Cost Action CA15119
Overcoming Barriers to Nanofluids Market Uptake
Training School program

Applications of nanofluids in advanced solar energy systems

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

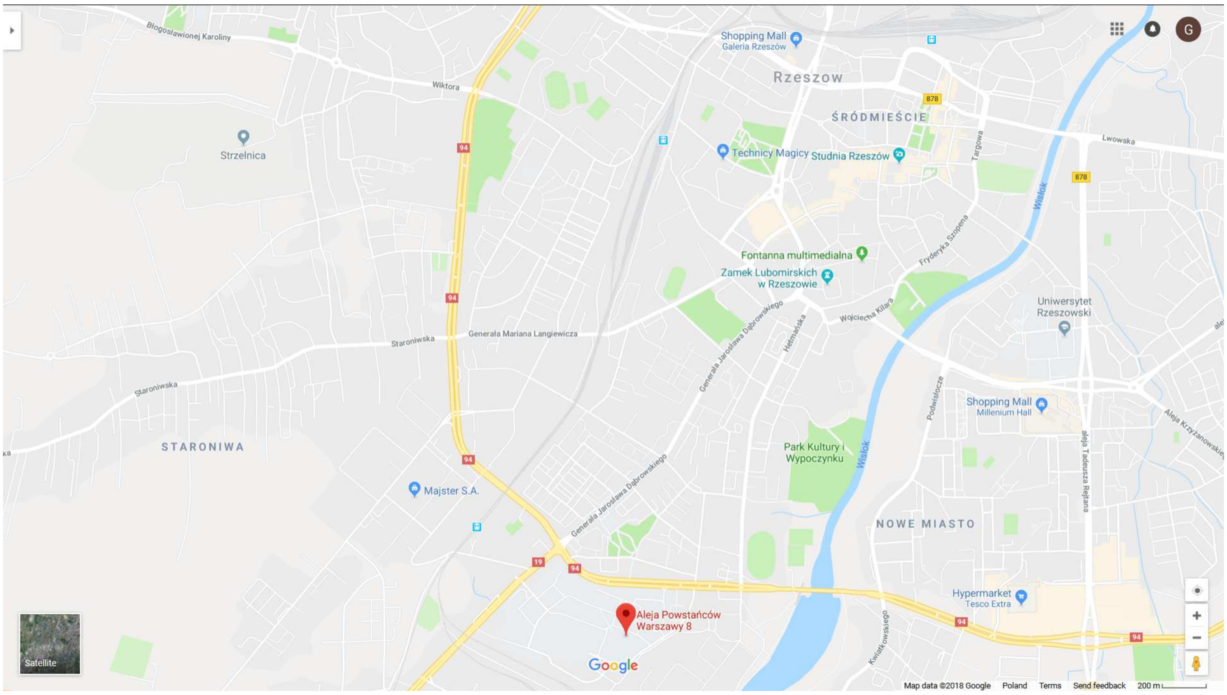
Rzeszów, Poland, 2018

Location

Rzeszów University of Technology
Al. Powstańców Warszawy 8
35-959 Rzeszów
Poland
Room: L-112

Map

https://goo.gl/maps/DqPgZpLqkvn



Program

19th September 2018 Wednesday

14:30 – 15:00 Signing list of participants
15:00 – 16:30 L1: Prof. Leonor Hernandez (Universitat Jaume I, Spain)
16:30 – 17:00 Coffee break
17:00 – 18:30 L2: Dr. David Cabaleiro (University of Vigo, Spain)
18:30 Walking tour from TS place to the city centre, excursion in the centre

20th September 2018 Thursday

8:30 – 9:00 Signing list of participants
9:00 – 10:30 L3: Prof. Sohel Murshed (University of Lisbon, Portugal)
10:30 – 11:00 Coffee break
11:00 – 12:30 L4: Prof. Alina Minea (Gheorghe Asachi Technical University of Iasi, Romania)
12:30 – 12:40 Joint photography in the front of the building
12:40 – 14:00 Lunch break
14:00 – 15:30 L5: Prof. Omid Mahian (King Mongkut's University of Technology Thonburi, Thailand)
15:30 – 17:00 L6: Prof. Patrice Estellé (Université de Rennes 1)
17:00 – 18:30 Visiting *Soft Matter Physics Laboratory* and performing some experiments on preparation of nanofluids and investigation of their rheological, thermal, electrical and optical properties.

