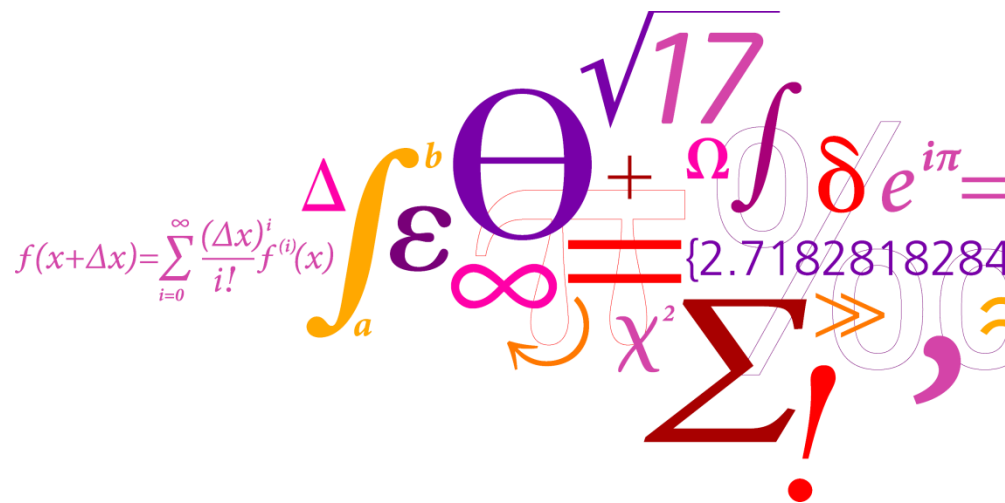


Prospects of the use of nanofluids as working fluids for organic Rankine cycle power systems

Maria E. Mondejar, Jesper G. Andreasen, Maria Regidor, Stefano Riva, Georgios Kontogeorgis, Giacomo Persico and Fredrik Haglind



Project nanoORC: nanofluids as working fluids for organic Rankine cycles



This project has received funding from the European Union's Horizon 2020 research and innovation programme with a Marie Skłodowska-Curie Fellowship under grant agreement No 704201.

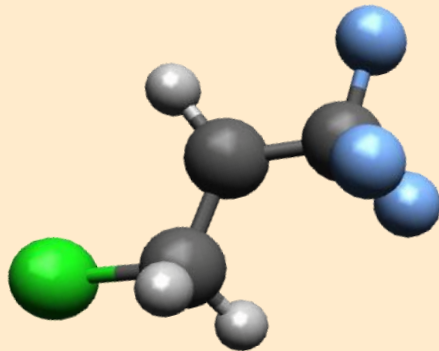
Project nanoORC: partners



Project nanoORC: objectives

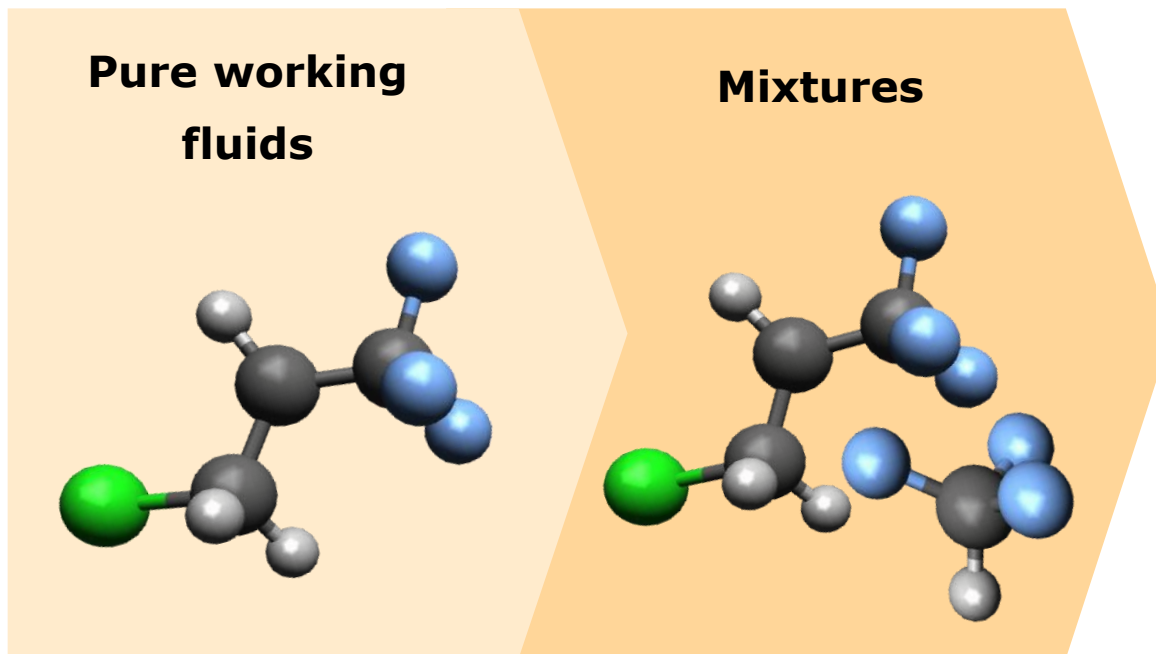
The purpose of this project is to develop models for the estimation of the thermophysical properties of **new working fluids**.

**Pure working
fluids**



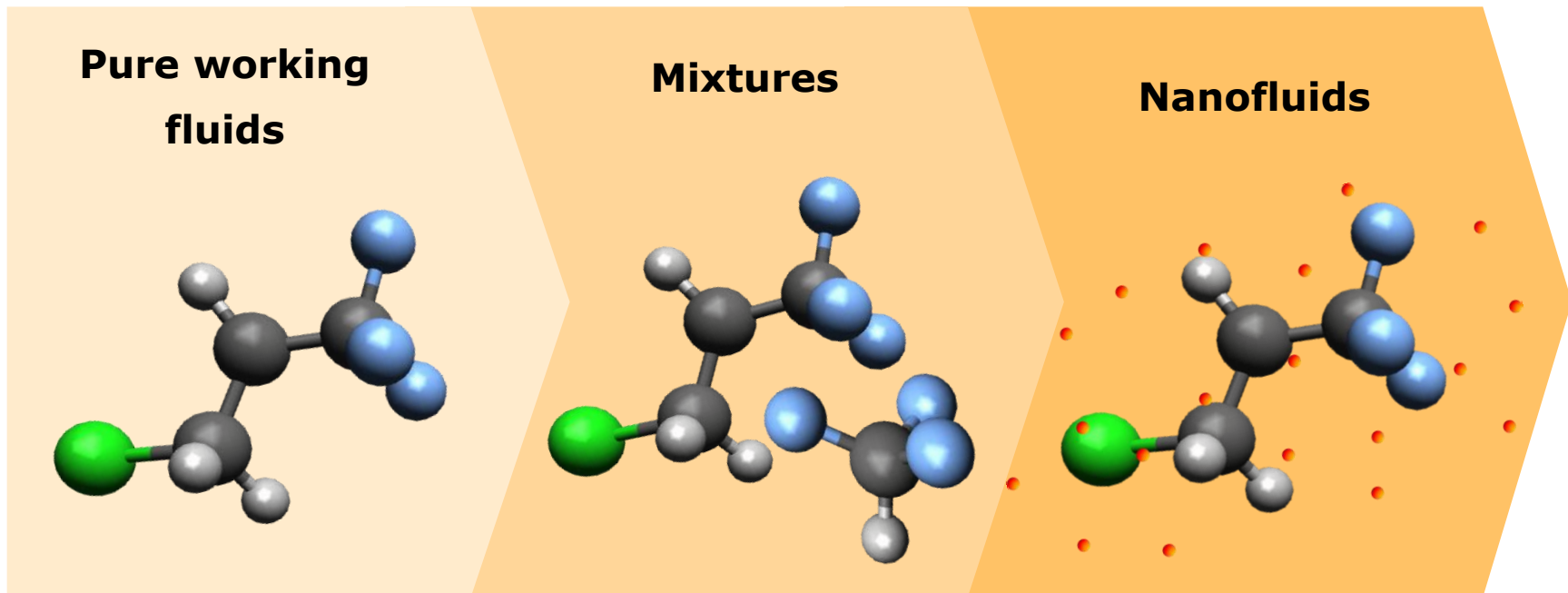
Project nanoORC: objectives

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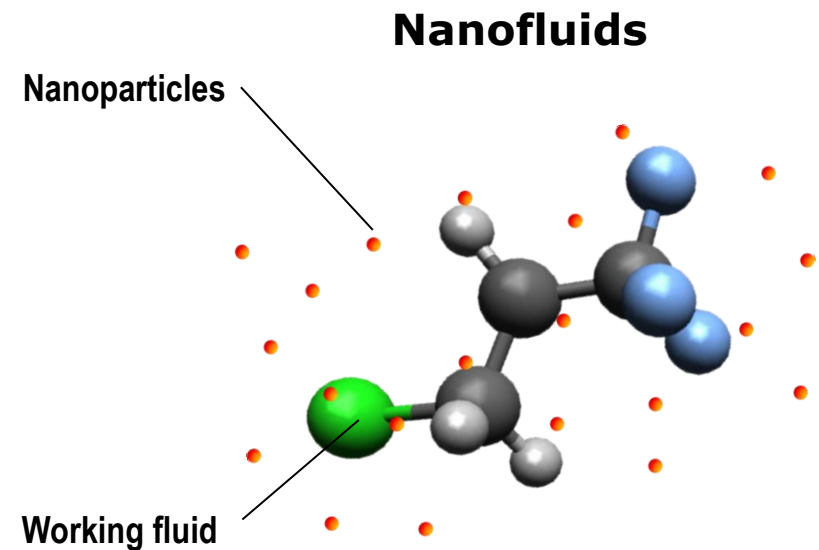
Project nanoORC: objectives

The purpose of this project is to develop models for the estimation of the thermophysical properties of **new working fluids**.



