PERFORMANCE IMPROVEMENT OF HOUSEHOLD REFRIGERATION SYSTEM USING VARIOUS NANO ADDITIVES-A REVIEW

Abstract

Nano-based refrigerants, which are both energy efficient and ecologically beneficial, are currently being favored. The latest development, possibilities, in addition to research of nano-base refrigerant in refrigeration system is discussed in this study. It was discovered that different thermal properties of nano refrigerants have been observed to be favorable. Reduced power consumption, increased (COP), enhanced pressure fall characteristic of nano-oil, and increased conductivity of heat of mixture-refrigerant are just a few of the benefits. As a result of this study, nanoparticles appear to be a strong contender for inclusion in a standard refrigeration system.

Keywords: Heat transmission; pressure fall; refrigerant; nanoparticles; COP

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I. INTRODUCTION

Refrigeration systems typically require a lot of energy. According to studies, the refrigeration systems in supermarkets might consume between 50and 80 % of the total electricity utilized [1]. As a result, experts have been looking for ways to improve refrigeration systems. Physical qualities of refrigerants such as gumminess, conductivity of heat, and relative density play a crucial role in elevated-recital energy rescue to the cooling section in refrigerate and cool operations like the single depicted shown in Figure 1. The creation of a more efficient thermal system has risen to the forefront in recent years, since the need for energy continues to rise as the world's population grows. The enhance in the signify hotness as a consequence of the release of dangerous compounds and orangery gas into the surroundings is also a source of worry. The majority of these emissions are caused by the depletion of fossil fuels and the usage of environmentally unfriendly refrigerants. Sustainability necessitates the development of ecologically friendly and more efficient energy-carrier refrigerants. Each nano-feedstock, on the other hand, has its own set of thermo-substantial property. Nanofluids, on the supplementary offer, have been used in a variety of fields and sectors, including medication delivery and medicine, nuclear energy, automotive, lubrication, micro channels, renewable energies, electronic cooling, methods of heating and cooling, and exchangers of heat [2]. C.O.P of the framework with utilizing nano materials is higher than the C.O.P of the framework without utilizing nano particles by 9.11% hypothetically and 10.53% really. The vitality utilization is diminished by 13.30% when utilizing nano particles. And warm exchange coefficient is expanded by 70.83%[2]. Groupings of TiO2 nano-lubricants (0.3, 0.4 and 0.5g/L) in a marginally adjusted R134a Household fridge. Reception of TiO2 nanoparticles upgraded the cooling rate and energy saving capability of the framework extensively [3]. The most noteworthy hotness move upgrade because of utilizing MWCNT nano-oil is 75.4% in contrast with pure R600a which can be accomplished with 0.3% nanoparticles focus at 90 kg/m2s mass speed [4]. 0.04% Ni/R134a nanorefrigerant consumed somewhat more power than the customary R134a refrigerating framework [5]. TiO2 nanoparticles with R123 refrigerant plays out that volume parts and temperature have huge impacts over consistency of nanofluids [6]. The thickness of the nanorefrigerant diminishes with the increment of temperature, and the particular hotness increments by expanding the nanorefrigerant temperature and diminishes by expanding the convergence of CuO/R134a [7]. Al2O3/R141b gives the best hotness move upgrade among the sorts of nanoparticle liquids that were utilized in this review followed by ZnO, CuO and SiO2 [8]. R22 and the blend containing 0.06% volume of nanoparticles (copper oxide) in the refrigerant shows expanded hotness move rates [9]. Nanolubricants have excellent tribological properties, which means they can minimise friction, wear, and increase lubrication. This can assist various mechanical elements in the refrigeration system, particularly the compressor, last longer. [10]. When the temperature rises to the ideal concentration of nano-refrigerants, the thermal conductivity rises with it. Up to the ideal concentration of nano-refrigerants, the viscosity increases as the temperature rises. [11-12]. CuO nanoparticles had no influence on the flow boiling of R-134a/POE mixes in a horizontal tube with a nanolubricant mass fraction of 0.5 percent, and there was no effect on the heat transfer coefficient. [13]. The increase in thermal conductivity of nano fluids containing 0.16 percent and 0.32 percent, respectively, was determined to be 0.132 W/m K and 0.164 W/m K, ensuring a considerable rise in heat transfer coefficient [14]. The power intake of the HFC134a refrigerant the usage of mineral oil and nanoparticles aggregate as lubricant become stored with 26.1% much less power intake used with 0.1% mass fraction

TiO2 nanoparticles as compared to the HFC134a and POE oil system, that's pretty considerable for a home refrigerator [15]. Compared with the refrigerator using pure R600a as the working medium, concentrations of 0.1 and 0.5g/L TiO2R600a can save 5.94% and 9.60% of electricity consumption, respectively, and the freezing speed of the nano-refrigeration system was faster than that of the pure R600a system [16-17].

