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# "CHARACTERIZATION OF NON-ENCAPSULATED THERMOCHROMIC LIQUID CRYSTALS AS BULK MATERIAL AND AS AN EMULSION FOR APPLICATION IN MICRO-DEVICES"

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## KEY WORDS

Liquid crystals, bulk material, emulsion, emulsification, temperature, micro reactor

## ABSTRACT

During the last couple of years, there has been a rapid increase of interest for the development and application of microsystems and microflow devices. Microflow devices (micropumps, microvalves, micro heat exchangers, micro sensors, micro reactors…) are integrated in conventional processes and become a part of significance in future industrial applications and transport systems, as well as in the existing processes re-designs. Therefore there is a great need to gain more precise and accurate parameters of process parameters in micro structured reaction systems, but this is still quite challenging.
In Microfluidics, it is well known that some of the differences between the published experimental data on the dynamic and thermal behaviour of micro-flows and the values predicted by using classical theories were originated from the experimental methods used for the investigation of micro-flows, and in particular, for the determination of the local values of the main physical parameters (pressure, temperature, velocity). Even though many different kinds of measuring techniques have been proposed and tested in micro-devices, the need for the measurement techniques development and novel approaches is increasing.
One possibility, chosen for local temperature measurements, is the use of a non-intrusive optical technique called Liquid Crystal Thermography. Its primary advantage over competing techniques is in reduced cost and ease of implementation. Although its practical application has numerous complexities with regard to optical access and colour interpretation, it is still one of the most promising technique [1, 2].

The aim of this study was to use this technique to measure the temperature inside a simple micro reactor with a single micro-channel ( 500 x 200 µm, l ~ 35 mm). Non-encapsulated thermochromic liquid crystals (TLC) (UN R25C10W, Hallcrest) were used as tracer particles due to their ability to show temperature changes in the range of 25 – 35 ºC. A set of experiments were performed in order to widen knowledge about non-encapsulated liquid crystal properties and sensitivity as bulk material. In terms of morphology, bulk material was characterized by optical microscopy, and rheological properties through viscosity, shear stress and shear rate parameters. Its behaviour in aqueous solution was observed through surface tension and contact angle measurements.

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In order to use TLC particles for local temperature measurements in a fluid flowing through a micro channel, the TLC size must be reduced below 10 μm. The reduction of the particle size can be useful in order to increase the number of particles introduced within the flow or to reduce the influence of the particles on the working fluid. For sure, the use of smaller TLC particles means a reduction of the light emitted by the particle, which can be compensated by the usage of more powerful light source, or in case of a steady state situation, combining different pictures in one for each particle observed.
Since recently, it was demonstrated that a stable suspension of TLC in an aqueous solution was not possible, unless the TLCs are dispersed as droplets forming a water-based emulsion [2]. Different emulsification techniques can be used in order to obtain from the bulk material a series of TLC particles with a low diameter.
Preparing emulsions with a Shirasu Porous Glass (SPG) membrane was approved as an appropriate technique for uniform particles size distribution [3, 4], but now a series of open questions appear in terms of stability and degradation of the TLC material and emulsion. During the emulsification process, many parameters like temperature, pressure and shear stress can alter the behaviour and stability of the TLC material and even cause loss of its original properties. Therefore, other emulsification techniques should be tested and the results will be used as basis for further investigations. With controlled, not so high pressure (≥ 35 kPa) and temperature (≥ 65 ºC), other emulsification techniques are proposed [5]. In this study, the influence of pressure and temperature during the emulsification process will be investigated by using Ultra Turrax emulsification technique. The aim is to observe where is the limit in relation to droplet size, colour play and stability, and to investigate the lower limit of the particle size that can still show colour play. This is still unknown and it is the crucial aspect for application of non-encapsulated thermochromic liquid crystals as temperature tracer particles inside the micro-device with aqueous and especially with gaseous medium flow. With estimated high potential for applications in various systems in chemical process engineering area, this method in gaseous flow seems quite promising.
Hence, after preparation of the emulsion, the particle-size distribution will be characterized with the same techniques as bulk material. The results obtained from bulk material and emulsion will be compared, whereafter the TLCs emulsion will be firstly introduced in the micro channel in steady state in aqueous fluid, and then in air. Changes of particles behaviour can be expected due to possible oxygen quenching, ergo gases like $H_e$, pure $N_2$ or some gas mixtures will be considered for future application.

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