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Analytical miniaturization and nanotechnologies

Arben Merkoçi*a and Jörg P. Kutterb

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This themed issue of Lab on a Chip is focused around the “III International Workshop on Analytical Miniaturization and NANOtechnologies (WAM-NANO2012)”, to be hosted in Barcelona (Spain) on June 11th and 12th, 2012. It covers the latest international developments on the use of nanotechnologies and nanomaterials for the design and applications of lab-on-a-chip (LOCs) and other miniaturized analytical (bio) systems. Nanotechnology is currently one of the most fascinating and challenging fields of research and development. It is highly multidisciplinary, involving research from all scientific and engineering disciplines and as such is bringing significant support to analytical miniaturization. Nanotechnology provides great opportunities for innovation through the converging of knowledge in materials, photonics, electronics, biology and medicine, with technology-driven and application-driven approaches with interest for analytical applications. This themed issue showcases several important achievements in analytical miniaturization developments where nanotechnology is poised to bring advances in current knowledge.

The major focus of this issue is on clinical analysis in which nanotechnology enables novel devices and systems with an improved analytical performance. Lechuga et al., (DOI: 10.1039/C2LC40054E) show their last achievements in their LOC platform with ‘on-chip’ detection using a bimodal waveguide (BiMW) interferometer. This platform achieves sensitive, label-free and real time biosensing with special interest for point of care diagnostics. Also working with optical detection but using two-dimensional photonic crystals (2D-PC) fabricated by nano-imprint lithography (NIL), Endo et al. (DOI: 10.1039/C2LC40066A) could detect insulin in a label-free mode through measurements of the refractive index changes caused by specific interactions between the antigen and an antibody. Electrochemical methods also are offering various opportunities for LOC applications. The contribution of nanomaterials such as carbon nanotubes (CNT) has

Prof. Arben Merkoçi is head of the Nanobioelectronics & Biosensors Group at ICN (Institut Català de Nanotecnologia) in Barcelona. His research is focused on the integration of biological molecules (DNA, antibodies, cells, and enzymes) and other receptors with micro- and nanostructures as they apply to the design of novel sensors and biosensors. He is the author of over 150 manuscripts, special journal issues, and books on nanomaterials and biosensors and also serves as an Editor of the Nanoscience and Nanotechnology Encyclopedic Series launched by John Wiley & Sons.

Prof. Jörg P. Kutter received his B.S in Chemistry in 1991 and his PhD in Analytical Chemistry in 1995, both from the University of Ulm, Germany. After graduation, he became a postdoctoral research fellow at Oak Ridge National Laboratory (Oak Ridge, TN, USA) developing microchip-based analytical tools. In June 1998, he joined the Department of Micro and Nanotechnology of the Technical University of Denmark (DTU) in Lyngby, Denmark. In 2006, he was appointed professor in experimental lab-on-a-chip systems at DTU. He is group leader of the ChemLabChip Group focusing on the development of microfluidic devices for applications in life sciences.
been one of the main focuses of the
research in this field. By using a CNT/
PDMS based device with electrochemical
detection, Carrilho et al. (DOI: 10.1039/
C2LC40141J) could detect serotonin at a
detection limit of 0.2 nmol L$^{-1}$. Focusing
on diagnostics, but applying a biosensor
that integrates contactless conductivity
transduction and folic acid as bioreceptors,
the same group reports (DOI: 10.1039/
C2LC40157F) the sensitive detection of an
FR-x cancer biomarker. As demonstrated
by Delamarche et al. (DOI: 10.1039/
c2lc00015f), capillary driven microfluidics
are simple to use. These platforms provide
new opportunities to perform fast biological
assays with nanogram quantities of
reagents and microliters of samples. In this
context, the authors describe the use of
capillary soft valves (CSVs) as a simple-to-
implement and actuate approach for stopping
liquids in capillary-driven microfluidics. They illustrate the operation of these
valves during the detection of DNA.

