PROJECT TITLE: High Accuracy Photopyroelectric Calorimetry for Magnetic Nanofluids
PROJECT CODE: PN-II-ID-PCE-2011-3-0036
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Progress Report 4

General Objective: PPE study of thermal properties of magnetic nanofluids.

1. Synthesis of magnetic nanofluids with different structural parameters.

One of the objectives of this stage was the synthesis of magnetic nanofluids with Fe_3O_4 nanoparticles with controlled size and stabilized in time, so that the nanoparticles keep their superparamagnetic properties. Two types of nanofluids have been synthesized: (i) magnetic nanofluids with Fe_3O_4 nanoparticles with controlled size, stabilized with hydrophobic layer and dispersed in organic solvents as colloidal suspensions; (ii) magnetic nanofluids with Fe_3O_4 nanoparticles with controlled size and stabilized with hydrophilic layer and dispersed in water.

2. Behaviour of the static and dynamic thermal parameters of magnetic nanofluids as a function of carrier liquid and type of surfactant.

In this section of the research, the behaviour of the static and dynamic thermal parameters of magnetic nanofluids as a function of carrier liquid and type of surfactant has been investigated. The first investigations have been performed on liquids with well known properties (water, transformer oil, some volatile liquids, etc) in order to prove the suitability of the method for such type of investigations. The obtained results for both thermal effusivity and diffusivity were in good agreement with literature data.

Concerning the carrier liquid, two types of magnetic nanofluids have been investigated, having as carrier liquids water and decahydronaphtalene (DHNA). It was found that the carrier liquid influences drastically the values of both thermal diffusivity and effusivity of the magnetic nanofluids.

Concerning the type of surfactant, a magnetic nanofluid having water as carrier liquid, Fe_3O_4 as nanoparticles and double layers of different fatty acids as surfactant was investigated. It was found that the different types of surfactant change the value of the thermal effusivity with about 16%, 1530 $Ws^{1/2}m^{-2}K^{-1}$ (LA+MA) to 1790 $Ws^{1/2}m^{-2}K^{-1}$ (PA+OA). Concerning the value of the thermal diffusivity, it is practically unchanged by the type of surfactant (it ranged between 14.54 $x10^{-8}$ m^2/s and 14.79 $x\ 10^{-8}$ m^2/s).

3. Temperature dependence of the thermal parameters and detection of phase transitions, if existing.

During our investigations, no phase transitions have been found for the measured nanofluids in the temperature range of interest (20^0C-100^0C). Consequently the amplitude and phase of the PPE signal presented in all cases a monotonic behaviour as a function of temperature.

However, in order to prove the suitability of the PPE method for phase transitions detection, some materials with well known phase transitions have been investigated. A second order phase transition was found for TGS single crystal at about 49 ^{0}C and a first order one for oleic acid at 5 ^{0}C.

Concerning materials used for the synthesis of magnetic nanofluids, we found a phase transition (ñlower critical solution temperatureò) for the hydrogel NIPA, known as a thermo-sensitive material, at about 32 °C .

4. Dissemination of the results

International conferences

1. Thermal Characterization of Magnetic Nanofluids by Photopyroelectric (PPE) and Photothermoelectric (PTE) Calorimetries.
D. Dadarlat, R. Turcu, L. Vekas
IC-ANMBES, Brasov, June 13-15, 2014

2. Photothermal Investigation of Polymerization Processes of some Resin-based Dental Materials.
D. Dadarlat, M. Streza, D. Prodan, M. Moldovan, C. Prejmerean
IC-ANMBES, Brasov, June 13-15, 2014

3. Thermoelectrics (TE) used as detectors of radiation. An alternative calorimetry based on the photothermoelectric (PTE) effect.
D. Dadarlat, P. R. N. Misse, A. Maignan, E. Guilmeau, M. Depriester, A. Hadj Sahraoui
ATOM-N2014, Constanta, Aug.21-24, 2014

4. An Alternative Calorimetry Based on the Photothermoelectric (PTE) Effect. Application to Magnetic Nanofluids.
D. Dadarlat, P. Misse, A. Maignan, E. Guilmeau, R. Turcu, L. Vekas, M. Depriester, A. Hadj Sahraoui
2nd Conference on Photoacoustic and Photothermal Theory and Applications (CPPTA), Warsaw, Poland, Sept. 23-26, 2014.

5. Discussion on optimal coupling medium and its thickness in photoppyroelectric calorimetry.
K. Strzałkowski, D. Dadarlat, M. Streza, A. Marasek
2nd Conference on Photoacoustic and Photothermal Theory and Applications (CPPTA), Warsaw, Poland, Sept. 23-26, 2014.

ISI journals

1. Photopyroelectric Calorimetry of Magnetic Nanofluids. Effect of Type of Surfactant and Magnetic Field.
D. Dadarlat S. Longuemart , R. Turcu , M. Streza , L. Vekas , A. Hadj Sahraoui, Int. Jour. Thermophys., 2013, DOI 10.1007/s10765-013-1549-1

2. Thermophysical analysis of II-VI semiconductors by PPE calorimetry and lock-in thermography.
M. Streza, K. Strzakowski and D. Dadarlat
AIP Conference Proceedings 1565, 156 (2013)

3. Simple method for highlighting the temperature distribution into a liquid sample heated by microwave power field.
V. Surducan, E. Surducan, D. Dadarlat
AIP Conference Proceedings 1565, 167 (2013)

4. The photothermoelectric technique (PTE), an alternative photothermal calorimetry.
D.Dadarlat, M Streza, R. Chan Yu King, F. Roussel, M. Kuriakose, M. Depriester, E. Guilmeau, A. Hadj Sahraoui
Meas. Sci. Technol. **25,** 015603 (2014)

5. Low cost method for temperature measurements on a multilayer system heated by a microwave power field.
V. Surducan, E. Surducan, D. Dadarlat
Meas. Sci. Technol **25,** 015011 (2014)

6. Complementary photothermal techniques for complete thermal characterization of porous or semi-transparent solids.
D. Dadarlat, M. Streza, O. Onija, K. Strzalkowski, C. Prejmerean, L. Silaghi-Dumitrescu, N. Cobirzan
J. Therm. Analysis Calor. 2014, DOI 10.1007/s10973-014-4091-x
7. Thermoelectrics (TE) used as detectors of radiation. An alternative calorimetry based on the photothermoelectric (PTE) effect.
D. Dadarlat, P. R. N. Misse, A. Maignan, E. Guilmeau, M. Depriester, M. Kuriakose, A. Hadj Sahraoui
Proc SPIE, 2014-accepted

Non-ISI journals

1. Contact Photothermal Techniques for Thermal Characterization of Liquids
D. Dadarlat
Journal of Advanced Thermal Science Research, 1, 9-14 (2014)

Detailed results of this stage can be found in Research Report 4 (Romanian) and in the above mentioned disseminated papers.