What are nanofluids?

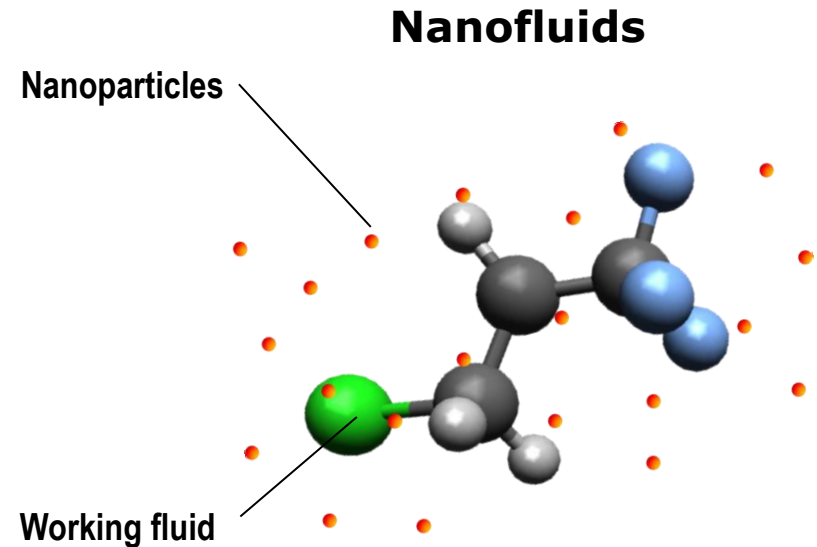
Nanofluids are colloidal dispersions of nanoparticles in base fluids, which can be any inorganic or organic heat transfer fluid.



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- Enhanced thermal properties
- Increased heat transfer rates
- Reduced heat exchanger equipment



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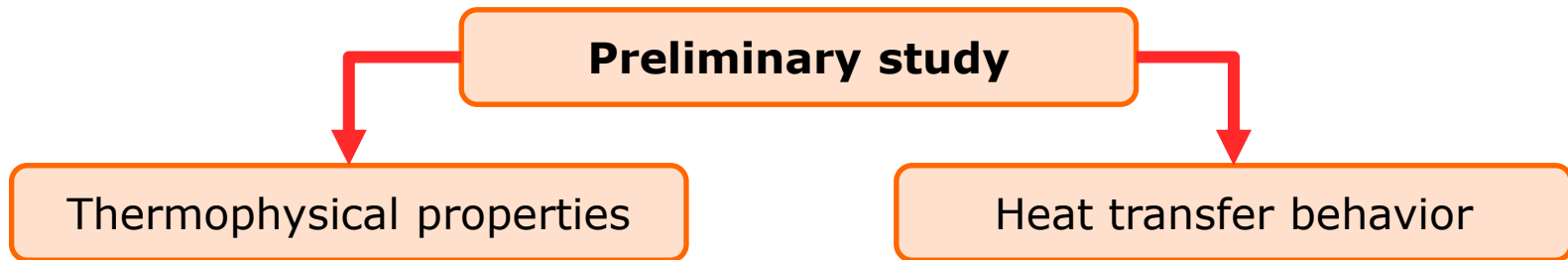
- Enhanced thermal properties
- Increased heat transfer rates
- Reduced heat exchanger equipment

- Nanofluid stability
- Settling in heat exchangers
- Migration of nanoparticles to the gas phase
- Influence on expanders performance

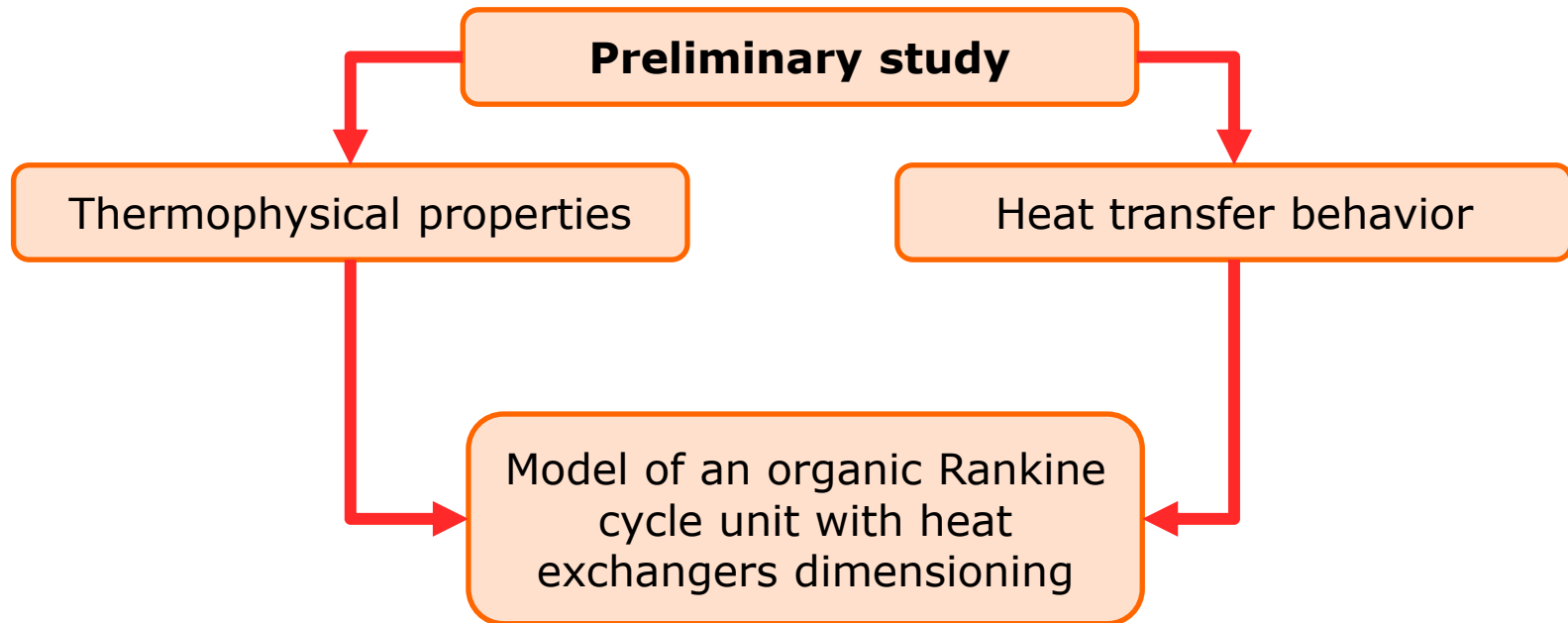
What could be the potential of nanofluids?

Preliminary study

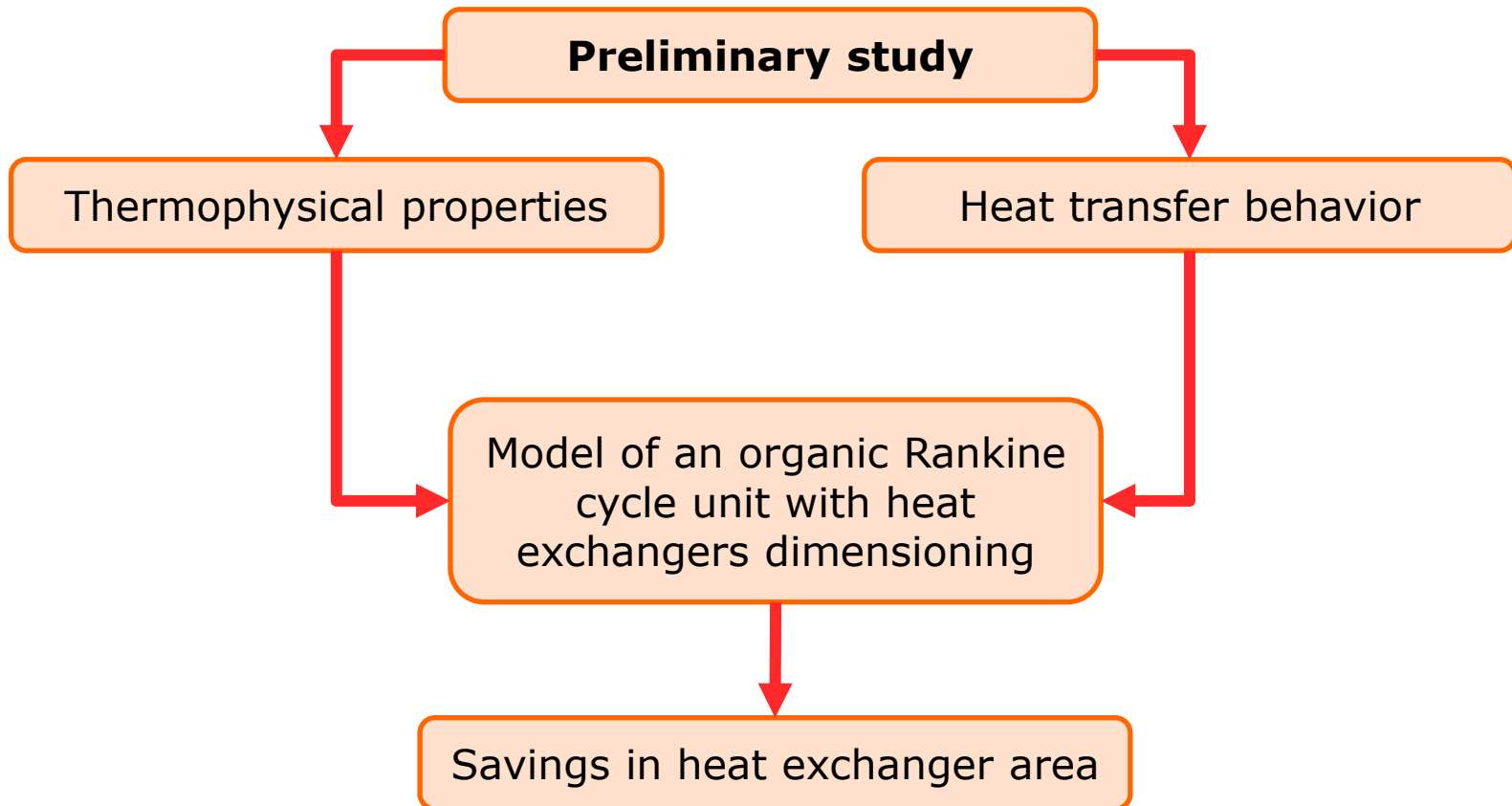
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What could be the potential of nanofluids?



