Faculty of Science and Engineering

Profile report: Lab-on-a-chip for advanced (bio)analytical chemistry
(NL: Lab-on-a-chip voor geadvanceerde (bio)analytische chemie)

- Discipline: Analytical chemistry, micro-nanofluidics, biomedical engineering
- Level: tenure-track assistant professor
- Focus: Research
- Fte: Full time (1.0)

1. Scientific discipline

The essence of lab-on-a-chip is the exploitation of micro-nanotechnologies such as microfluidics for ultra-small volume (femtoliter to microliter) liquid handling and sample processing. Debuting in the late 1980's, lab-on-a-chip is now recognized as an enabling technology that is applied to a myriad of life science applications, from bioanalysis and biosynthesis to organ-on-a-chip and *in vivo* fluid dynamics.

2. Vacancy

This position was created in the context of the sector plan Pharmaceutical Sciences and will be embedded in the Groningen Research Institute of Pharmacy (GRIP), in the research group Pharmaceutical Analysis. The position falls within the framework of the newly instated career development program, Career Paths in Science and Engineering. As the focus domain of the position is research, the criteria of the career path with a focus on research apply. Please see the link for more information.

3. Selection committee (BAC)

Prof. G.J. Poelarends	Scientific Director of GRIP; Committee Chair
Prof. K. Poelstra	Education Director of GRIP
Prof. E.M.J. Verpoorte	Chair of Pharmaceutical Analysis research group; Professor of Analytical Chemistry and Pharmaceutical Analysis
Prof. P.L. Horvatovich	Professor of Computational Mass Spectrometry; Chair of Analytical Biochemistry research group
Prof. W.R. Browne	Professor of Molecular Inorganic Chemistry (Stratingh Institute of Chemistry)
Prof. N. Pamme	Professor of Analytical Chemistry, Stockholm University (Sweden)

Student member: To Be Named at a later date

Advisors: Prof. R. Gosens (Chair, GRIP Board), F. Salverda (HR), Dr. R. van Calck (GRIP Scientific Coordinator).

4. Research area

Networks of seamlessly interconnected microchannels with dimensions exact to the micrometer are the basis for the lab-on-a-chip (LoC) tools used by bioanalytical chemists and biomedical engineers alike. The real power of LoC is provided by the ability to very precisely control fluid volumes at the femtoliter-to-microliter scale at flowrates of nanoliters per minute to microliters per second through these microchannels. Unique manifestations of fluid flow and molecular transport at the microscale are afforded on the one hand by the selected microchannel geometries and networks, and on the other hand by precisely applied external forces (pressure, electric field, acoustic force, etc.). The result has been a broad spectrum of novel analytical approaches exploiting these behaviors to measure biomolecules, particles and cells. LoC has thus been a significant source of innovation in analytical and bioanalytical chemistry over the past three decades.

The enhanced performance in (bio)chemical processing that can be achieved in small volumes is the inherent added value that motivates the miniaturization of analytical devices and instrumentation in the pharmaceutical sciences. Small volumes mean faster analysis in smaller samples, with the possibility to run multiple samples in parallel arrays. As an example, the development of "sample in, answer out" LoC devices in the last two decades has resulted in user-friendly handheld diagnostic tools becoming increasingly accessible. This is succinctly illustrated by the advent of massive Covid testing by untrained citizens during the pandemic and underscores the many developments already made in user-friendly LoC and other diagnostic devices in the years prior to Covid. Other successful examples include glucose point-of-care devices, as well as devices for determining DNA profiles in forensic applications and lithium in blood samples in the doctor's office. Molecular diagnostics, proteomics, and metabolomics, areas in which analysis is paramount, have benefited in recent years from LoC-based sample processing (e.g. analyte extraction, concentration) and analysis. LoC has also become an essential technology, together with tissue engineering using e.g. patient stem cells, in the development of advanced *in vitro* systems like the organ-on-a-chip. LoC devices can house live cells or tissues for days or even weeks (depending on cell type), using microfluidics to engineer biomimetic cellular microenvironments. Besides facilitating the generation of physiological processes *in vitro* for fundamental mechanistic studies, LoC is thus also set to make a crucial contribution to the reduction, refinement and replacement of animal testing in drug development. There is in addition a significant role for LoC in the new Green Deal initiative adopted by healthcare and pharmaceutical companies, which addresses sustainability issues related to production and other aspects in these sectors.

Moving forward, this position in LoC provides rich opportunities for the further exploration of microflows and molecular transport as a means to analyze biomolecules, micro particles and cells more easily and efficiently. This position will contribute original research to the LoC field, while simultaneously supporting many GRIP efforts to collect new information about physiological systems and their response to new therapies.

5. Embedding: institute (and base unit)

The Groningen Research Institute of Pharmacy is positioned within the Faculty of Science and Engineering (FSE), and is physically located within the University Medical Centre Groningen (UMCG) of the Faculty of Medical Sciences (FMS) - hence, in an ideal position to benefit from collaborations between the two faculties. Together with Medical Sciences, GRIP participates in a joint UMCG-FSE Research Institute. Pharmaceutical research within GRIP is multidisciplinary and bridges the clinical and biomedical sciences on the one hand, and chemistry, mathematics (statistics) and physics on the other. The interaction between the pharmaceutical sciences with these fundamental and clinical sciences offers excellent opportunities for cutting-edge research.