Ag-water nanofluid has the very best cooling overall performance wherein SiO2 water nanofluidis the lowest. Thermal conductivity of Ag is higher, and for SiO2 , it's miles lower [18]. The maximum large difficulty that confronts a producer while the use of HC refrigerants is the willpower of a suitable degree of threat and the related liability [19]. The maximum COP was determined to be 4.00, which was obtained with pure PAG oil at 130W power consumption, while the lowest COP was 3.71, which was obtained with 0.6g/L nano-lubricant at 120W power consumption [20]. CuO nanoparticles with varying mass fractions of 0.5, 1, and 1.5 percent were dispersed in the baseline combination (R600a/oil) to make R600a/oil/CuO nano-refrigerants. The results show that nano-refrigerant has a higher frictional pressure drop than the baseline mixture, and that increasing the nanoparticle concentration increases the frictional pressure drop [21].With temperature and particle volume fraction, the thermal conductivity of Al2O3/R600a nanorefrigerant increases. However, with nanoparticle concentration, the rate of increase is faster than with temperature. The greatest thermal conductivity measured was 0.1111 W/mK, which is 32.69 percent higher than the pure refrigerant's value [22]. Evaporator cooling capacity rises more than 5 times over pure R600a for any tube diameter with Al2O3/R600a nanorefrigerant, heat transfer area of the evaporator may be lowered or the evaporator of fixed size can now be used for higher heat load [23]. When compared to pure R141b, the Cu-R141b–SDBS nanorefrigerant improved boiling heat transfer performance [24]. Raising the Brownian motion parameter and the thermophoretic parameter increases the temperature distribution [25].At a 0.5 wt% concentration of nano-additives, thermal conductivity rose by 22.7 percent [26]. The thermal conductivity of the samples was increased by 10.07 percent and 8.01 percent, respectively, when graphene oxide nanoparticles were added [27].The usage of refrigerant-base nanofluids is ahead traction, despite the fact that the disadvantages are still being studied.The feedstock is being studied, as well as the loading of nanofluids into refrigeration systems, in order to achieve considerable beneficial effects. They want to make smaller and more economical refrigeration equipment by exhibiting several promising elements such as improved band steaming and convective warm transport coefficients [28]. We provide a brief overview of nano refrigerant uses in home and industrial refrigeration systems in this study. In addition, numerical analysis will be used to examine the effects of nanorefrigerants in a variety of thermal systems. We also present a review of key boundaries of nanoparticle for refrigeration system that must be considered for the period of different investigations, as well as potential outlook investigate areas and spaces that require greater consideration as of inquisitor in the current work.

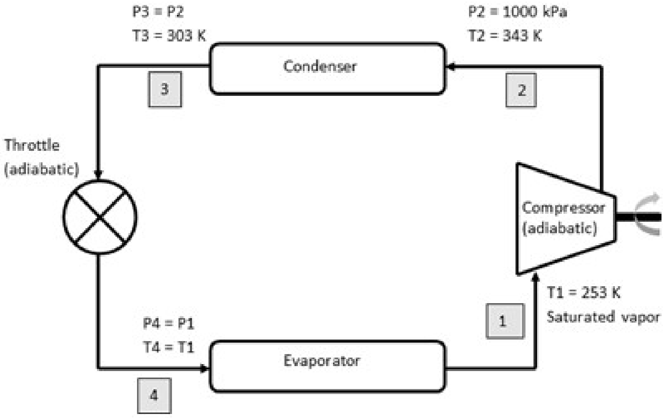


Figure 1: VCR system

II. REFRIGERATION SYSTEMS WITH NANOREFRIGERANTS

Quick overview of the field of refrigeration systems used with nanofluids development.

This field of learn research space were studied to gain a sense of the effort that has been made in the region. The inquiry was carried out using the search term "Nanorefrigerant or Nanoparticle-base Refrigerant" and "Thermal presentation or high temperature transport presentation," and the following were discovered: (Figures from 2 to 7).

Fig. 2 shows the consistent increase in publishing in the nanorefrigerant research domain from 2006 to 2020. This increase demonstrates that this field of study has enormous promise for improved refrigerants and refrigeration system.

The top referenced writers in nanorefrigeration are displayed in Figure 3. In descending order, the most referenced writers are Trisaksri, Ikholeslami, and Jiang, all of whom have studied significantly in this topic and delivered interesting results. Trisaksri and Wongwises, for example, conducted a thorough examination of these fluids. Similar work has been done in this area by others.

Fig. 4 depicts a graph of h-index for author working in the nanorefrigeration field. We can observe that Saidur and Mahbubul are among the top performers in this category. They have an h-index of above 8.