Thermophysical properties of nanofluids

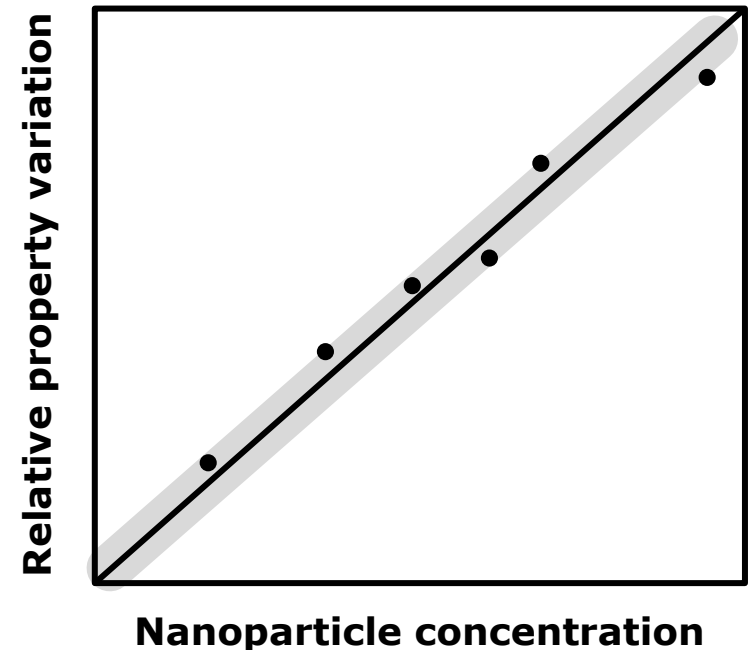
Thermophysical properties

- Density ρ
- Thermal conductivity k
- Heat capacity c_p
- Dynamic viscosity μ

Thermophysical properties of nanofluids

Thermophysical properties

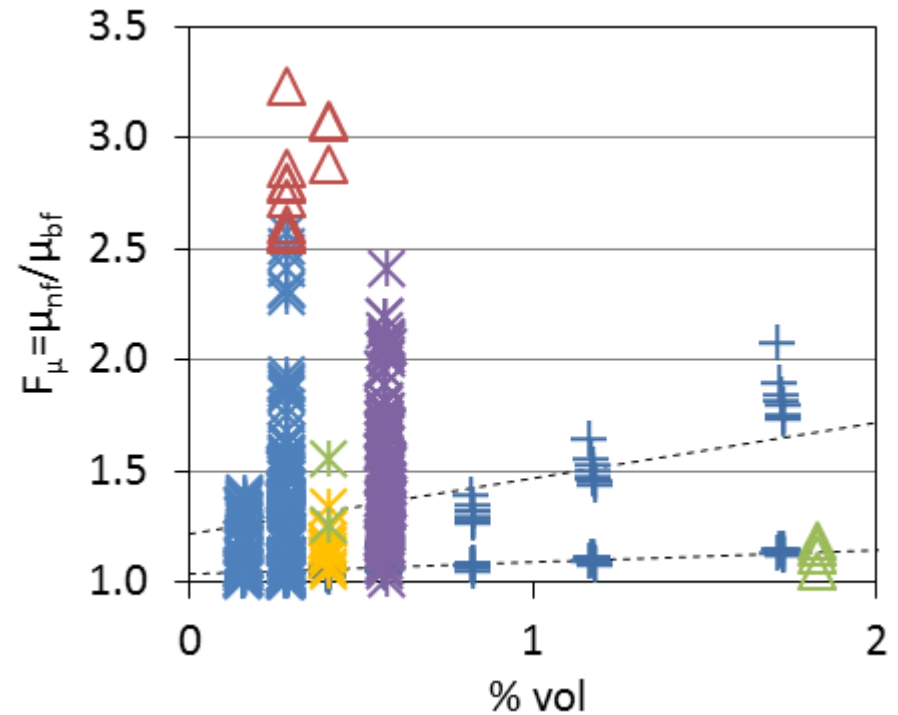
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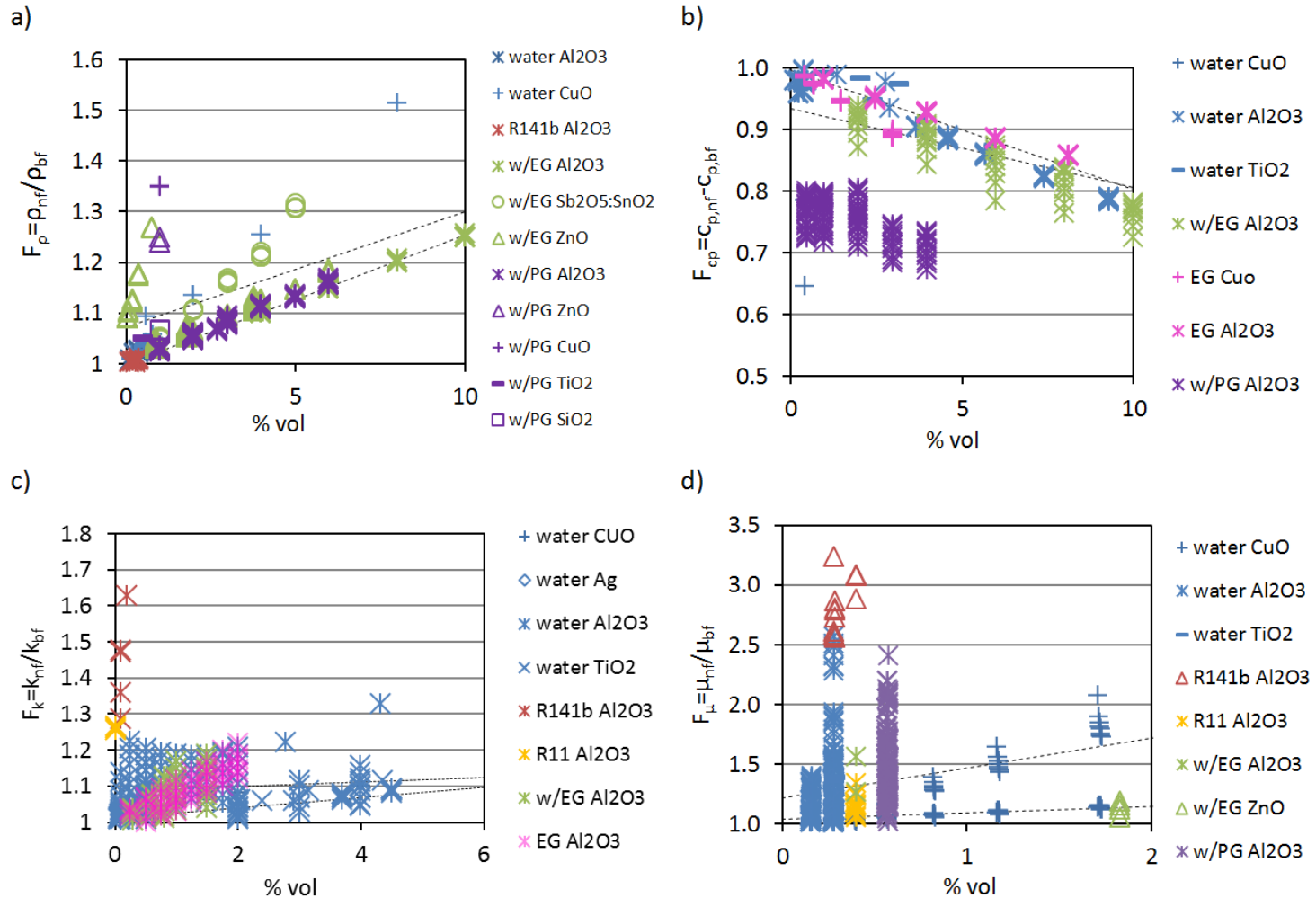
Thermophysical properties of nanofluids

