	Coefficient of performance
Cp	Specific heat capacity ($J\ kg^{-1}\ K^{-1}$) for water at 30 °C
DEC	Double-end-capped
TEM	Transmission electron microscopes
GWP	Global warming potential