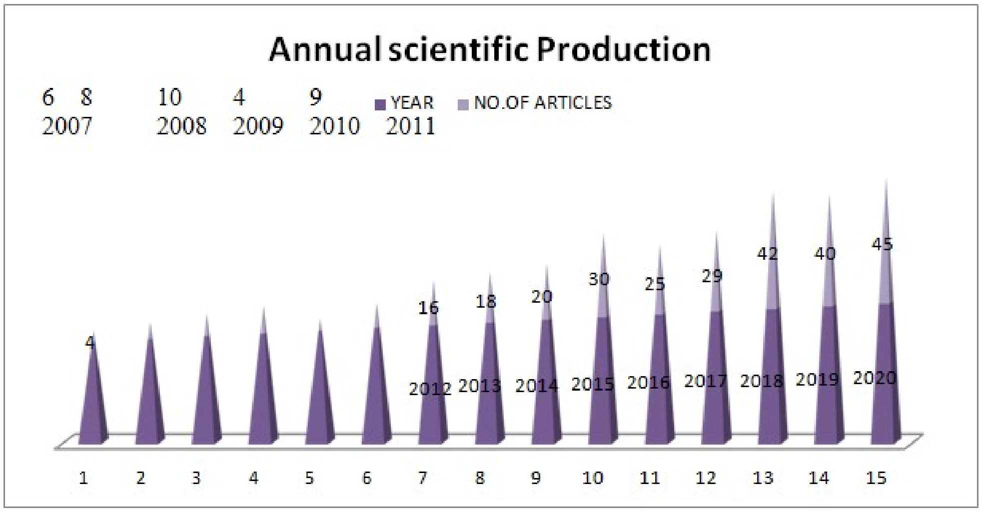


Figure 2: A chart of yearly technical creation

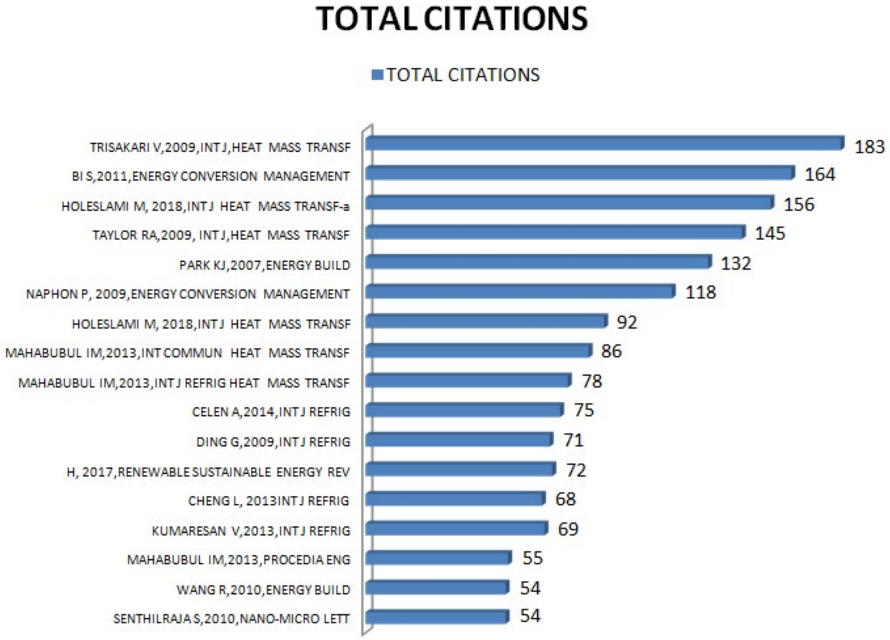


Figure 3: A chart of Most cited research documents

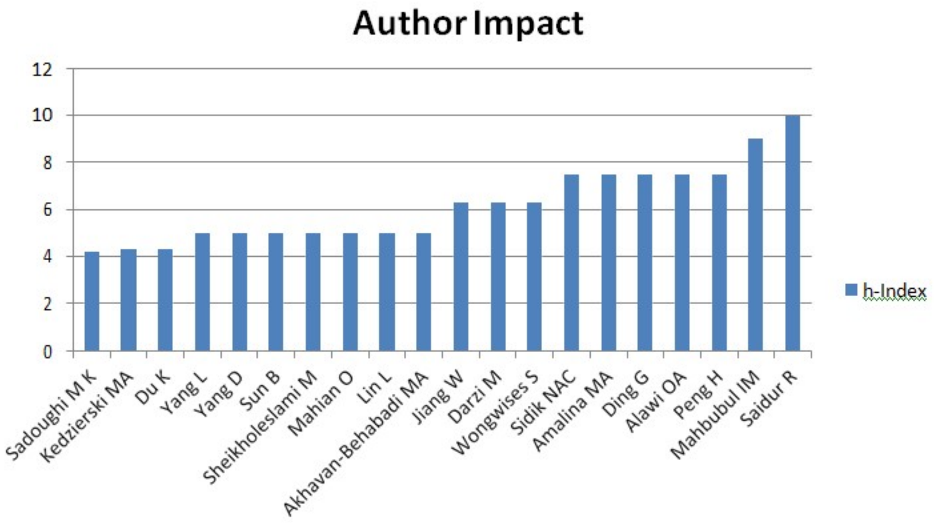


Figure 4: A chart of Author's h-index

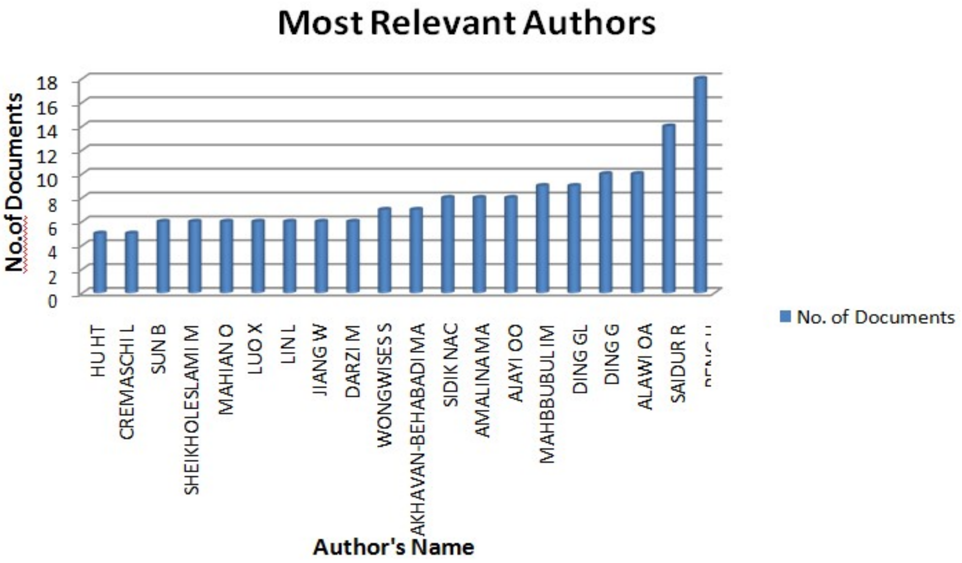


Figure 5: A chart of Number of research documents by authors in this field

Peng and Saidur have the most papers in the field of nanorefrigerants, as shown in Figure 5. They each have a number of documents in excess of ten, indicating that they are actively working in this field.

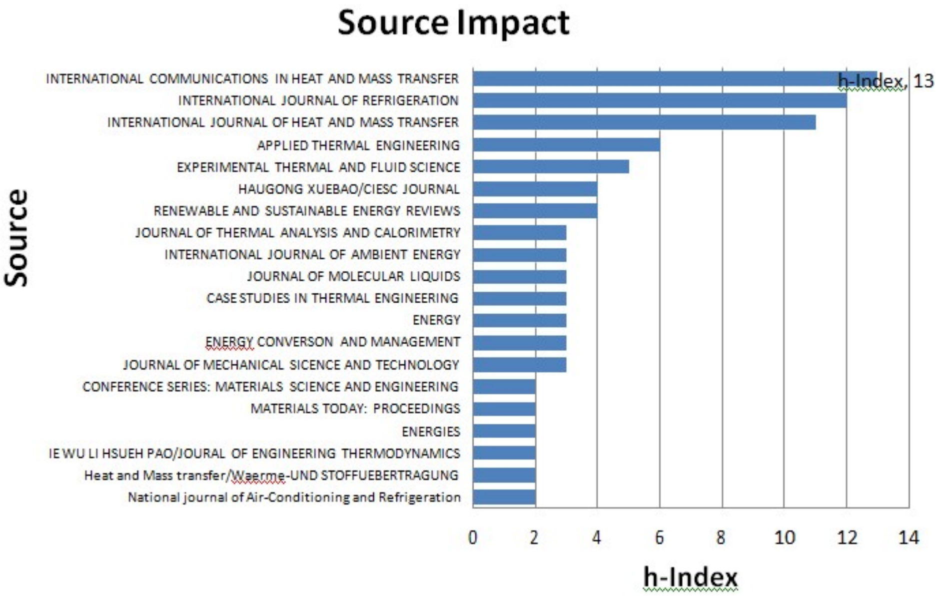


Figure 6 : A chart of the h- index of various journals

The h-index of worldwide relations in heat and mass transfer, international journal of refrigeration, and international journal on heat and mass transfer is more than 10, as seen in Figure 6. Demonstrating that these journals have available significant papers in this field.