Thermophysical properties

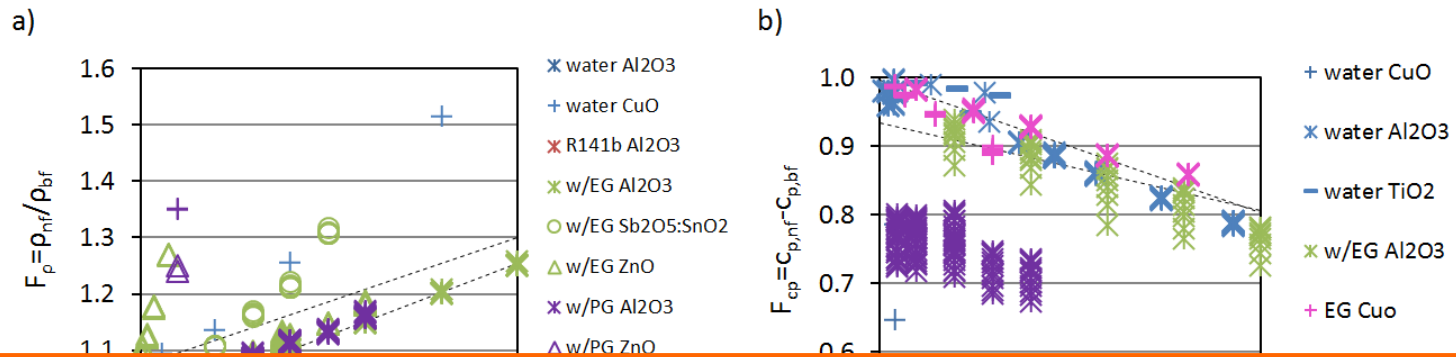
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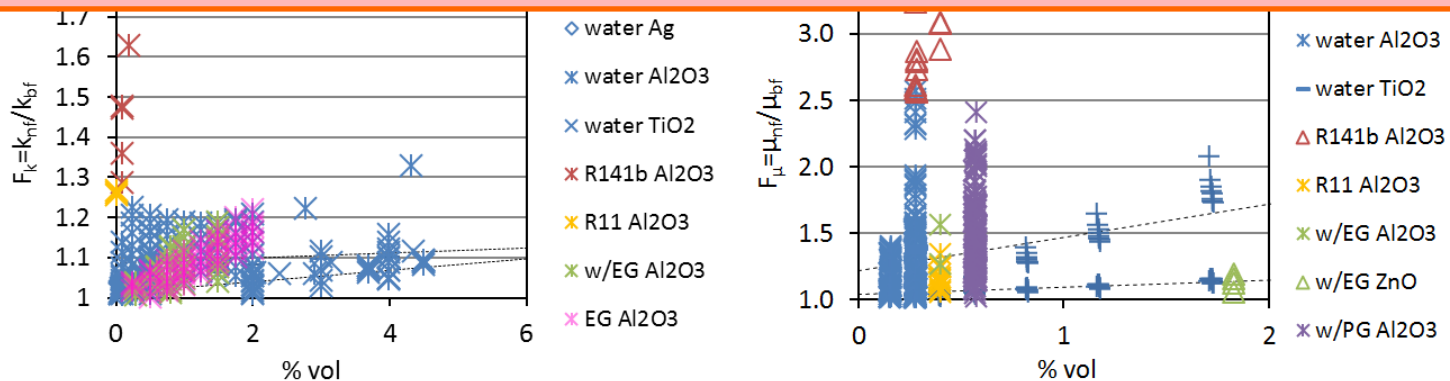
Thermophysical properties of nanofluids



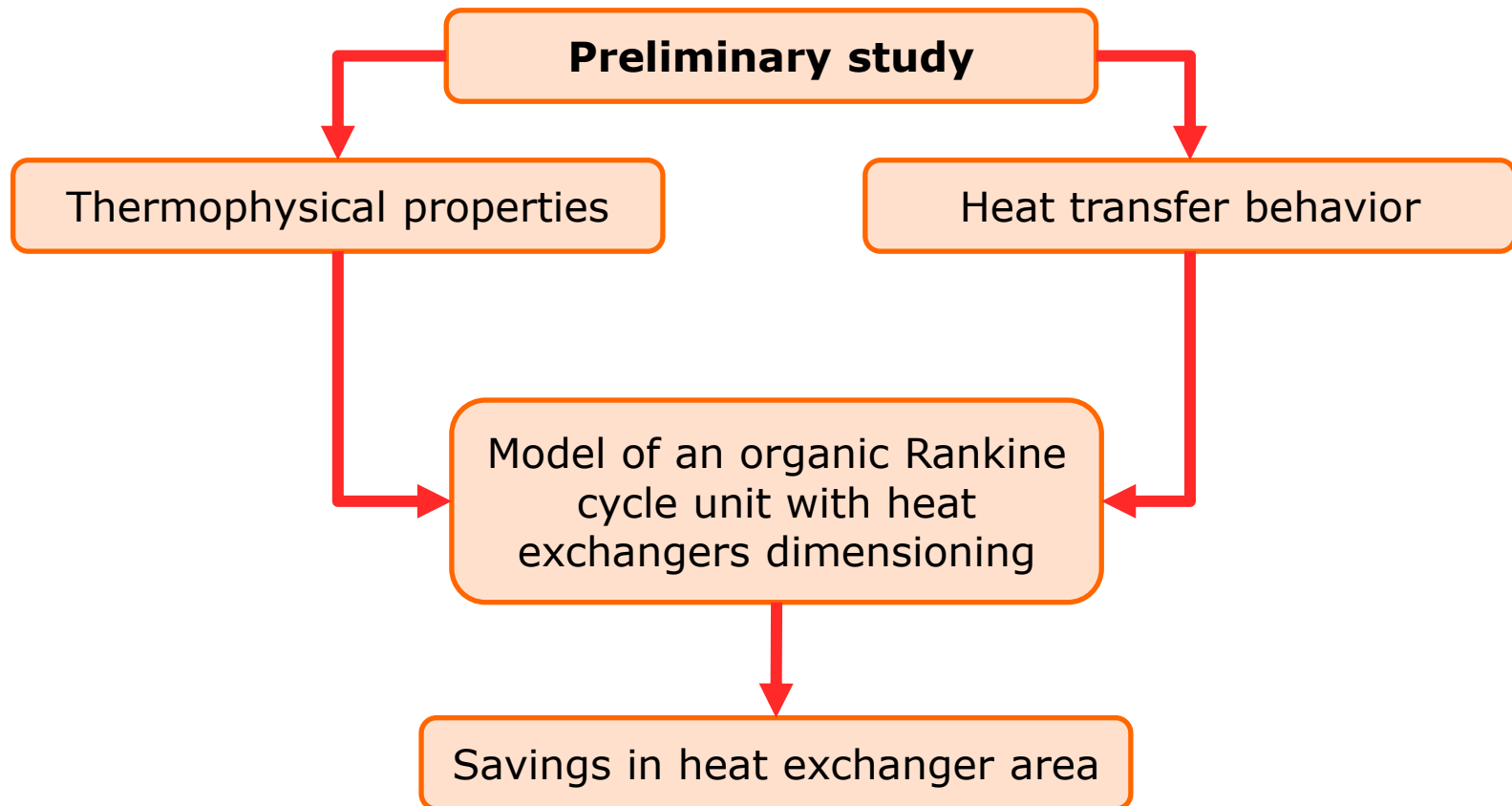
Thermophysical properties of nanofluids



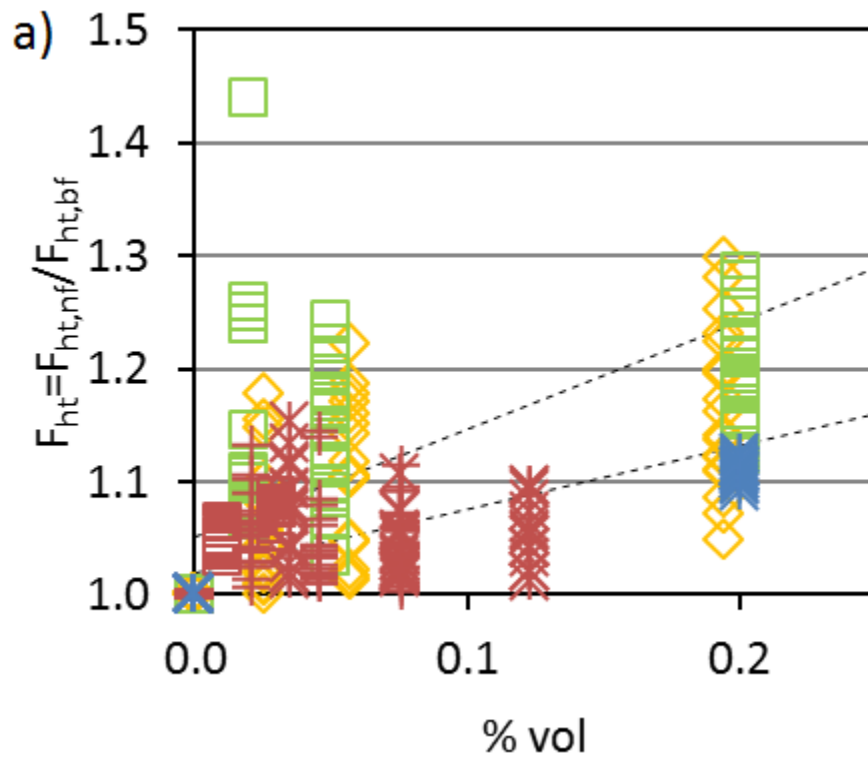
Thermal conductivity and dynamic viscosity present the highest disagreement between predictive correlations and experimental data, and even among experimental data under the same conditions



What could be the potential of nanofluids?

