Organic photo sensors: a revolution for the development of innovative particle sizing methods

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According to all experts, OLED (organic light-emitting diode) technology is close to fully revolutionize the lighting sector. While lesser-known and developed, the technology of Organic Photo Sensors (OPS) is also rapidly developing with promises of bringing totally new solutions for our day-to-day life, for manufacturing process control as well as for scientific instrumentation.

Metal-semiconductor photodetectors (Si, GeSi, PbSn,...) offer fast and high sensitivity responses over a large electromagnetic spectrum. To our best knowledge, nearly all sensors (APDs, photomultipliers, CCD or C-MOS sensors) used for flow diagnoses are based on Silicon since the latter offers the best performances in the visible range. However, the production of Silicon photo sensors with large, complex-shaped and multiple photosensitive area(s) is delicate and extremely costly. By the way, the aforementioned limitations of the metal-semiconductor technology are directly connected to the complex manufacturing process of the wafers as well as their crystalline structure and mechanical properties. On the other side, with organic photo sensors, one can expect to produce, on demand, and for a reasonable price, arbitrary sized and shaped photosensitive areas. Furthermore, these plastic-like photosensitive films are conformable, so that they can be bent, without a significant loss of performance, down to curvature radii of few centimeters.

This communication aims to present the work in progress conducted by a French industry/academic consortium, called OPTIPAT, to develop innovative OPS based light scattering methods to characterize particle systems encountered in various fluid mechanics problems. At this step, little can be said on the photosensitive and electronic characteristics of the OPS under development. However, in few words, they are comparable to those of Silicon technology, except that the response time of organic sensors is far inferior (about the millisecond).

A Monte Carlo [2] type code has been fully developed to evaluate and optimize the response of OPS when recording the scattering diagrams of particle systems flowing through a cylindrical channel (i.e. cylindrical pipe). The numerical optimization has led to create a nephelometer or Multi-Angle Light Scattering (MALS) prototype to measure particles within the size range (D=5-50µm). This prototype uses accurately the OPS properties, indeed the size and shape of the sensitive zones are evolving according to the collection angle and moreover the OPS are bend around a cylinder.

As an illustration of the results simulated from the nephelometer configuration that will be presented, Figure 1 presents numerical predictions for the evolution of a light scattering intensity based ratio (R) that is highly sensitive to the mean diameter (D) of log normal particle size distributions (PSD).

Despite the rather good agreement found between Lorenz-Mie Theory (LMT) and the Monte Carlo models, which both predict a simple power law relation between R (quantity to be measured) and D (quantity we want to determine), the Monte Carlo simulations account for many effects that are neglected by LMT based model: arbitrary laser beam shape and position, sensors photosensitivity, shape and near-field location, false reflections at the pipe interfaces and between the particles, etc. In fact, the agreement found here is the result of an optimization process of the laser beam waist, OPS and optical filter distances and shapes. The key idea being that LMT is useful to get rapidly a first estimation of D, whereas Monte Carlo calculations, which are more time consuming, should be reserved to improved the final resolution.