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Editorial

ACS Sensors from a Microfluidics Perspective

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Earlier this year, I was delighted to accept Justin's offer to join the *ACS Sensors* Editorial team. This was soon after Pittcon 2020 in Chicago, where I'd had the chance to spend a wonderful afternoon with the Editors-in-Chief of the society's "measurement science" journals and better understand the journals' interrelationship. The decision was in all truth an easy one, not least because of the journal's raison d'être, but because of Justin's enthusiasm and commitment to disseminating the very best advances in sensing science.

Although I would not necessarily consider myself as someone embedded within the "chemical sensing community", the use of optical sensing techniques and concepts has underpinned almost all of my group's work over the past two decades. Our interest in using microfluidic tools for performing chemical and biological experiments has in large part been driven by the evolving demands of contemporary scientific research, where the need to perform rapid and sensitive measurements on small sample volumes is increasingly viewed as requisite. In this regard, the adoption of microfluidic tools makes complete sense, since physical and chemical processes can be more easily controlled and harnessed when instrumental dimensions are reduced to the micron scale.[1] Today, it is fair to say that the relevance of such technology is without doubt and is characterized by a range of features that accompany system miniaturization.

Despite the central role of microfluidic tools in modern-day chemical and biological research—in areas such as materials synthesis, single cell analysis, molecular evolution, point-of-care diagnostics, and tissue/organ engineering[2]—it is fair to say that they have yet to fully realize their potential as enabling technologies in experimentation. In my opinion, this is in large part due to the unmet challenges associated with effectively probing the small volumes characteristic of microfluidic environments. Put simply, "microfluidic" tools are only able to add value because system downsizing is almost always accompanied by significant gains in analytical performance, for example, in terms of throughput, efficiency, information content, and automation. This means that our ability to efficiently probe such small volumes is often key in defining utility in a given application. For instance, a droplet found within a microfluidic segmented flow might have a diameter of 10 μm, and a volume of just over 500 fL. If this droplet encapsulates an analyte present at a concentration of 10 nM only 3000 molecules will be present. This back-of-the-envelope calculation highlights the enormity of the sensing challenge and confirms that molecular detection will always be a primary issue determining the practicality and application of any microfluidic tool.

So, what are the big challenges associated with small volume detection? As in all sensing problems, factors such as sensitivity and limit of detection are often to the fore.[3] In this regard, optical methods based on fluorescence consistently provide for outstanding limits of detection, excellent analytical sensitivities, and often operate at the single species/molecule level. Unsurprisingly, such methods are well suited for noninvasively probing small volumes and low analyte concentrations. Moreover, the diversity of established fluorescent probes, bioconjugation chemistries, and assays makes "fluorescence" an obvious choice for the researcher. That said, fluorescence is far from a panacea for sensor science. Indeed, the vast majority of molecules do not fluoresce and the information content associated with condensed-phase fluorescence measurements can often be limited. Absorbance-based sensing, while being perhaps the most commonly used optical tool on the macroscale, is severely compromised within microscale environments due to its path length dependent nature, and thus we continue to seek more universal detection tools that operate efficiently within small-volume environments. Fortunately, recent years have seen an abundance of new optical sensing concepts that promise much for those of us who need to rapidly and sensitively probe complex biological samples within small volumes. Advances in plasmonic sensors, such as those based on photonic crystals or 2D materials, offer new and exciting opportunities in the biosensing arena. Moreover, surface enhanced vibrational, nanomechanical, and photothermal spectroscopies are beginning to offer sensitive and robust routes to "label-free" detection of a wide range of chemical and biological species.

In the short time that I have been working as an Associate Editor for the journal, I have been thrilled to see so many exciting and truly novel optical sensing concepts within our submissions. Many of these are still in the review process, but some have already been published. For example, in the October issue, McKendry and co-workers describe an elegant cantilever-based sensor for assaying phenotypic antibiotic resistance in clinical samples and within 45 min (10.1021/acssensors.0c02028). Such an antimicrobial sensitivity testing platform already matches current gold-standard methods in terms of assessing minimum inhibitory concentration values,

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but promises even more significant improvements in detection time and sensitivity, through transferal to a microfluidic format. Moreover, in November's issue, Gil Garnier and colleagues at Monash University report a beautiful point-of-care fibrinogen diagnostic that works with whole blood (10.1021/acssensors.0c01937). The structural and operational simplicity of the diagnostic combined with facile distance-based readout ensures sample-to-result times of only a few minutes and thus therapeutically useful diagnosis of early hypofibrinogenemia. Both of these papers show how smart, yet simple, optical sensing solutions can have significant impact on unmet healthcare challenges, and I am sure that we will be seeing many more of these within the journal over the coming months and years.

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Notes

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REFERENCES

(1) deMello, A. J. Control and detection of chemical reactions in microfluidic systems. *Nature* **2006**, *442*, 394−402.
(2) Chiu, D. T.; deMello, A. J.; Di Carlo, D.; Doyle, P. S.; Hansen, C.; Maceiczyk, R. M.; Wootton, R. C. R. Small but Perfectly Formed? Successes, Challenges, and Opportunities for Microfluidics in the Chemical and Biological Sciences. *Chem.* **2017**, *2*, 201−223.
(3) Gooding, J. J. What Does Ultrasensitive Really Mean? *ACS Sensors* **2019**, *4*, 528−528.

https://dx.doi.org/10.1021/acssensors.0c02510
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