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A Smart Optofluidic Sensing Platform Ensuring Patients' Safety during Parenteral Nutrition Administration

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Parenteral nutrition (PN) is a lifesaving treatment for a large number of patients suffering from different pathologies, from cancer to intestinal failure, from eating disorders to inflammatory bowel disease. In PN, liquid nutritive drugs are injected into the patient's body intravenously through an infusion delivery pump. As reported in the scientific literature, among all medical treatments, PN is the most commonly prone one to human errors [1]. In particular, very often wrong PN mixtures (PNMs) are administered. The consequences can be very dangerous to the patient's health, leading to death in the most severe cases. Despite this fact, currently no standard safety protocols or control devices are implemented to prevent medication errors in PN. Hence, in the framework of the DSF (Digital Smart Fluidics – project No. 1175234, founded by POR FESR 2014–2020), we have developed an optofluidic sensing platform to distinguish different types of transparent commercial PNMs on the basis of their refractive index (RI). Indeed, each mixture contains different concentrations of glucose, amino acids, and electrolytes, determining different values of their RI. The instrumental configuration of the sensor (Fig 1(a)) features a laser diode that generates a red beam (wavelength of 670 nm) travelling obliquely through a plastic cuvette channel containing the PNM under test. Light is then back-reflected by a mirror applied to the back of the cuvette, and finally exits the channel at a position that depends on the RI of the PNM. The position of the output light spot is easily detected with a linear position sensitive detector (PSD) [2]. The two photo-currents I_1 and I_2 generated at the extremities of the sensitive area are given as the PSD outputs: by proper normalization, it is possible to retrieve the measured light beam position as $p_{PSD} = L/2 \times (I_1 - I_2)/(I_1 + I_2)$, where L is the PSD length. The sensor response is then retrieved, after defining the baseline signal measured in presence of deionized water in the cuvette, as *Sensor response* = $p_{PSD,PNM} - p_{PSD,water}$. The sensing platform was first calibrated with standard glucose-water dilutions, obtaining a sensitivity of 13960 µm/RIU. Then, six commercial PNMs produced by Baxter S.r.l. (Deerfield, IL, USA) and Fresenius Kabi (Bad Homburg, Germany) were flowed in the cuvette channel and tested. Results are reported in Fig. 1(b): the bar chart highlights that every PNMs can be distinguished from all the others since the values of the sensor response are significantly different, also considering their standard deviations. These results are very promising: the optofluidic configuration allows contactless, non-invasive measurements and it is low-cost, easy-to-use, suggesting the possibility of its integration into commercial pumps for infusion (Fig. 1(a)).

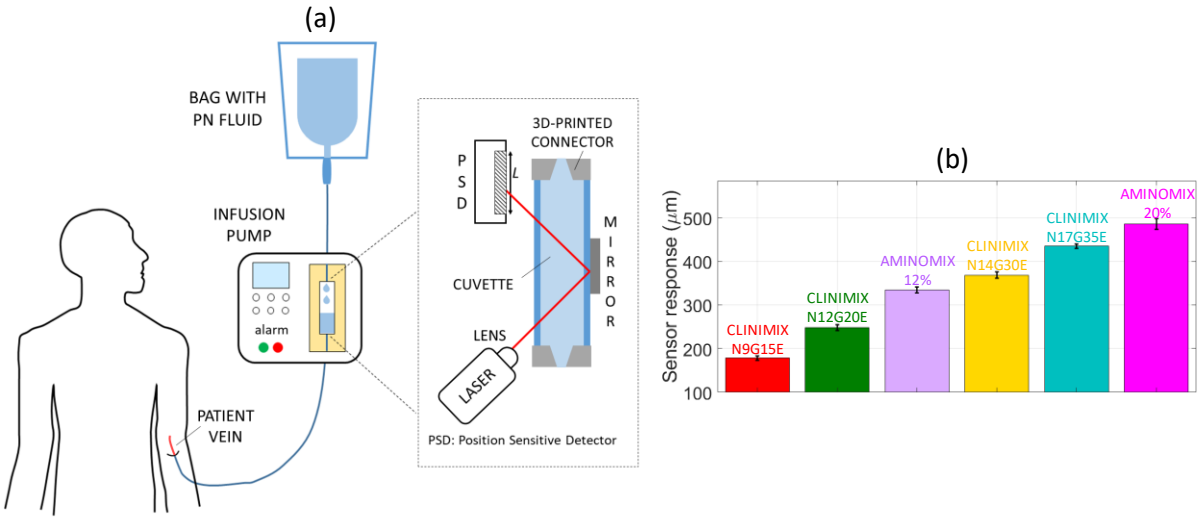

Fig. 1 (a) Schematic configuration of the optofluidic sensor that could be easily integrated into commercial infusion pumps. (b) Experimental results showing that the sensing platform can be successfully exploited for identification of six commercial PNMs.

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