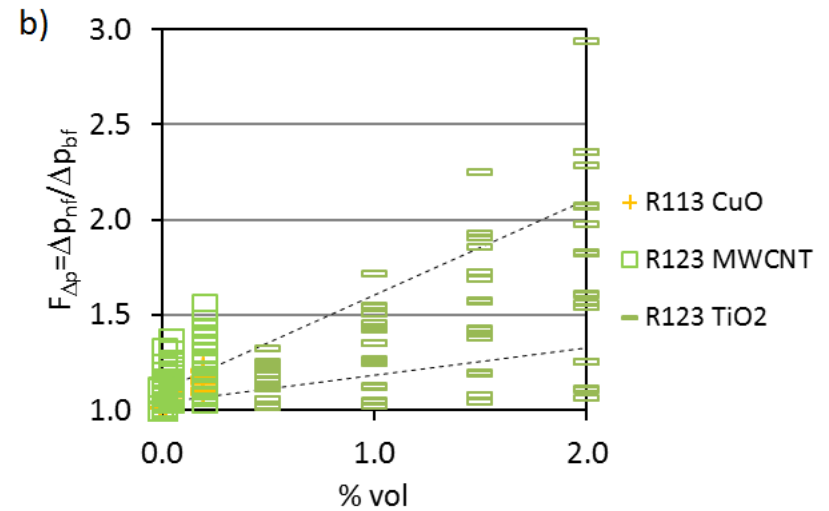
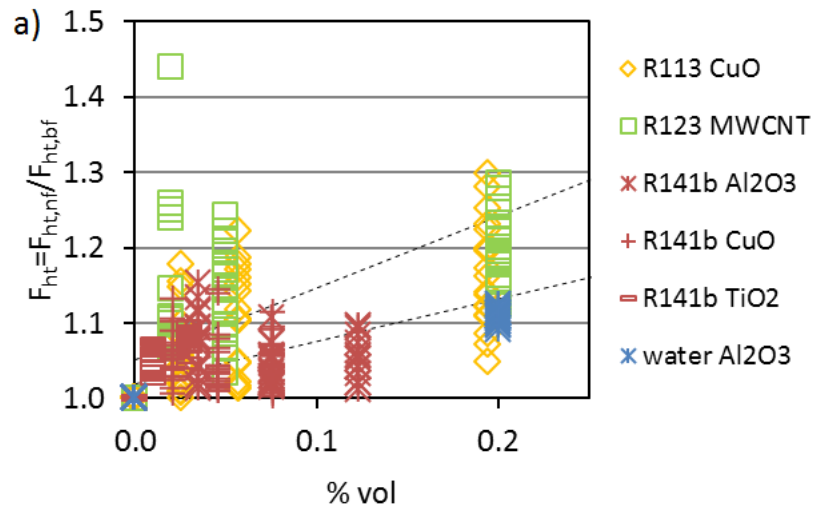


Heat transfer of nanofluids

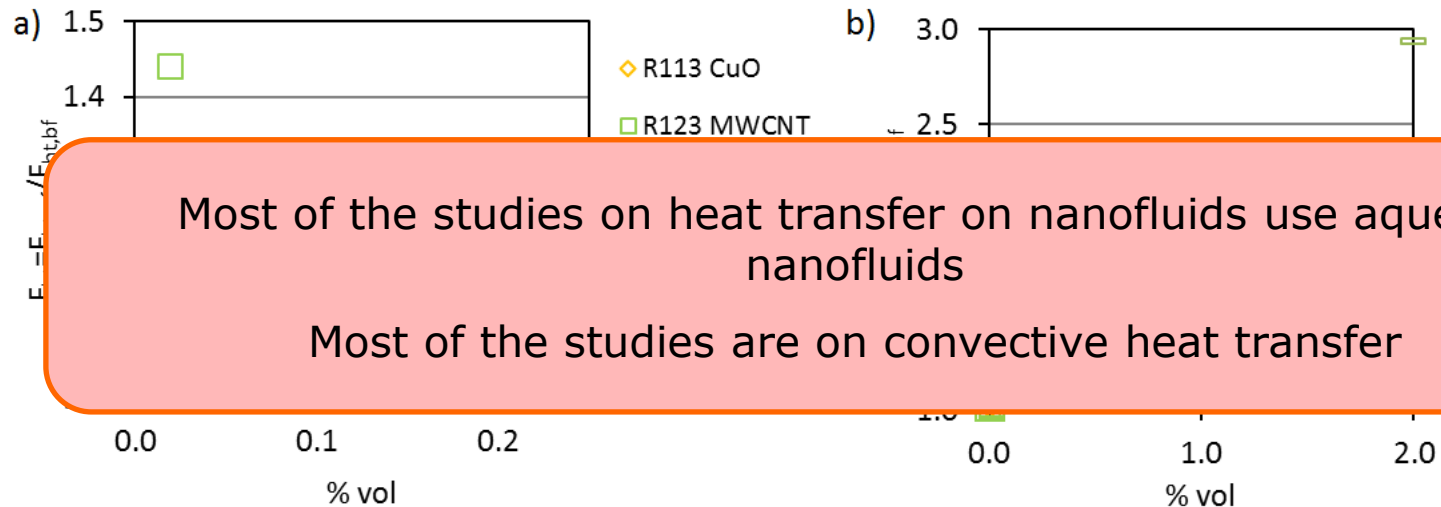


Heat transfer behavior

Heat transfer of nanofluids



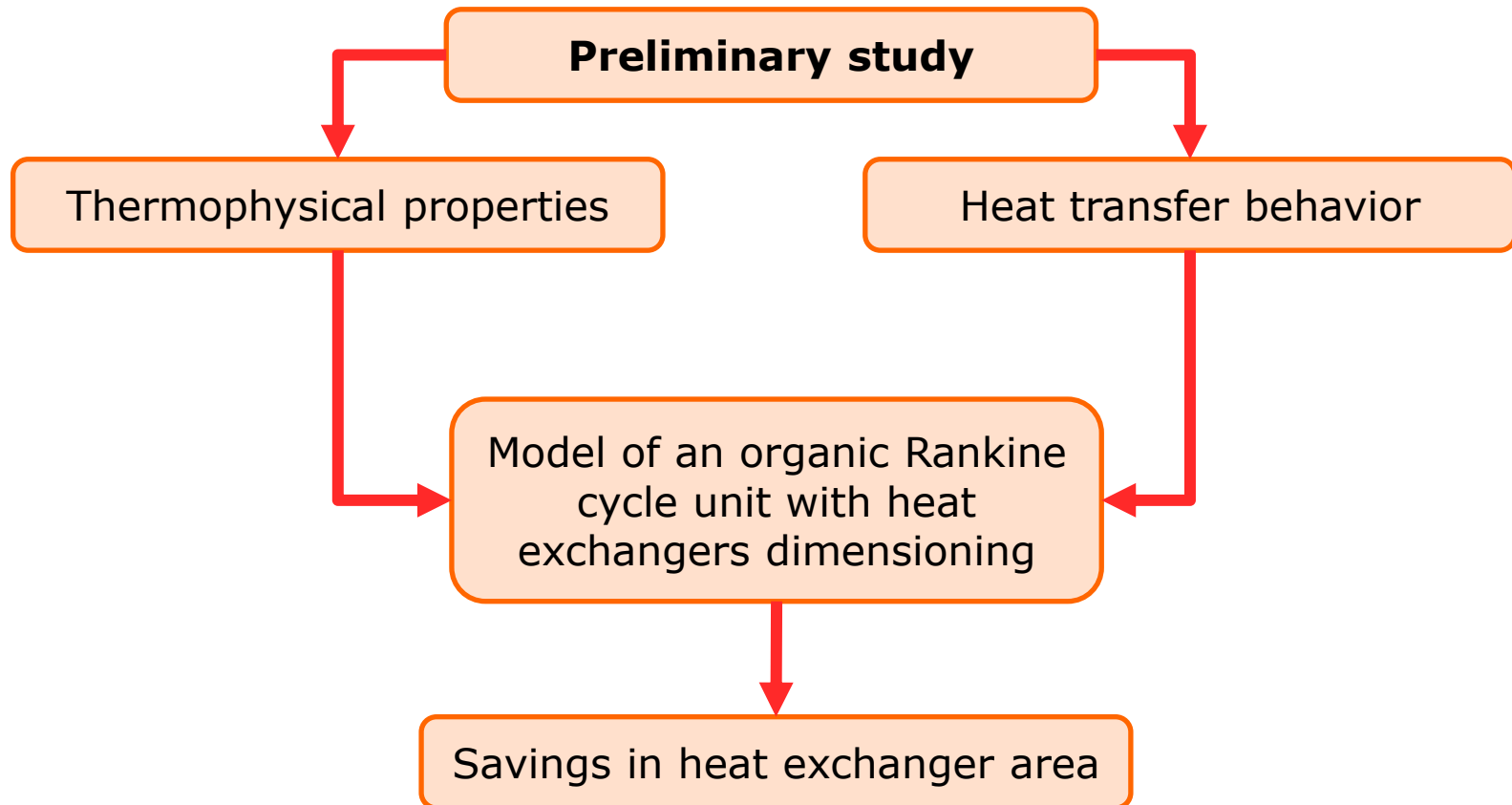
Heat transfer of nanofluids



Most of the studies on heat transfer on nanofluids use aqueous nanofluids

Most of the studies are on convective heat transfer

What could be the potential of nanofluids?