21st September 2018 Friday

8:30 – 9:00 Signing list of participants
9:00 – 10:30 L7: Prof. Elisa Sani (Istituto Nazionale di Ottica, Italy)
10:30 – 11:00 Coffee break
11:00 – 12:30 L8: Dr. Gaweł Żyła (Rzeszow University of Technology)
12:30 – 13:00 Closing

Contents

1 Introduction to Solar Nanofluids

L. Hernández
Department of Mechanical and Engineering Construction, Jaume I University, Castellón de la Plana, Spain

Nanouptake (Overcoming Barriers to Nanofluids Market Uptake) is a COST Action that aims to create a Europe-wide network of leading R+D+i institutions, and of key industries, to develop and foster the use of nanofluids as advanced heat transfer/thermal storage materials to increase the efficiency of heat exchange and storage systems.

It started in April 2016 and will in April 2020. Up to now the network has been growing and different activities (including training schools, working group meetings, short term scientific mission, etc) have been developed so that many outputs have been generated (joint publications, H2020 proposals, etc)

A presentation of the past activities and results obtained so far together with the information about the expected items within the Action will be given.

After that, a presentation of about solar nanofluids, together with information about solar nanofluids industrial applications in the energy sector will be given.

2 An overview of phase change material nano-emulsions in solar thermal applications: design, characterization and thermal performance

D. Cabaleiro R[G]
Construction Technologies Institute, National Research Council, Padova, Italy
Departamento de Fisica Aplicada, Universidade de Vigo, Vigo, Spain

F. Agresti, S. Barison
Institute of Condensed Matter Chemistry and Technologies for Energy, National Research Council, Padova, Italy

S. Rossi, S. Bobbo, L. Fedele
Construction Technologies Institute, National Research Council, Padova, Italy

Energy storage is a key issue to overcome the intermittency of different renewable sources and promote the development of environmentally-friendly thermal facilities such as those based on solar technologies. Among the different ways to storage thermal energy, phase change materials (PCMs) are particular interesting since these materials allow large densities of energy storage within reduced temperature ranges. In order to integrate PCMs into domestic solar thermal applications, one method that is attracting increasing attention is replacing the carrier fluid conventionally used with a phase change material emulsion (PCME) [1]. PCMEs are latent heat storage fluids consisting in dispersions of fine PCM droplets in heat transfer fluids such as water or glycol-water mixtures. Thus, phase change material emulsions combine the high thermal energy storage density of the PCM particles and the good heat transportation of the carrier fluid. Small emulsion droplets are desirable in order to ensure long-term stabilities and low pumping powers. However, size reduction can lead to sub-cooling phenomena, which must be addressed through different strategies such as the addition of suitable nucleating agents [2].

This presentation aims to comprehensively review previous research on PCMEs as potential thermal energy storage and transfer media in solar applications. A brief overview of formulation parameters including PCME components, emulsification methods and physical-chemical properties of PCM nanoparticles will be first presented. Particular attention will be given to experimental studies about PCME stability through storage time as well as under freeze-thaw cycles, mechanical shear and alteration of electrolyte charges. Main results on phase change characteristics of PCMEs will then be discussed, analyzing the effect that surfactant type, PCM droplet size and nucleating agents have on sub-cooling phenomena. The influence of PCM content on other thermophysical properties, namely isobaric heat capacity, thermal conductivity, dynamic viscosity and density, will also be analyzed. Finally, recent research evaluating thermal and hydrodynamic behavior of PCM nano-emulsions will be shortly summarized. This presentation will therefore provide an insight of the characteristics, advantages and challenges of PCM nanoemulsions in the development of advanced solar energy systems.