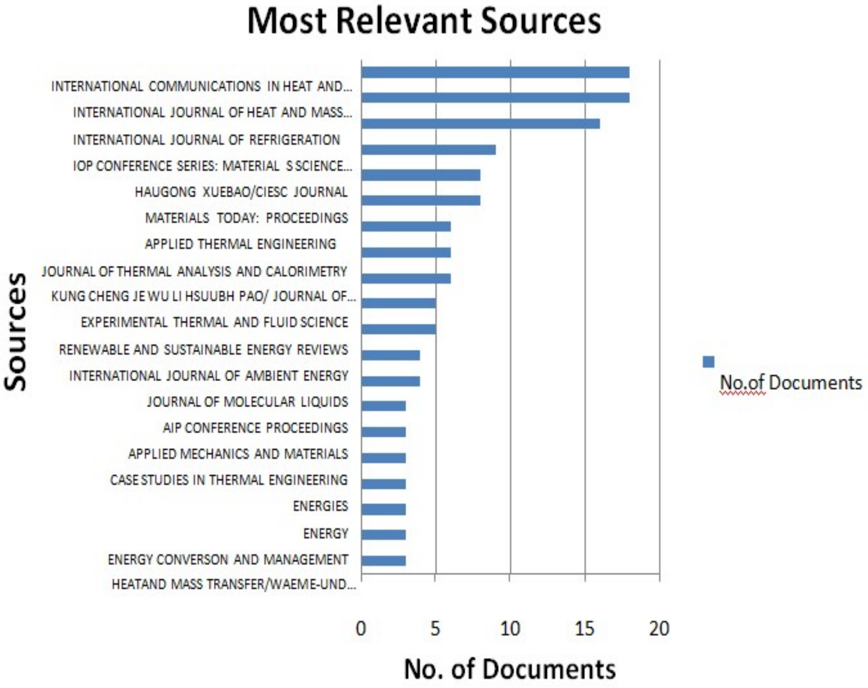


Figure 7 : A chart of various of documents published by various journals

Global relations in heat and mass transfer, International journal on heat and mass transfer, and International journal of refrigeration all include more than 15 papers, as shown in Figure 7. Demonstrating that these journals have published in various articles in this field. Nanofluids increase the performance of refrigeration and air-conditioning systems.

This paper examines the impact of nanofluids on the performance of nanofluids in refrigeration and air- conditioning system. The addition of CuO nanoparticles to the Nano-refrigerant will improve the thermal conductivity, heat transfer, and thermo-physical characteristics of the Nano-refrigerant, considerably improving the performance of the refrigeration system [29]. The potential of TiO2–BaCl2–H2O nanofluids as a novel type of phase change material was examined in order to enhance the thermophysical properties of BaCl2–H2O PCM[30]. The heat transfer coefficient was improved by nanoparticles (Al2O3, CuO, SiO2, and MgO) by 2.1–17.5 percent [31]. When compared to a comparable baseline R-134a/POE combination, test findings for R-134a/POE/CuO, nanoparticle volume fraction of 0.02 percent, demonstrate no influence on the heat transfer coefficient [32]. R134a with 30 nm Al2O3 at 1 Vol.f.% is a great choice since it has a minimal environmental effect and outstanding thermal performance, making it ideal for refrigerant systems [33]. At 2 m/s intake velocity, the pumping power for TiO2-water nanofluids with 4 percent Vol. was 0.26W, while at 6 m/s inlet velocity, it was 5.64W. [34]. In a fixed Reynolds number, heat transmission improves as the volume concentration of nanoparticles increases [35]. The energy performance of an R600a-TiO2 nano-refrigerant-driven refrigerator is proportional to the viscosity of the nanolubricant. When compared to LPG refrigerant, the pressure ratio of the system showed a reduction in the range of 0.60 to 3.06 percent for all TiO2 concentrations and 40g charge of R600a refrigerant [36]. The thermo physical characteristics of nanorefrigerants, performance effectiveness of refrigerators and air conditioners were investigated by Mahbubul et al. [37]. Based on established correlations, a combination of Aluminum oxide (Al2O3) and R-134a containing 4.5% metallic oxide was employed as a nanorefrigerant in an even horizontal pipe at 283K to 308K temperature range. In terms of density (12%), viscosity (13.48%), and thermal conductivity, a nanorefrigerant blend of Al2O3 and R134a outperforms R134a when used alone (27.51 %). R-134a, on the other hand, had a larger specific heat capacity than the nanofluid combination. In comparison to R-134a, the nanorefrigerant combination had a better COP in concentration (3.18%), specific heat capacity (2.43%), and Conductivity of Heat (14.2%). Application and preparation techniques for nano-refrigerants were discussed [38]. The nanofluid's stability potential was also investigated, and it was discovered to be influenced by the nanoparticle concentration in the refrigerant [39]. As a result, the nanoparticle concentration must be tuned to ensure long-term stability.