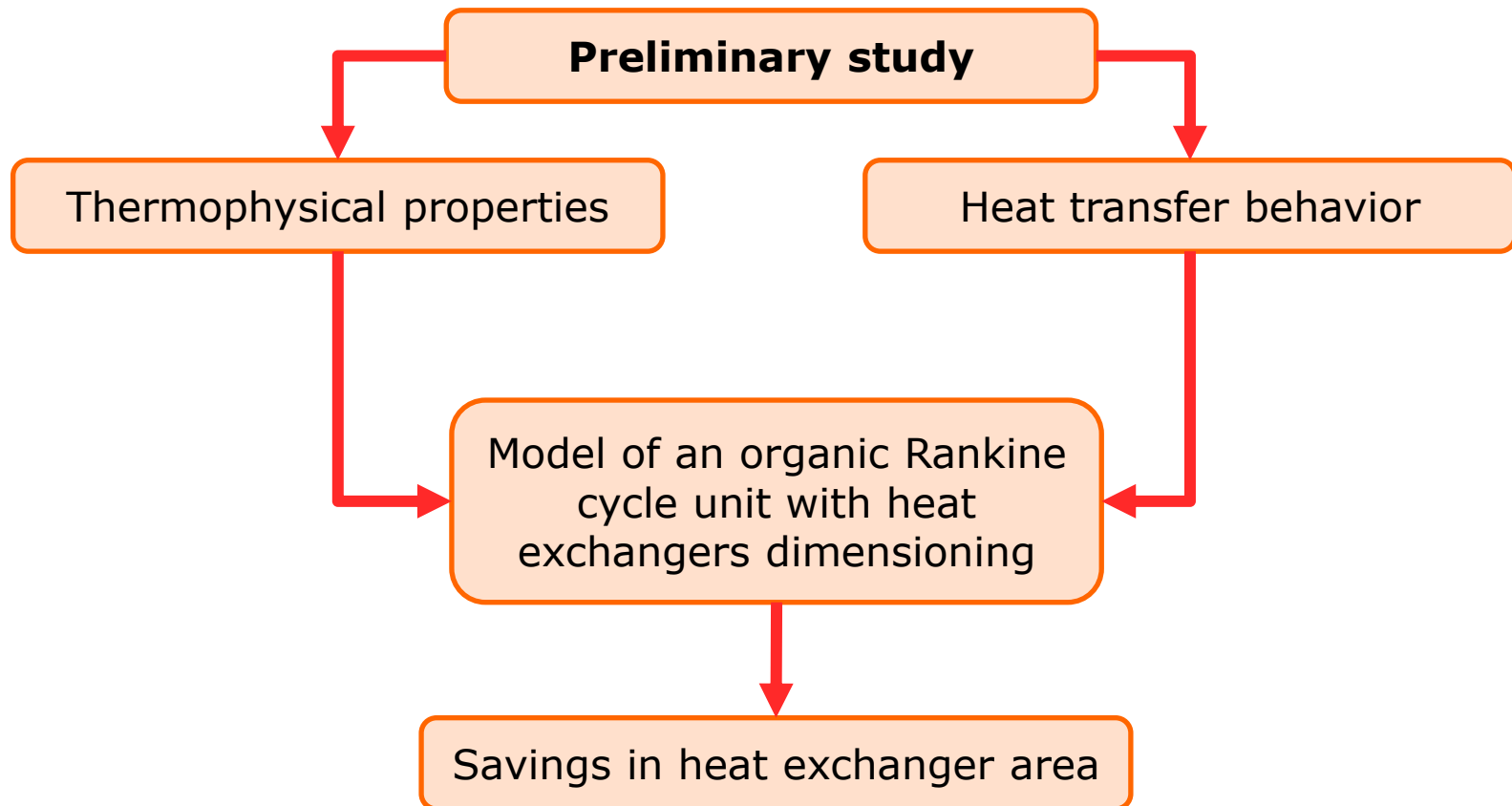
What could be the potential of nanofluids?

Model of an organic Rankine cycle unit with heat exchangers dimensioning

What could be the potential of nanofluids?

- Heat source: water at 90°C / Heat sink: water at 20°C
- Organic Rankine cycle unit using R32 without regeneration
- Operation conditions were optimized for maximum power output and minimum cost
- Heat transfer improvement and pressure drop increase is only considered in the evaporator
- Total migration of nanoparticles to the vapor phase
- The properties of different nanoparticles are only considered in the single phase heat transfer processes
- A Monte Carlo simulation is performed by using the ranges of variation of the properties of the nanofluid

What could be the potential of nanofluids?