[1] Zhang et al. Sol. Energy Mater Sol. Cells 147 (2016) 211–224.
[2] Shao et al. Energ. Buildings 94 (2015) 200–217.

3 Nanofluids properties and thermal management applications

S.M.S. Murshed
Department of Mechanical Engineering, Universidade de Lisboa, Lisboa, Portugal

As one of the popular research topics, nanofluids attracted huge research interest on its various areas such as thermophysical properties (e.g., thermal conductivity), different heat transfer features as well as application related works from all over the world which reveals the great potential and real-world impact of this research field. This lecture will cover nanofluids key thermophysical properties as well as cooling features including convection and phase change for thermal management systems. It will also briefly discuss nanofluids development and sample preparation at the beginning. Examples of prototype and real applications of nanofluids in thermal energy and cooling technologies will be provided together with evaluating their performances in those systems/areas. Furthermore, future challenges and impacts of these new class of fluids particularly in thermal management and energy areas will be highlighted in this lecture.

4 CFD techniques in the study of nanofluids and their possible applications in solar energy

A. Minea
Department of Technologies and Equipments for Materials Processing, Gheorghe Asachi Technical University of Iasi, Romania

Both numerical and experimental researches on nanofluids increased promptly over the last few years. In spite of some inconsistent reportsmainly due to the underprovided understanding of the involved mechanismsnanofluids have been developed as a very good heat transfer fluid, especially in heat exchangers. Recently, some new classes of nanofluids appeared, namely hybrid nanofluids and ionanofluids. Hybrid nanofluids were defined as a new class of nanofluids with possible applications in almost all the fields of heat transfer. This is mainly because of the synergistic effect through which they provide promising properties of all of its constituents.

Nonetheless, hybrid nanofluids are a new sort of nanofluid that can be prepared by mixing two nanofluids, by suspending (i) different types (two or more than two) of nanoparticles in a base fluid, or by suspending (ii) hybrid (composite) nanoparticles in a base fluid.

Basically, a hybrid material (fluid or solid) is a substance that combines the physical and chemical properties of different materials simultaneously and provides these properties in a homogeneous phase. A significant amount of research has been done in regard to the properties of nanocomposites and hybrid materials consisting of carbon nanotubes (CNTs) to be used in electrochemical-sensors, biosensors, nano catalysts, etc. but the use of these hybrid nanomaterials in nanofluids is at its very beginnings and has not been developed as such.

Ionanofluids were engineered as nanoparticles suspended in ionic liquids. Ionanofluids possess great potential in many new and advanced applications particularly related to thermal management and energy harvesting. Preliminary numerical and experimental results are very interesting in demonstrating their possible usage for heating and it also underlies the large uncertainty that exists in characterizing thermophysical properties of these new fluids. Nonetheless research on ionanofluids is very important and tremendous efforts are needed in order to fully describe these new heat transfer fluids and to explore their potential in wide range of applications.

The idea of using nanofluids is to further improve the heat transfer characteristics of individual fluids and to beneficially combine different properties from oxides, carbon nanotubes, metals, composites etc. Latest research in this area clearly showed that proper characterization may make nanofluids a very promising heat transfer media. However, a lot of research is still needed in the field of preparation and stability, characterization, and applications to overcome the barriers in implementing these new fluids in real-life applications, especially in solar energy area.

5 Nanofluids application in Solar Energy Systems

O. Mahian R^G
King Mongkut's University of Technology Thonburi, Thailand
School of Aeronautic Science and Engineering, Beihang University, Beijing, PR China

This presentation deals with the application of nanofluids in solar energy systems. First, an overview will be given on Renewable Energy as well as Solar Energy status which includes the contribution of various renewable energy sources to total consumed energy in the world. Next, an overview of application of nanofluids in various solar systems is studied especially solar collectors and solar desalination systems. Afterwards, the steps done for the study(both experimentally and theoretically) on the effect of nanofluids on the evaporation rate inside a solar still equipped with a heat exchanger will be presented. Finally, some suggestions for future study in the field of nanofluid applications in solar energy will be given by highlighting the challenges.