Several studies have been conduct to determine the thermal characteristics of refrigerant-based nanofluids [40]. Different refrigerants were used to examine an aluminium oxide (Al2O3) based nanofluid [40- 41]. The results revealed that adding nanoparticles to the refrigerant improved the frictional pressure decrease significantly. Transmission and convection be also observed to raise as a outcome of the CuO nanoparticles being added to the refrigerant. The refrigeration system was also charged with a mixture of R134a and CuO [42]. The studies on the use of nanoparticles with natural refrigerants such as NH3 and CO2 not performed[43]. The frictional pressure loss in a vapour compression refrigeration cycle was investigated using R600a and CuO [44].. Their research revealed an increase in the COP and a decrease in power usage. The hotness of the cooling section of the refrigerator dropped significantly around 6% - 10% when the baseline case-R134a was compared to the nanorefrigerant case (R134a + Al2O3) [41]. Similarly, in R134a [45], the heat transfer coefficient of nano refrigerant was investigated using Al2O3 nanoparticles. Their findings revealed that when particle concentration grew, the entire heat transmit coefficient, conductivity of heat, and specific heat lowered.

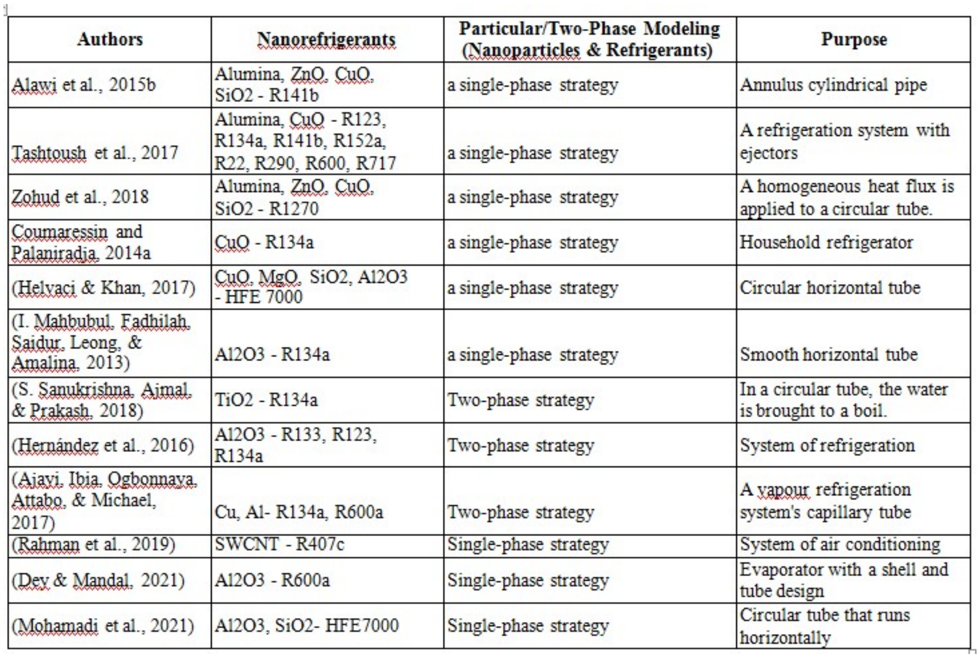
A group of researchers looked through the literature to see how nanofluids affect the energy effectiveness of system that utilise nanorefrigerants and nanolubricants [46]. They were discovered that using nanofluids in refrigeration systems improves the mechanical and thermodynamic features of the system. The use of zinc oxide (ZnO) nano lubricant (R152a) saved 19.1% of energy while posing no threat to the ozone layer, lowering the risk of global warming, and improving the efficiency of refrigeration systems. Using titanium oxide (TiO2) nanoparticles charged into several common refrigerants, the cooling efficacy of refrigerants was investigated [47- 49]. In a residential refrigerator, different concentration (gm./L) of TiO2 in a 25g of refrigerant R600a were investigated [47]. When comparing pure R600a to R600a with TiO2, a group of researchers determined that R600a with TiO2 consumes around 11% less energy [48].

The use of TiO2 particles has been proven to boost cooling rates while drastically lowering energy usage. R-134a, on the other hand, was used in their experiment [49]. Their findings revealed that adding Titanium oxide nanoparticles to the refrigerant system enhanced the refrigerator's COP considerably [49]. A group of researchers performed a algebraic analysis on a nanofluid made since mango bark [50]. The original idea was put to the test, and the results revealed a significant increase in Nusselt number of roughly 68 percent. The presentation of the condenser of the refrigerator's vapour compression was investigated using the mass flow rate and heat rejected [51]. When nanorefrigerant was used, their results showed an increase in mass flow rate and a decrease in heat redundant at the condenser part. Cupric Oxide (or) Copper (II) oxide as the nanoparticle and R600a as the base solution were used to study the pressure drop of nanorefrigerant [52]. Their research used a variety of nanoparticle mass fluxes, and the findings revealed a considerable pressure reduction owing to the refrigeration cycle's condensation flow pattern. To explore the energy characteristics of LPG refrigerant, researchers used various quantities of Al2O3 [53]. According to a group of researchers, a absorption of 0.6 gm/L yielded the best results, while a absorption of 0.3 gm/L outperformed other concentration in terms of COP. On the other hand, at a absorption of 0.6 gm/L, the temperature of the ejection was lost. Available energy extent is taken into account in the investigation [54]. When compared to other nanomaterials, TiO2 and CuO nano-based refrigerants use the least amount of energy.

In the refrigerant R134a, two distinct nanorefrigerants (Aluminium Oxide-Ethylene glycol and Titanium Oxide-Ethylene glycol oils) are used as nano-based particles. With the application of Al2O3, the COP of the refrigeration system increased by around 11%, whereas TiO2 delivers a noteworthy increase of about 20% of COP [55]. In a different study, Al2O3 was used with an R290/R600a refrigerant combination [56]. The blend concentration of all the fluids involved determines how much better the coefficient of performance improves. The optimum result is obtained when the R290/R600a ratio is 0.8:0.2 and Al2O3 nanoparticles are used [56]. By means of inclusion of nano-particles in the refrigerant mixture, COP rises while power consumption decreases.