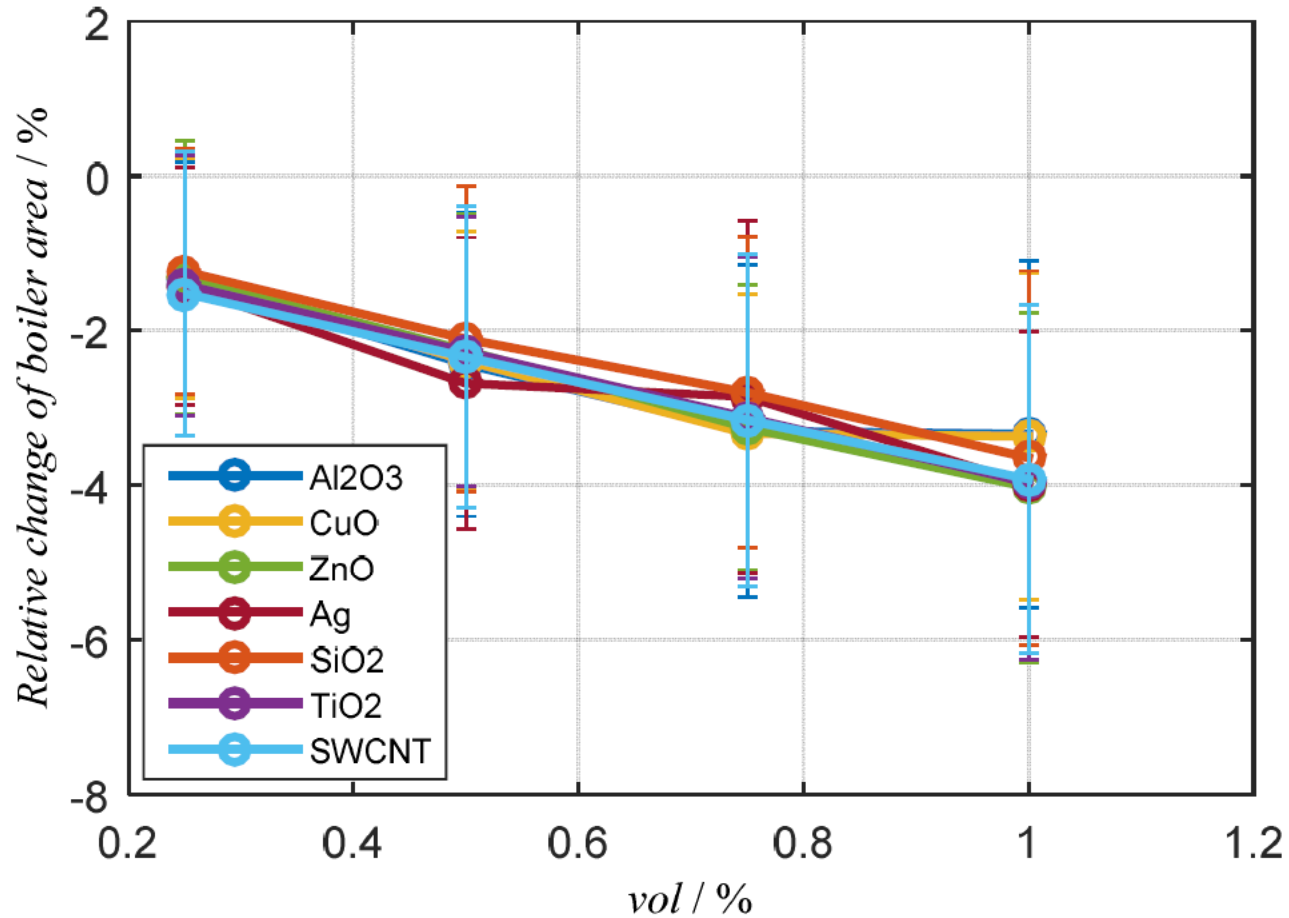


Analysis of results

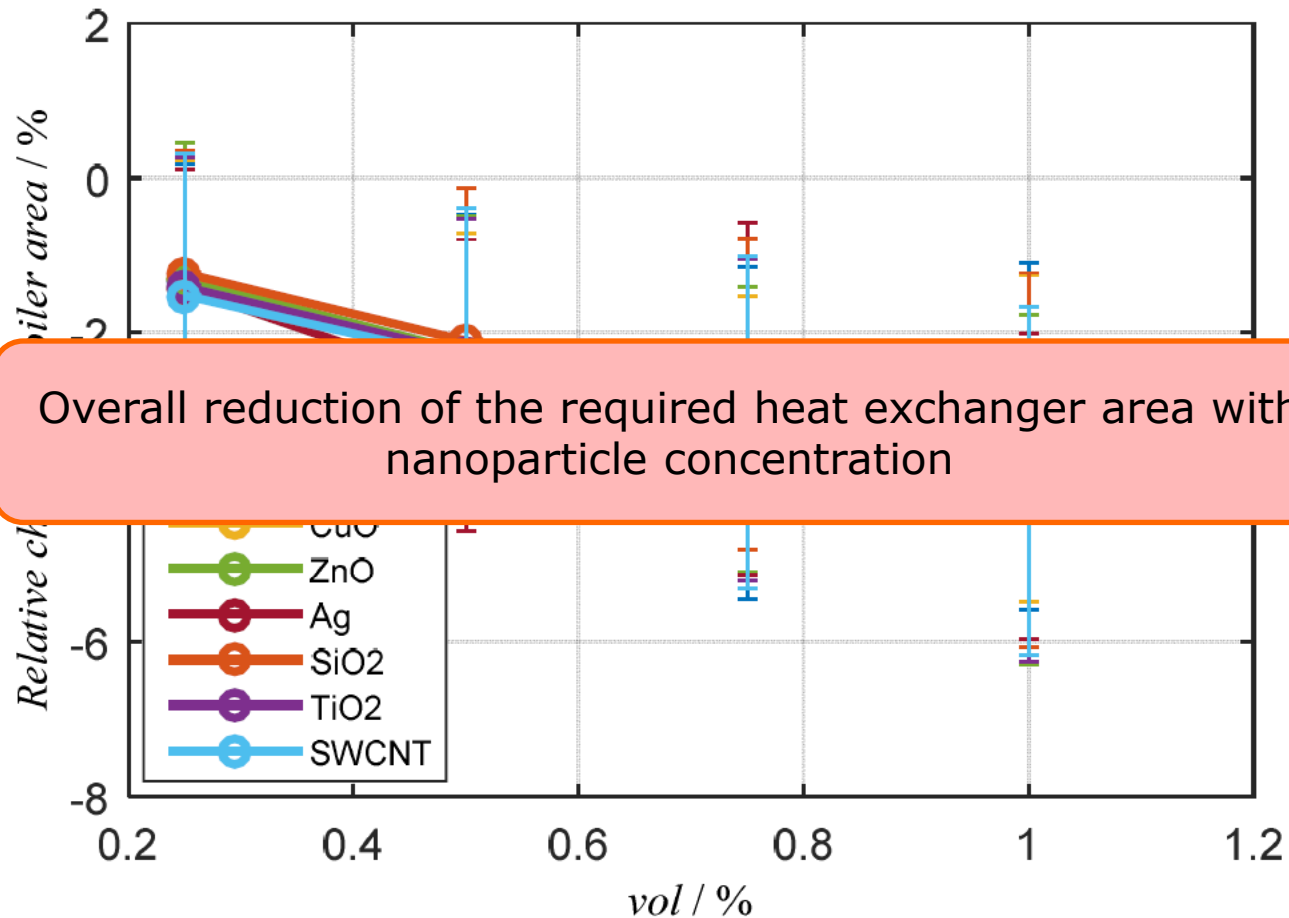
- Evaporator heat exchanger area
 - Net power output
- Pressure drops in the evaporator