With this vacancy, GRIP's ambition is to strengthen its leading role in the area of LoC for bioanalytical applications in the pharmaceutical sciences. Though there are strong programs pursuing LoC technology for life science applications at the University of Twente, Technical University of Delft, and Eindhoven University of Technology, the embedding of an LoC program within a pharmacy institute like GRIP is unique for the Netherlands. The Pharmaceutical Analysis research group has a well-established LoC rapid prototyping facility (Class 100 cleanroom), micromilling station, and some additive manufacturing capacity (3D fused deposition modelling and stereolithography (SLA) 3D printing).

The Pharmaceutical Analysis group has expanded in recent years with the addition of three tenure-track assistant professors specializing in the kinetics of intracellular nanomedicine uptake (Christoffer Åberg, May 2017), 3D organ-on-a-chip systems for studying tumor microenvironments and their influence on therapy success (Anika Nagelkerke, Nov. 2018), and *in vitro* models for investigating disease mechanisms underlying cancer-neural system interactions (Mihaly Balogh, March 2022). Prof. Daan Touw is also a part-time member of our team, specialized in clinical pharmacokinetics, clinical toxicology and pharmacology, and seconded to Pharmaceutical Analysis by the UMCG department of Clinical Pharmacy and Pharmacology, where he is the head of the laboratory. Together with the microfluidics/LoC expertise (analytical and organ-on-a-chip) of group head, Sabeth Verpoorte, the group has a unique spectrum of expertise spanning physics, physical chemistry, analytical chemistry and microfluidics through to cell biology and pharmacy practice. The new position will strengthen LoC bioanalytical capability in the group, and ensure continuity of this discipline within GRIP.

6. Local and (inter)national position

LoC research at GRIP presently has strong ties with the Stratingh Institute of Chemistry (Prof. W.R. Browne, Prof. S. Otto), as well as with the Groningen Research Institute for Asthma and COPD (GRIAC; Prof. I. Heijink, who is a partner in a nationally funded project) and with the UMCG, the department of Clinical Pharmacy and Pharmacology. At the national level, a bachelor and master programme in Pharmacy is offered by the

Universities of Groningen, Leiden and Utrecht. The Leiden Academic Centre for Drug Research houses the Metabolomics and Analytics Centre headed by Prof. T. Hankemeier, where LoC and organ-chip technologies form part of the available expertise.

There is a large Dutch initiative, the Human Organ and Disease Model Technologies Consortium (hDMT), involving most Dutch universities having pharmaceutical or medical research. The LoC-work done within the consortium is mostly aimed at providing biomimetic microenvironments for cells and tissue, however, with little emphasis on bioanalytical chemical monitoring.

An academic position in Lab-on-a-Chip for Advanced (Bio)analytical Chemistry is unique in the Dutch academic Pharmacy landscape, and stimulates microtechnology and micro-nanofluidics development through direct embedding in a pharmaceutical sciences environment. Our expertise in LoC has allowed us to have previous collaborations with the University of Amsterdam (Prof. P. Schoenmakers), Maastricht University (Prof. R. Heeren) and Wageningen University and Research (Prof. M. Nielen, Prof. H. Bouwmeester).

Internationally, present collaborations in the area of LoC for (bio)analytical chemistry exist with the Vrije Universiteit Brussel (Prof. S. Eeltink), Queen's University (Kingston, Ontario, Canada; Prof. R. Oleschuk), University of Kansas (Prof. S. Lunte), and the Czech National Academy of Sciences (Prof. N.S. Lynn).

7. Expected contributions to research

The assistant professor is expected to develop an internationally leading, independent research line focusing on LoC for advanced (bio)analytical chemistry. There is room for the fundamental study of flows and transport in LoC systems as a basis for new analytical principles. Implementation of new principles for LoC analysis in different pharmaceutical application areas would also be well received. In particular, LoC-based approaches for *in situ* monitoring of physiological processes *in vitro* would support ongoing organ-on-a-chip development efforts within the Pharmaceutical Analysis research group and GRIP in general. Measurement principles could include, but are not limited to, electrochemical, optical or affinity-based detection. Other options for implementation of (bio)analytical LoC are of course also possible, including applications in the hospital pharmacy (Prof. Touw).

An important aspect of the function will involve the acquisition of substantial external funding and the supervision of PhD students. Collaboration with relevant groups in the Faculty of Medical Sciences and the FSE, and with colleagues on both a national and international level is also expected.

8. Expected contributions to teaching

The assistant professor will contribute to the Bachelor programs for *Pharmacy* as well as *Life Science and Technology*, and the Master programs for *Pharmacy* and *Medical Pharmaceutical Sciences*. In this framework, the assistant professor could participate in courses focusing on subjects such as *Analytical Chemistry*, *Pharmaceutical Analysis*, and *Instrumental Analysis*. The assistant professor will be involved in the development of new courses (related to the role of analysis in e.g. drug development) and/or in restructuring existing ones. In addition, the assistant professor is expected to supervise BSc and MSc students within the research group with research projects, essays and colloquia.

9. Expected contributions to the organization

The candidate is expected to have an active interest and to provide a positive contribution to the management and organizational tasks of the institute. At the level of FSE, the candidate will contribute to the organization of the faculty, for example by participating in working groups and committees, in the fields of teaching, research and management. The candidate will participate in relevant national and international organizations.