CURRENT TRENDS IN NANOFLUIDS RESEARCH

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Introduction: Nanofluids are defined as engineered colloidal suspension of nanometer-sized particles with applications in thermal sciences. Since the "nanofluid" term was coined by S.U.S Choi in 1995, there has been an exponential increase in the number of indexed journal publications (see Figure 1) whose limit is very difficult to predict due to its strong multidisciplinarity and that it will depend on, among other factors, the number of industrial applications that scientists are able to find.

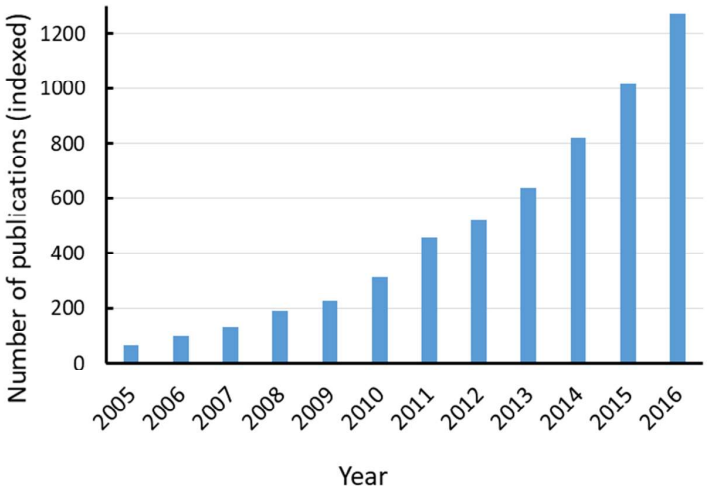
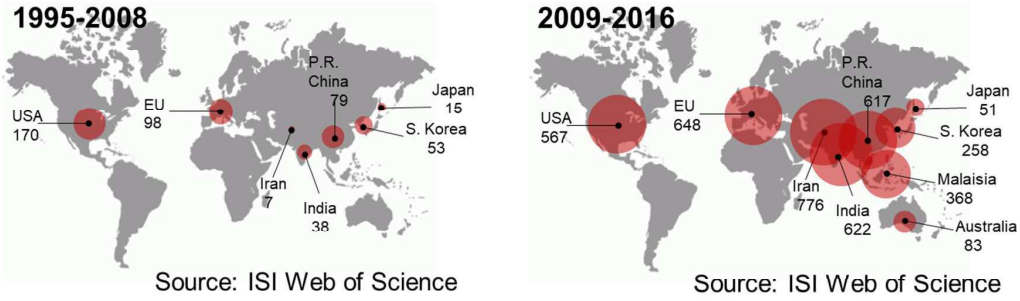


Figure 1. Number of publications in JCR indexed journals with the term "nanofluids" as topic (source: ISI web of Science).

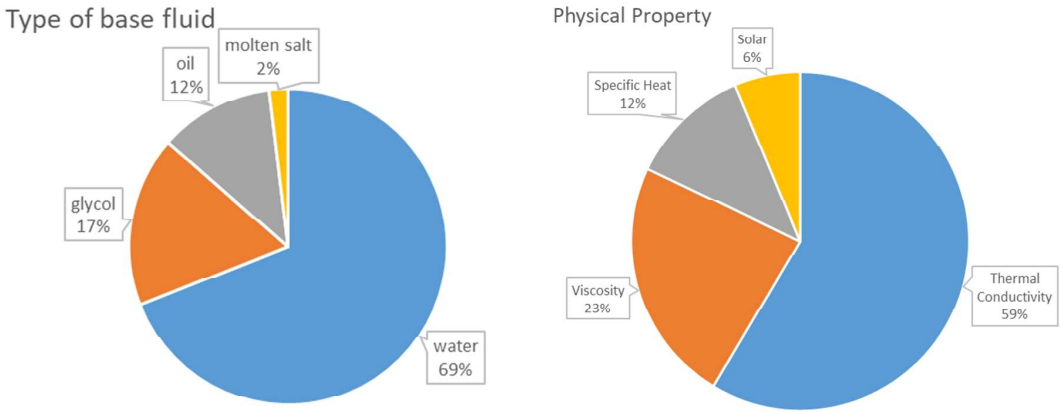
Important changes has been produced in the nanofluid research community in the last decade. The most important one is related with the location of the research groups with active research activities in this field. Nanofluid research started in the USA and EU; however, emerging Asian nations, such as Iran, India and China, are making huge efforts in this research field and have surpassed EU countries in recent years (Figure 2).



a) b)

Figure 2. Number of publications in JCR indexed journals with the term "nanofluids" by country (source: ISI web of Science).

If all the nanofluids related papers published in JCR indexed journals are considered (Figure 3) it is possible to observe that most of publications are linked with the thermal conductivity measurement and/or modelling of water-based nanofluids. This fact can be explained by the importance of water as heat transfer fluid, the relative easy dispersion of nanoparticles by the control of the pH value and the working temperatures.



a) b)

Figure 3. Percentage of publications in JCR indexed journals with the term "nanofluids" by: a) Base Fluid; b) Physical Property.