Savings in heat exchanger area

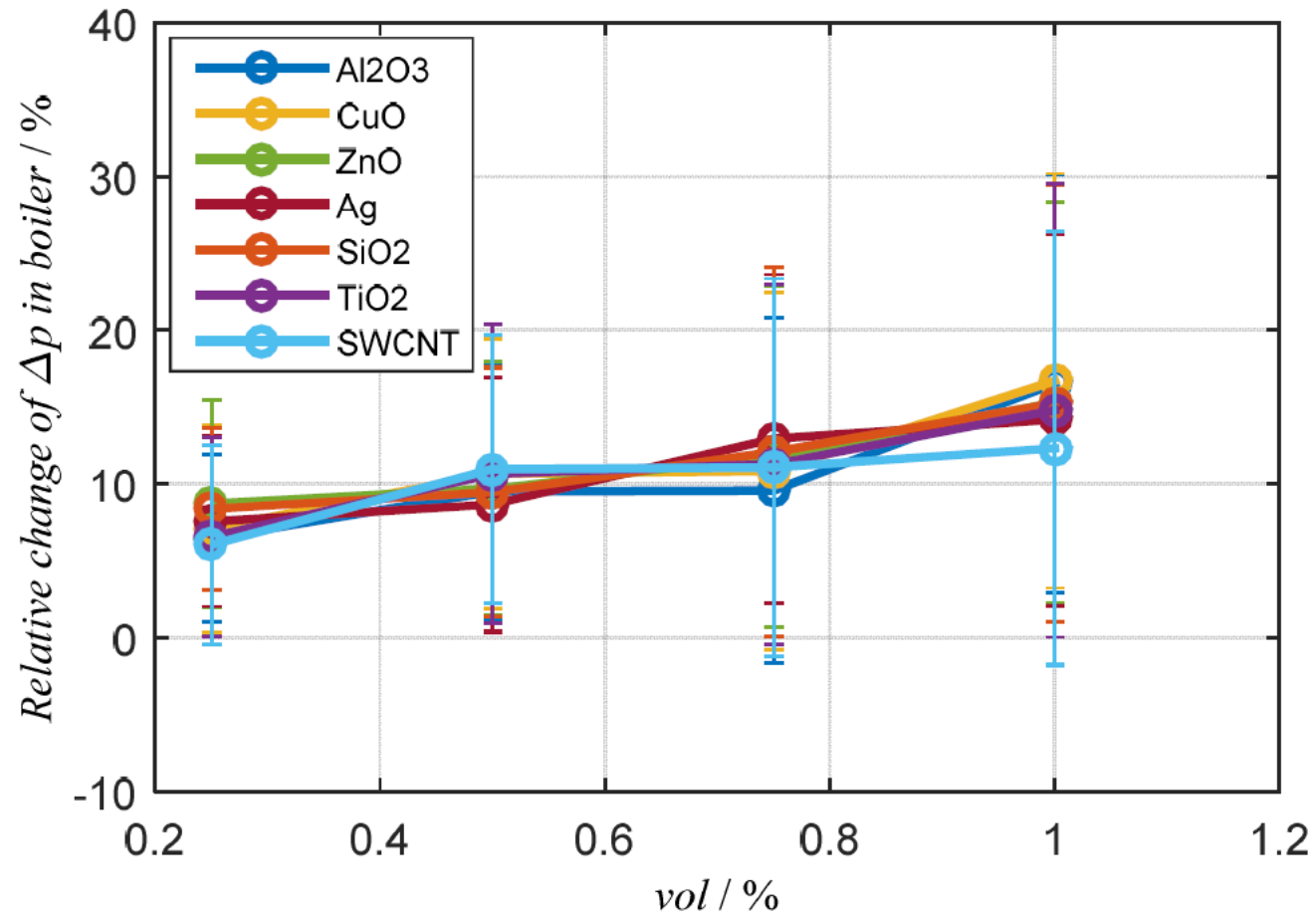
Reduction of heat exchangers' area



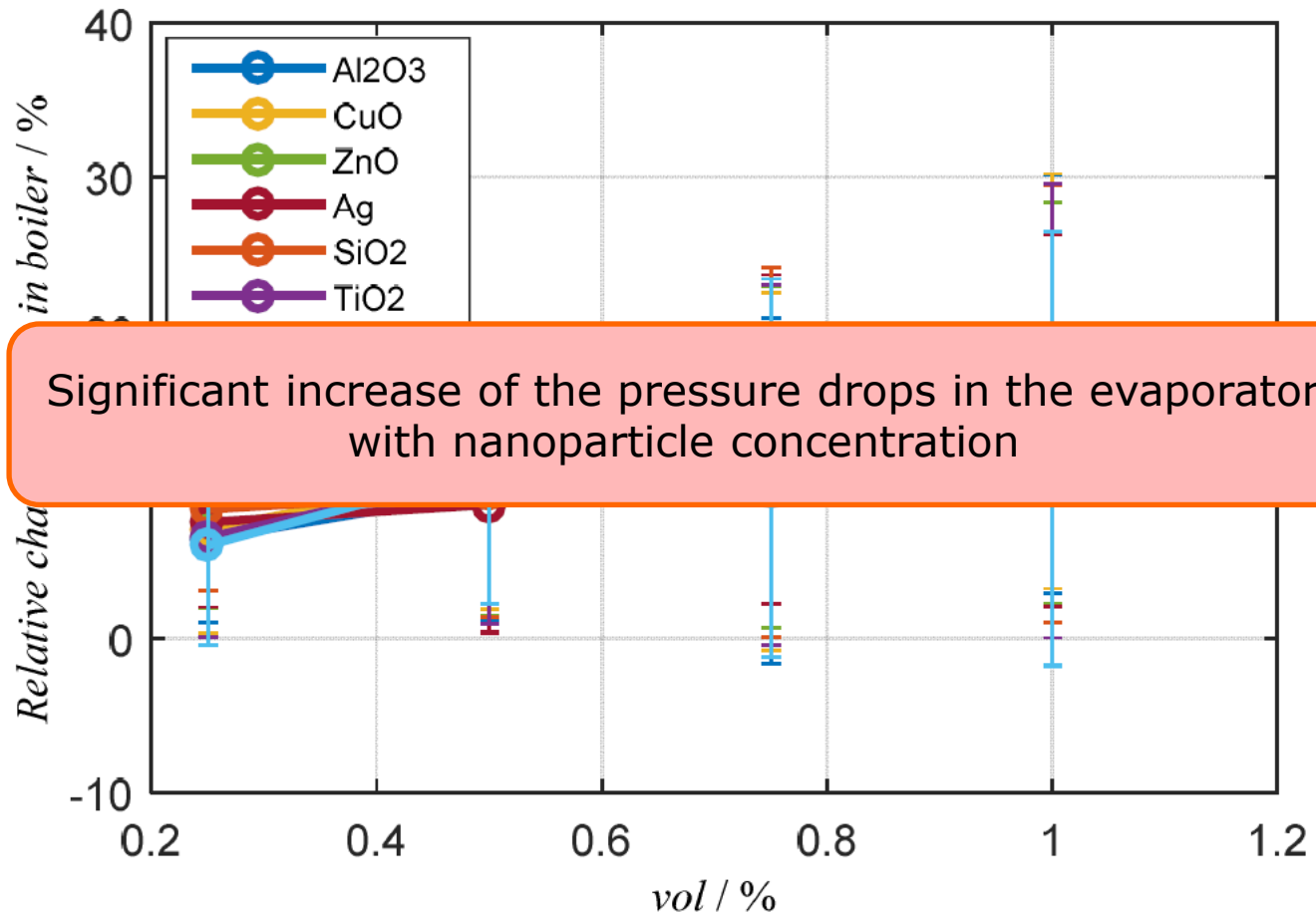
Reduction of heat exchangers' area



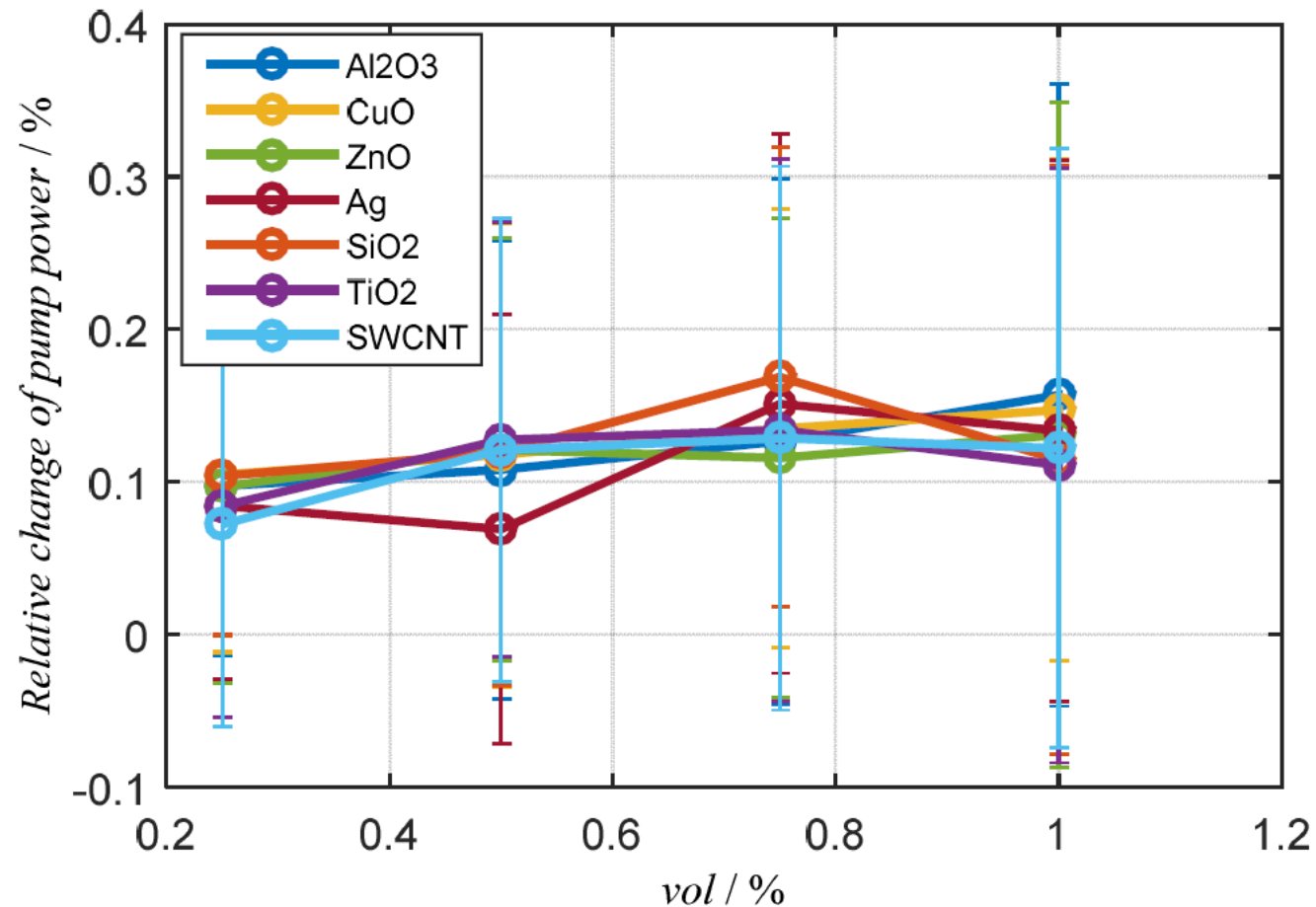
Pressure drops in evaporator



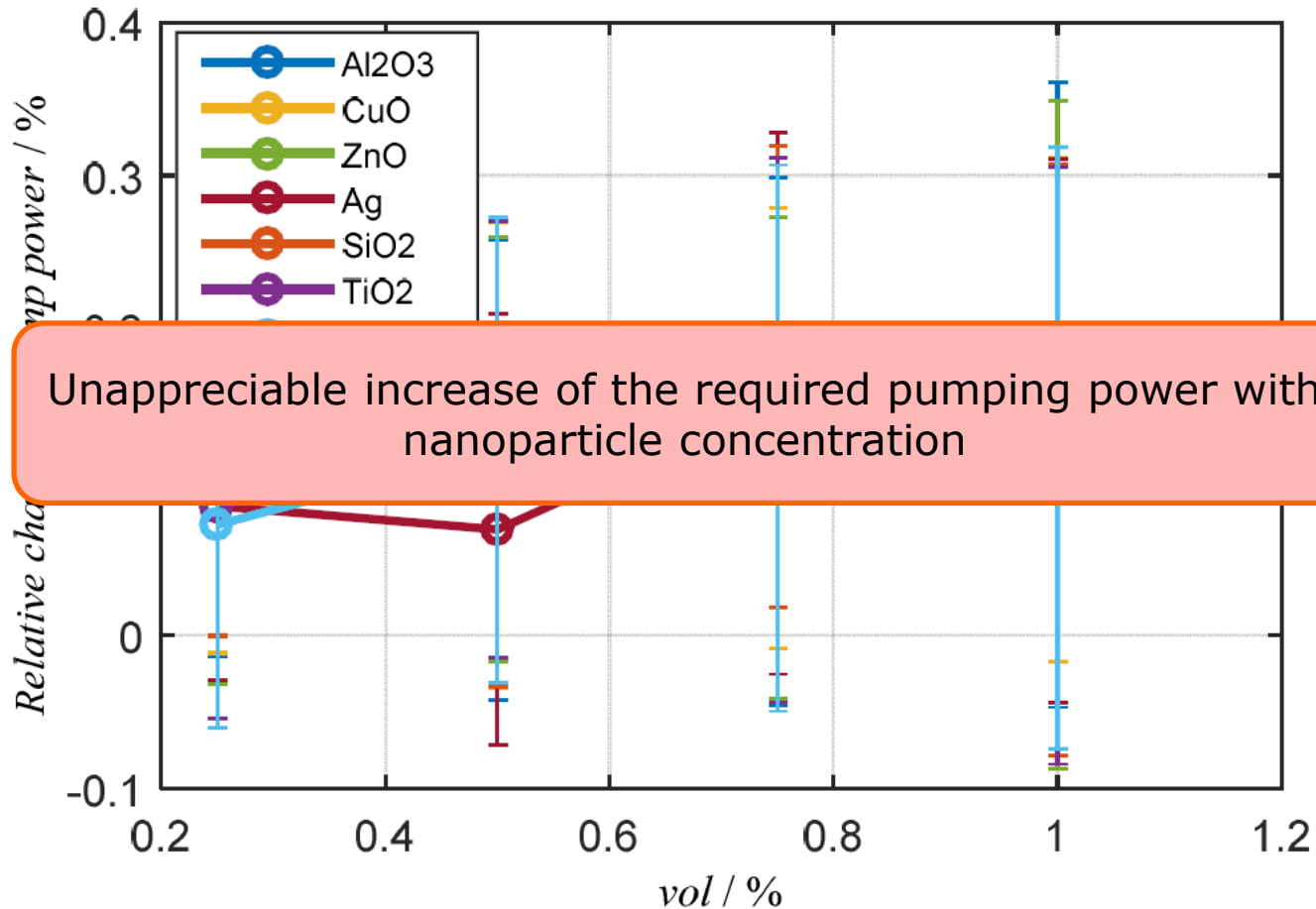
Pressure drops in evaporator



Increase of pumping demand



Increase of pumping demand



Conclusions

- The heat exchanger area requirements decrease with the addition of nanoparticles to the working fluid.
- The relative reduction in heat exchanger area is around 4 % for a nanoparticle volume concentration of 1 %.
- The increase in pressure drop for the same concentration rises to around 18 %, but no negative impact on the pump power consumption is appreciated.
- Future work:
 - Extending the database of thermophysical properties and heat transfer of nanofluids
 - Analyze different ORC configurations and component design

Questions & suggestions?