6 Surface tension of nanofluids

P. Estellé
Laboratoire de Génie Civil et Génie Mécanique, Université de Rennes 1, Rennes, France

Nanofluids are recent nanomaterials with improved thermal properties that could enhance the efficiency and reliability of heat transfer systems in many applications. In addition to usual thermal and rheological behaviors, relevant properties of nanofluids for heat transfer calculation, thin film flows, droplet impingements, boiling or microfluidic are surface tension and wettability.

So, the aim of this lecture is to present the current knowledge in surface tension of nanofluids. First, heat transfer processes involving the influence of surface tension are highlighted and the main methods used for surface tension measurement are presented. Special attention is given to pendant drop technique that we use in our lab, explaining the main steps of our experimental procedure. Then, we focus on the influence of the temperature, role of surfactant and base fluids, impact of nanoparticle nature, size and shape on surface tension of nanofluids from literature background [1]. In addition, some own results are presented as well as the collection of data obtained from the Round Robin test performed within the NanoUptake Cost Action [2]. Finally, recommendations, challenges and open questions are presented with the goal to develop studies about surface tension and wettability of nanofluids.

[1] P. Estellé, D. Cabaleiro, G. Żyła, L. Lugo, S.M.S. Murshed, Current trends in surface tension and wetting behavior of nanofluids, Renewable and Sustainable Energy Reviews 94 (2018) 931-944.
[2] M. Buschmann, Round robin test for surface tension and contact angle of nanofluids, 4^{th} Working Groups Meetings of NanoUpatke, 28-29 May 2018, Napoli (Italy)

7 Linear and nonlinear optical properties of (black) nanofluids

E. Sani

CNR-INO National Institute of Optics, Largo E. Fermi, Firenze, Italy

The present lecture will start with a summary of the literature about optical properties of nanofluids, with particular interest in solar energy applications. Then, the topic will be focused on the most representative results of several-year investigations carried out at SOLARLAB laboratory at CNR-INO, Italy, about black fluids based on different carbon nanoparticles (nanohorns, nanodiamonds and graphene nanoplatelets) in various base fluids. From the point of view of basic (linear) optical properties, which are of interest, for instance, for direct-absorption solar collectors (DASCs), sunlight absorption of nanofluids is considerably increased with respect to the pure base fluid. The profiles of absorption along the light propagation path can be tailored by a proper choice of nanoparticle concentration and morphology, opening thus promising perspectives to design optimized systems for even non-conventional architectures. Recently, we studied nanofluids also at high light intensities, where the materials response is nonlinear. We demonstrated a remarkable spectrally-broadband optical limiting (i.e. the decrease in transmittance at increasing light intensities) at 1064, 532 and 355 nm wavelengths for all the three carbon nanoparticles, with system-dependent characteristics. The significant microbubble production in the nanofluids under high intensities suggests also a possible use of these nanomaterials for direct vapor generation in sunlight exploitation systems.

8 Rheological properties (and its' influence on laminar and turbulent flows) of nanofluids

G. Żyła
Department of Physics and Medical Engineering, Rzeszow University of Technology, Rzeszow, Poland

Application of nanofluids in solar systems require good understanding of its' thermal and optical properties. However, information about it rheological properties are also very important, and must be well defined.

In presented lecture a short introduction to the rheology of fluids will be presented. First part will focus on the basics of rheological measurements and Newtonian and non-Newtonian fluid mechanics. At the second part results of experimental studies on nanofluids rheological behavior will be presented and discussed. The influence of viscosity increase on heat transfer performance will be also presented. On the end we will try to answer the question: ,,*how to make a rheological measurement properly?*".

Notes

In emergency situations, call:
112 – emergency number (hospital, police, fire department)
+48 662 652 755 – Michał Wanic (private mobile)
+48 501 987 630 – Jacek Fal (private mobile)
+48 602 790 355 – Dr. Gaweł Żyła (private mobile)