Nano-oil in R600a refrigerant was investigated by means of a micro-fin pipe [57]. The loading parameters of the nano-oil, as well as the condensation pressures, were studied. The cooling cycle was likewise conducted in its purest form, with no additives. The results revealed that using isobutene (R600a) in the refrigerators exchanger of heat enhances heat transmission (condenser). The temperature transmission coefficient is raised to a substantial intensity of around 77%. According to one set of researchers, loading nanoparticles with low down vapour value appears to exist extremely efficient for elevated high temperature transmission [57]. The refrigerant R718 and other refrigerants were used to do computational and experimental assessments of nanoparticles [58]. When compared to when they didn't employ nano-particles, their thermal performance improved by 25%. However, the best results were obtained when Al2O3 was used in R134a, whereas the worst results were obtained when TiO2 was used in R404a. CuO and R134a have also been used in computational investigations [59].

Table 1: A review of statistical studies on nanorefrigerants



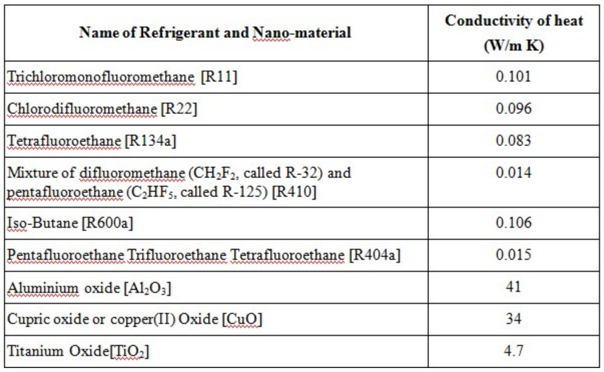
Authors	Nanorefrigerants	Particular/Two-Phase Modeling (Nanoparticles & Refrigerants)	Purpose
Alawi et al., 2015b	Alumina, ZnO, CuO, SiO2 - R141b	a single-phase strategy	Annulus cylindrical pipe
Tashtoush et al., 2017	Alumina, CuO - R123, R134a, R141b, R152a, R22, R290, R600, R717	a single-phase strategy	A refrigeration system with ejectors
Zohud et al., 2018	Alumina, ZnO, CuO, SiO2 - R1270	a single-phase strategy	A homogeneous heat flux is applied to a circular tube.
Coumaressin and Palaniradja, 2014a	CuO - R134a	a single-phase strategy	Household refrigerator
(Helvaci & Khan, 2017)	CuO, MgO, SiO2, Al2O3 - HFE 7000	a single-phase strategy	Circular horizontal tube
(I. Mahbubul, Fadhilah, Saidur, Leong, & Amalina, 2013)	Al2O3 - R134a	a single-phase strategy	Smooth horizontal tube
(S. Sanukrishna, Ajmal, & Prakash, 2018)	TiO2 - R134a	Two-phase strategy	In a circular tube, the water is brought to a boil.
(Hernández et al., 2016)	Al2O3 - R133, R123, R134a	Two-phase strategy	System of refrigeration
(Ajayi, Ibia, Ogbonnaya, Attabo, & Michael, 2017)	Cu, Al- R134a, R600a	Two-phase strategy	A vapour refrigeration system's capillary tube
(Rahman et al., 2019)	SWCNT - R407c	Single-phase strategy	System of air conditioning
(Dey & Mandal, 2021)	Al2O3 - R600a	Single-phase strategy	Evaporator with a shell and tube design
(Mohamadi et al., 2021)	Al2O3, SiO2- HFE7000	Single-phase strategy	Circular tube that runs horizontally

The introduction of Cu based nanoparticles boosts the heat transfer coefficient, according to the findings. For experimental assessment, the refrigerants R134a, R600a, and Polyalkylene Glycol oil were employed with Copper Oxide-based nanoparticles [60]. Their findings revealed that R134a has a lower COP than R600a due to R600a's lower energy consumption when compared to R134a. The Nusselt number was calculated using TiO2 nanoparticles in R134a refrigerant [61]. During the testing, a variety of nanoparticle concentrations were utilised. Increases in heat flow, Reynolds number, and nanoparticle concentration were shown to enhance Nusselt numbers [61]. Copper, Copper Oxide, Aluminium, and Aluminium Oxide nanoparticles were investigated as a possible driving force for improving the refrigeration competence of R141b in soft and within uneven tubes, and the results showed that Cu-R141b nanofluid perform considerably improved when compare to new nanofluids, with ribbed tubes performing improved than soft tubes [62].

III. A DISCUSSION OF NANO REFRIGERANT PROPERTIES

This section presents the review of the impacts of nanorefrigerant characteristics on refrigeration systems, as well as the implications of nanorefrigerant characteristics on refrigeration systems are being investigated. [63] Conducted a thorough examination of the physical temperature parameters and performance aspects of a system of refrigeration employing nanofluids made of refrigerants. They proposed, among other things, that refrigerant thermal conductivities and nanoparticle thermal conductivities have a considerable influence in the distinctive behavior of nanofluids, especially when they are utilised for heat transfer applications. The COP and the refrigeration system effectiveness are then determined by means of heat transfer. Thermal conductivities of typical refrigerants and nanoparticles are shown in Table 2. The qualities of the refrigerant are reported to enhance when nanoparticles are added. This improvement is dependent on the nanoparticle's concentration, size, and material qualities, conductivity of heat, specific mass and specific coductance are examples of these characteristics. The flow as well as heat transfer characteristics of an alumina/isobutane nanorefrigerant were investigated [64]. They looked at percentage by volume of 1 to 6% alumina particle at various temperature, as well as the mass flow through a smooth tube. They found that reducing the percentage by volume of nanoparticles reduces the conductivity of heat, fluidity, coefficient of convective heat transfer, and specific mass of the nanorefrigerant even as increasing at any temperature, the Nusselt number and specific heat for the nanorefrigerant (alumina/isobutane). However, when temperature increased, the Nusselt number, conductivity of heat, massic heat capacity, and coefficient of convective heat transfer all increased, whereas Specific mass and fluidity decreased.

Table 2: Conductivity of heat of various refrigerants and nano-materials.