However, if we focus on the publications of the last 3 years and compare them with the previous ones, it is possible to observe that, although water remains the most popular base fluid, medium and high temperature heat transfer fluids are gaining attention. The change in the current trends is more evident in the case of the physical properties. Thermal conductivity and

boiling phenomena are losing some of the attention. The case of thermal conductivity can be explained by the huge number of previous publications about this topic and the boiling by the difficulties found in controlling the nanoparticle deposition process in the hot surface. It is worth mentioning the case of "solar" property, referred in this work to the use of solar nanofluids as solar direct volumetric absorbers. In this case, the important increment observed in the last graph of Figure 4 is partially explained by the late appearance of this type of nanofluids (first paper in 2009) and its direct use in the emerging solar thermal renewable energy sources.

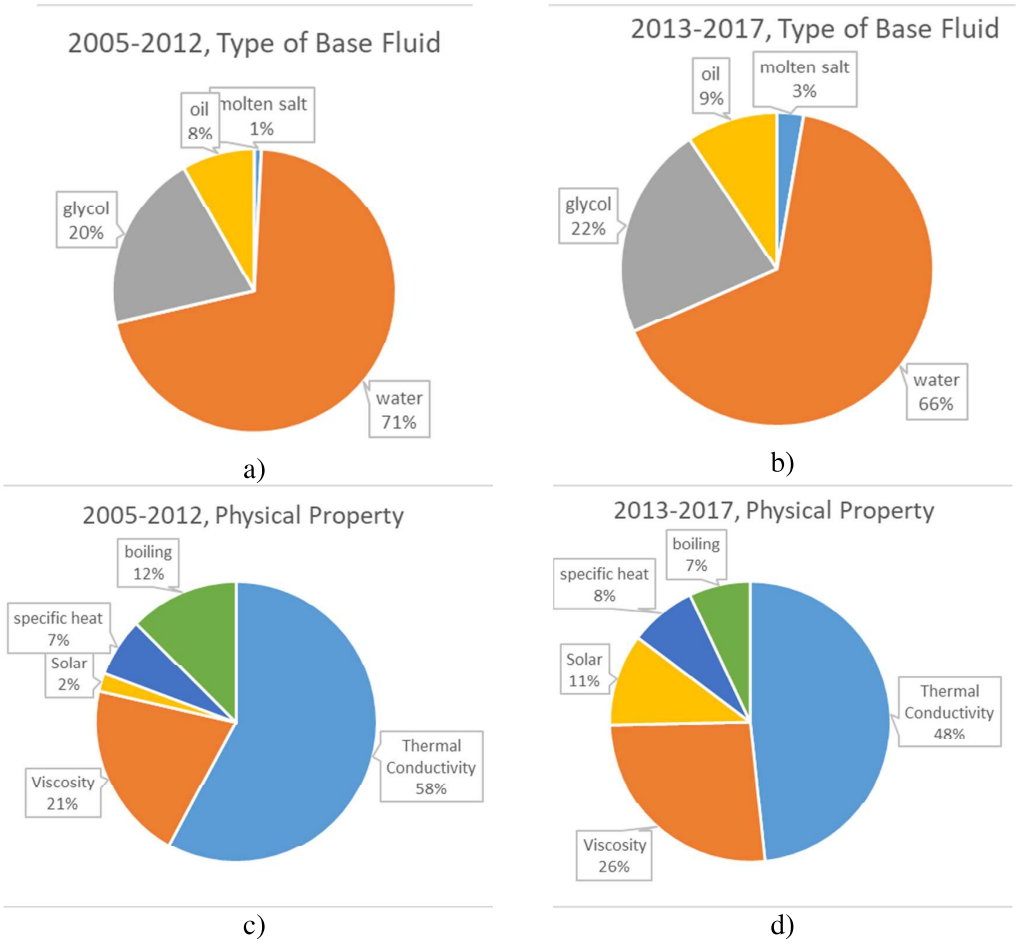


Figure 4. Comparison of percentage of publications in JCR indexed journals with the term "nanofluids" by: a and b) Base Fluid; c and d) Physical Property.

Summary:

- Water-based nanofluids and thermal conductivity measurement/modelling are the most important research topics in the nanofluids research field.
- However, new trends can be observed in the last three years with more research papers focused on medium and high temperature heat transfer and storage fluids and physical properties based on solar applications.
- It is expected that this trends will be accentuated in the future. However, it will be difficult to beat the water as heat transfer fluid due to its important practical applications and facility in obtaining the nanofluids.

References:

1. S. Choi, Enhancing thermal conductivity of fluids with nanoparticles, *ASME Fluids Engineering Division* 231 (1995) 99.
2. H. Masuda, A. Ebata, K. Teramae and N. Hishinuma, Alteration of thermal conductivity and viscosity of liquid by dispersing ultrafine particles (dispersion of gamma-al2o3, sio2 and tio2 ultrafine particles) *Netsu Bussei* 4 (1993) 227–233.