Experimental study on acetone vapor as the tracer molecule for molecular tagging thermometry in gas microflows

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Molecular tagging, gas microflows, luminescence, phosphorescence

In recent years, gas flows in microdevices have become of particular relevance in several interesting microfluidic applications [1]. In these devices, the gas is subjected to rarefaction effects, and local thermodynamic disequilibria are manifested as velocity slip and temperature jump at the wall. Limited experimental data is available in this domain, particularly concerning local measurements of velocity and temperature [1, 2]. The Molecular Tagging Thermometry (MTT) technique has shown great potential to get local temperature data [2-5]. This technique introduces luminescent tracer molecules (such as acetone) in gas flows to map temperature profiles. In this study, preliminary experiments and analysis have been carried out to understand the light emission dependency of acetone with temperature.

The MTT setup can be divided into two distinct parts: (1) a gas circuit for flow seeding and control of operating conditions and (2) tagging and detection elements composed of heating elements, temperature sensors, and laser for molecular tagging, data acquisition and processing system. Experimental acquisition of the light intensity of pure acetone, excited at a wavelength of 310 nm, as a function of delay time, was carried out at pressures varying between 15,000 Pa and 1000 Pa and various conditions of temperature (20 °C, 34 °C, and 50 °C).

Analysis of the experimental data clearly indicates a dependency of light intensity and phosphorescence lifetime with temperature. This study is a step towards developing and implementing the molecular tagging thermometry (MTT) technique to map temperature profiles and to understand temperature jump at the walls in rarefied gas microflows.

Acknowledgements
This project has received funding from the European Union's Framework Programme for Research and Innovation Horizon 2020 (2014-2020) under the Marie Skłodowska-Curie Grant Agreement No. 643095, and from the Fédération de Recherche FERMAT (FR 3089).

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