Name of Refrigerant and Nano-material	Conductivity of heat (W/m K)
Trichloromonofluoromethane [R11]	0.101
Chlorodifluoromethane [R22]	0.096
Tetrafluoroethane [R134a]	0.083
Mixture of difluoromethane (CH_2F_2, called R-32) and pentafluoroethane (C_2HF_5, called R-125) [R410]	0.014
Iso-Butane [R600a]	0.106
Pentafluoroethane Trifluoroethane Tetrafluoroethane [R404a]	0.015
Aluminium oxide [Al_2O_3]	41
Cupric oxide or copper(II) Oxide [CuO]	34
Titanium Oxide[TiO_2]	4.7

Researchers often explore with attributes such as fluidity, hotness, quantity, volume of nano-particles, conductivities of heat, and specific mass. Hydrofluoroethers-7000, for example, are a new baseline generation refrigerant. Table 3 summarizes the various refrigerant-based fluids that were investigated. The table summarizes the performance of several combinations of nano particles within the base liquid. It will help to refrigerator designer understand the characteristics of different hybrid-refrigerants.

Table 3: Summary of Nano-based refrigerant research.

Refrigerant sourcebased on nanofluids/nano fluids	Outcomes	Researchers
SiO_2 in HFE-7000	26% increase in the conductivity of heat report at 0.03% by volume.	(Nawi, Rehim, Azmi, &Razak, 2018)
TiO_2 in R600a TiO_2 R600a/mineral oil	9.5% less energy consumed employing 0.4 gm/L of TiO2-R600a. The use of TiO2 accelerated the freezing process. The COP increased to 60.4%, which is a huge improvement.	(S. Bi et al., 2011) (Jatinder et al., 2019)
Al_2O_3 in /Mineral oil Al_2O_3 in R141b Al_2O_3 in R134a	A total of 19.91% of energy was saved. With heat flux of $152 kWm^{-2}$. By 122% the heat transfer coefficient improves. Thermal conductivity has increased by 31%.; The density has increased by 12%., A 17 %increase in COP and a 15% rise in viscosity. COP increased by 9 to 12 %.	(Padmanabhan& Palanisamy,2012) (I.M. Mahbubul, A. Saadah, R. Saidur, M.A. Khairul, & A. Kamyar, 2015) (I.M. Mahbubul et al., 2015)(Singh & Lal, 2014) (Kotu & Kumar, 2013)
Al_2O_3 in R113/CuO R141b/CuO in R113	The mass fraction, density, viscosity, and heat flux are all inversely proportional to the migration ratio, which is directly proportional to the refrigerant's liquid phase density. The heat enhancement was observed to be around 33%.	(Hao Peng, Ding, & Hu, 2011b)(H. Peng, Ding, & Hu, 2011c)
CuO in R134a	With a 21.4 % maximum frictional pressure drop throughout the system, a 28.6 % increase in heat transfer enhancement was found.	(Bartelt, Park, Liu,& Jacobi,2008)
CuO in R134a	There was also an increase in heat transmission..	(Henderson, Park, Liu, & Jacobi,2010) (Abdel-Hadi et al., 2011)
CuO in R134a	Better performance and heat transfer from the evaporator	(T. Coumaressin & K.Palaniradja, 2014)
TiO_2 in R141b	Reduction in heat transfer	(V. Trisaksri & S. Wongwises, 2009)
SiO_2 in R134a	A total of 162 % heat transmission was measured. Heat transmission resulted in a decrease in particle concentration..	(S. S. Sanukrishna, Shafi, Murukan, & Prakash, 2019)
ZnO in R134a	The thermal conductivity of cubic and spherical shapes improved by 42 % and 26 %, respectively. The amount of energy utilized has decreased by 23%.	(Maheshwary,Handa, & Nemade,2018) (D.S.Kumar & Elansezhian, 2014)
TiO_2 in R123	As the concentration of nanoparticles rises, the viscosity decreases. Low concentration, on the other hand, was recommended for optimal performance.	(I. M. Mahbubul, Saidur, & Amalina, 2012) (O.Alawi, Sidik, & Kherbe et,2015)
TiO_2 in R134a	The COP increased by 19%, and around 17% less electricity is consumed.	(Subramani, Mohan, &Prakash, 2013)

Ti in R11	Efficiency increased significantly	(Naphon,Thongkum, &Assadamongkol, 2009)
Al in R141b	The usage of nanoparticles resulted in an increase in heat transmission.	(B. Sun & Yang, 2013)

When the concentration of Al2O3 in the vapour compression refrigeration system is increased, the heat transfer coefficient improves, according to (Kanthimathi et al., 2017). (Table 4). The best nanomaterial to use is still a work in progress, since the best results are dependent on a variety of circumstances.

As seen in Figures 2 and 3, the heat transmission and thermal conductivity rise significantly as the refrigerant concentration increases.

Table 4: Thermal conductivity and heat transfer coefficient of Al2O3 at different concentrations (Kanthimathi et al., 2017).

Concentration (%)	**0.04**	**0.2**	**1.2**	**3.1**	**4.0**
Heat Transfer Coefficient ($Wm^{-2}K^{-1}$)	436.3	554.6	2945.6	6784.6	10693.4
Thermal Conductivity (W/m K)	0.0828	0.084	0.086	0.091	0.094

Tests [65] were carried out using the same geometry and input requirements for four different baseline refrigerants. In Table 5, the refrigeration coefficient of performance (COP) varies depending on the input parameter. Despite the fact that the choice of an environmentally friendly refrigerant has recently become the topic of research. Since greenhouse gas emissions have a negative influence on our biodiversity,, we cannot remain complacent with current refrigerants. R600a and R290 had the same percentage increase in COP at 6% volume fraction of Al2O3 (Table 5) four types of refrigerants, according to [65]. Metallic fluids have a substantially greater thermal conductivity than normal fluids, according to research [65]. Clogging and abrasion are concerns with nanofluids that are dependent on nano–based particles in conventional fluids. Clogging and abrasions are likely to be less of an issue with nano-sized suspensions than with micro-sized suspensions [65]. The nano particle [65] is 103 times the size of a micron-sized particle, increased area of the surface allows for a significant raise in conductivity of heat, decrease of corrosion, and fluid constancy. When nanoparticles are generated in pulverized structure, there is a clustering problem, which causes the particles to settle in the liquid. To avoid overheating of the nanoparticles, dispersion is normally done with the use of an intermittently regulated ultrasonicator in liquid. The use of a hydrocarbon-based nanorefrigerant also poses a danger of flammability. However, in terms of COP improvements, R134a and R404a lag behind the other refrigerants. A refrigeration system's performance coefficient is calculated using Equation 1.