Quantum dots (QD) are also being
investigated as interesting essential ele-
ments for various bioanalytical applica-
tions including those performed within
microfluidics platforms. In addition,
microfluidic platforms can be used for in situ
synthesis of QDs. For this purpose, Alonso et al. (DOI: 10.1039/
c2lc00011C) report a green tape based
microfluidics system that achieves in-chip
CdSe QD synthesis at controlled high
temperature. Their approach promises
an interesting cost-efficient alternative
for nanocrystals synthesis in organic
media. Besides in-chip synthesis, in-chip
QD detection is very interesting
considering the various bioanalytical
applications where QDs can be used
as labels for DNA, proteins and even
cells. The electrochemical properties of
QDs can easily be evaluated using an
in-chip integrated electrochemical sys-
tem. Merkoçi et al. (DOI: 10.1039/
c2lc00007E) have designed a flexible

hybrid polydimethylsiloxane (PDMS)/
polycarbonate (PC) microfluidic chip
with integrated screen-printed electrodes
(SPE) to detect CdS QDs. In addition to
the in-chip CdS detection, a recirculation
system with the aim of achieving lower
detection limits using reduced volumes of
sample is also proposed.

An interesting application of lab-on-a-
chip systems concerns their use as plat-
forms for active transport through
nanomachines. Wang (DOI: 10.1039/
c2lc00003b) reviews the latest achieve-
ments by his and other groups in the field
concerning the use of nanomotors for
cargo manipulations and the develop-
ment of miniaturised LOCs to drive
transport processes along microchannel
networks. Focusing on cargo-lifting
within a LOC platform, Kuhn et al. (DOI: 10.1039/c2lc21301j) report an
interesting approach for a simple fuel-
free vertical propulsion of conducting
beads in liquid filled capillaries based on
bipolar electrochemistry. The developed
cargo-lifting approach might also be used
in the design of miniaturized microchan-
nel viscosimeters, valves and pumps.

Recent advances in ultra-compact,
rolled-up components as parts of lab-in-
a-tube total analysis system are reviewed
by Schmidt et al. (DOI: 10.1039/
c2lc21175k). The authors give an over-
view of the advantages that the system
brings to biosensing including the opti-
cal, electrical and magnetic components
related to detection. According to the
authors, “the lab-in-a-tube offers a great
opportunity in both reducing the size of
lab-on-chip systems as well as allowing
for a large number of data points taken
from individual organisms under similar
growth conditions”.

General aspects related to the use of
nanomaterials in lab-on-a-chip technolo-
gies have been reviewed by Merkoçi et al.
(DOI: 10.1039/C2LC40063D). The authors
show recent trends in the integration of
nanomaterials into LOC and the advan-
tages in relation to system sensitivity and
miniaturization. They also cover aspects
such as the use of nanomaterials in
building or modifying optical and electro-
chemical detectors, improving sample
pre-treatment or separation processes,
besides discussing the use of LOCs as
platforms for nanomaterials synthesis,
toxicology and drug delivery related
studies. Aspects related to the use of
carbon nanotubes for electrochemical
sensing in microfluidic chips are carefully
considered by Escarpa et al. (DOI: 10.1039/C2LC40099E). The single wall
carbon nanotubes (SWCNT) were char-
acterized by near infrared (NIR) spectro-
scopy yielding the Purity Index (NIR-PI)
as an important analytical parameter to be
considered prior to their application in
electrochemical sensing. Mogensen and
Kutter (DOI: 10.1039/C2LC40102A)
also review the state of the art on the
use of CNTs and other related
carbon nanomaterials, such as graphene,
in microchip chromatography. The
authors give a critical overview of the
various strategies used to implement
these nanomaterials for microfluidic
chromatography devices in terms of
separation efficiency and fabrication
strategies.

We really hope that the readers will
enjoy these high-calibre contributions in
this special issue, showcasing the many
facets of using nanotechnology in the
context of lab-on-a-chip devices.

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