COP = Heat Extracted/Work input [1]

Table 5: COP characteristics for Al2O3 at a volume proportion of 6% [65].

Refrigerants	COP has improved. (%)
Tetrafluoroethane [R134a]	19
Propane [R290]	22
Pentafluoroethane Trifluoroethane Tetrafluoroethane [R404a]	17
Iso-Butane [R600a]	22

Table 6 lists the features of typical nano-based particles for simple comparison, reference, and selection. Here are the results of five main intrinsic features of nano-based particles. These characteristics are especially important in the heat transmission of the hybrid energy carrier. The combination of Tables 3 and 6 is required for in-depth examination when selecting nanoparticles for refrigeration systems. When comparing parameters like conductivity of heat based-nanoparticles in Table no.6 with the potential results in Table no. 3, inferences may be derived. As a result, these features [Table 6] Physical, chemistry and heat transfer arguments for nanorefrigerants are crucial.

Table 6: Unique properties of some Nanoparticles

Particles made of nanomaterials	**Properties**
Silicon Oxide	Specific heat capacity – 749.9 J/kg KSpecific mass – 2.39 g/cm^3 Conductivity of Heat – 1.36 W/m K Molecular Weight. – 60.2 g mol^{-1}
Titanium Oxide	Specific heat capacity – 682.8 J/kg KSpecific mass – 4.24 g/cm^3 Conductivity of Heat – 4.73 W/m K Molecular Weight – 79.8 g mol^{-1}
Cupric Oxide	Specific heat capacity, - 880.2 J/kg KSpecific mass – 6.33 g/cm^3 Conductivity of Heat – 32.8 W/m K Molecular Weight – 79.55 g /mol
Aluminium Oxide	Specific heat capacity, - 525.3 J/kg K Specific mass – 3.86 g/cmConductivity of Heat – 36.21 W/m K Molecular Weight – 101.99 g mol^{-1}

Zinc Oxide	Specific heat capacity - 523.38 J/kg K Specific mass – 5.58 g/cm^3 Conductivity of Heat – 23.51W/m K Molecular Weight – 81.36 g mol^{-1}
Titanium	Specific heat capacity, - 520.91 J/kg K Specific mass – 6.29 g/cm^3 Conductivity of Heat – 16.96 W/m K Molecular Weight – 79.61 g /mol
Aluminium	Specific heat capacity, - 921.3 J/kg K ; Specific mass – 2.68 g/cm^3 Conductivity of Heat - 205.1 W/m K Molecular Weight-26.97 g /mol

1 **Proposed research directions:** Based on a survey of articles in the open literature, the following investigation directions are suggested.

- No investigate on the application of biobased nanorefrigerants has been published. The utilisation of biobased nanorefrigerants will be a fascinating research that will also benefit the environment.
- The concentration of nanoparticles has been revealed to have a substantial influence on heat transmission and thermo physical properties of nano refrigerants. The optimal nano refrigerant ratio depending on particle size, concentration, temperature, and flow conditions will require further investigation.
- There is a scarcity of research on numerical and analytical models for predicting physical attributes in the open literature. In this regard, future work is suggested.
- While most numerical studies concentrated on utilising a single-phase technique to deal with nanorefrigerants, the two-phase mixture model will provide hurdles in future studies because to its great accuracy and high processing cost at the same time.
- There are just a few researches on the usage of nanoparticles with natural refrigerants such hydrocarbons, NH3, and CO2 in the open literature. In terms of commercial and industrial applications, these investigations are required.
- There have been no research on the influence of nanoparticles on new blend refrigerants like R1234yf.
- Nano refrigerant flow through microchannels, twisted taped tubes, corrugated tubes, and other enhanced geometries is limited in research. Further study is needed to see how using nano refrigerants affect heat transfer coefficients and overall thermal performance of refrigerating systems.

IV. CONCLUSIONS

This paper reviewed a number of studies on nano-based refrigerants, appraised the subject's innovative development and promise, and offered a few innovative prospect studies in the field. The major point of debate was that nanoparticles have a lot of potential if they're used in a standard system of refrigeration. Nanorefrigerant has been shown towards the improve refrigeration system concert and heat transmission. It was also observed that the refrigeration system's better performance is aided by its reduced cost, longer lifespan, and greater total rate of heat transfer. The specific conclusions are as follows::

- The use of nanoparticles in refrigerants has the potential to improve system efficiency.
- Adding nanoparticles to refrigerant enhances the refrigeration system's coefficient of heat transfer and conductivity of heat.
- The use of nanoparticles in refrigerants minimizes the amount of energy used.
- The use of nanorefrigerants increases the refrigeration system's overall thermal performance.

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LIST OF ABBREVIATIONS

- COP-Coefficient of Performance TiO2-Titanium Oxide
- MWCNT- Multi-Walled Carbon Nanotubes CuO- Copper (II) oxide
- ZnO- Zinc oxide SiO2- Silicon dioxide

- R134a- Tetrafluoroethane R123- Dichloro-trifluoroethane R141b- Dichloro-fluoroethane R22- Chlorodifluoromethane POE- Polyolester oil
- R600a- Isobutane
- SDBS- Spectral Database for Organic Compounds BaCl2- Barium chloride
- H2O-water
- PCM-Phase Change Material MgO- Magnesium oxide NH3-Ammonia
- CO2-carbondioxide R152a- Difluoroethane
- R1234yf- Tetrafluoropropene