Microchimica Acta (2022) 189:398
https://doi.org/10.1007/s00604-022-05457-5

EDITORIAL

# Microchimica Acta expands to wearable tech

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Received: 16 August 2022 / Accepted: 17 August 2022 / Published online: 29 September 2022


*Microchimica Acta* has been established as one of the benchmark journals in Analytical Chemistry, and in particular, in the Science of Micro and Nanomaterials. This field is the journal's core and one of the main reasons for its past decade of Renaissance.

However, the trends in Bio-analytical Sciences and Technologies using micro- and nanomaterials are heading the expansion of *Microchimica Acta*. Thus, the journal has extended even more its scope to all these new tendencies, seeking to open new frontiers that guarantee quality research and impact of the journal to remain a reference in Analytical Chemistry in the field. The recent editorial written by the Editors in Chief highlights and discusses these new areas of expansion (see https://rdcu.be/cKmzj). Wearable technology for the development of novel sensors is included in this editorial as one of those new areas of expansion which is gaining a high significance in the analytical community.

Wearable technology is here to change our lifestyle. As cars were one day for transportation or computers in the communication field, convenient and affordable wearable technology is quickly getting accepted for wellness. Smart watches are an example of an early adoption of this trendy tech in our society, which enable monitoring of physical markers such as heart rate, oxygen saturation, or sleeping cycle, among others. The development of wearable hardware is combined with the advantages of internet of things (IoT), including wireless data transmission systems to send the data from the sensors to our ubiquitous smartphones.

Wearable devices specifically refer to those worn on the body, which eliminate the need of medical assistance to apply them and are non- or minimally invasive to the wearer. Watches, bracelets, skin patches, mouth guards, contact lenses, and skin patches modified with sensors or microneedles are some of the examples. They include a flexible substrate, a transducer (sensing element), a communication module, and a power module. The flexible substrate accommodates to the irregular surface of the body and is the support for the electronic circuitry. The transducer is mounted on the previous layer and translates the chemical information into an electrical or measurable signal. The data transmission is commonly a wireless antenna based on Bluetooth or other near field communication system. Finally, small batteries or capacitors are incorporated to power the device.

The current wearable-type sensors readily available in the market measure physical parameters. More recently, this tech is expanding to chemical targets in different biofluids. The collection of these dynamics would allow to be standardized clinical information and to obtain a complete picture of the health status. This idea is originating lots of novel research on the design, development, and application of chemical wearable sensors able to perform continuous analysis. Despite of the simplicity of the concept, there are many challenges involved that makes these sensors different from traditional chemical lab equipment. Wearable sensors aim at achieving same analytical performance (sensitivity, selectivity) than laboratory-based methods in a miniaturized platform that samples complex biofluids (interstitial fluid, saliva, sweat, urine) with the uncontrolled temperature, pH, or humidity conditions of human body and its environment. These challenges make the research of chemical wearable sensors an exciting topic where multidisciplinary teams can generate new solutions. Here, *Microchimica Acta* central objective is to expand the scope of the journal within the framework of Sciences and (Bio)-Analytical Technologies, as shown in the latest Topical Collection (see https://link.springer.com/journal/604/collections).

As editors of the journal, here we present the Topical Collection -*Microchimica Acta expands to wearable tech*-. The collection has a double objective, to highlight a set of high-quality works in the field of wearable sensor technology and, on the other hand, to attract new authors to the journal by disseminating the most cutting edge results of the

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(bio)sensor technology, and highlighting the central role, of these new trends, for the journal.

Recent progress in micro/nanomaterials, biocompatible, and flexible materials capable of accommodating on the anatomy enable bio-integration and withstand the stress caused by on-body applications. The interface between these wearable technologies and analytical chemistry is the focus on this Topical Collection, which includes wearable chemical sensors and biosensors. These sensing devices allow dynamic and real-time analytical data of the chemical and biochemical composition of the different biofluids decentralizing common lab methodologies.

This Topical Collection includes 1 review article and 6 research articles representative of wearable sensor technology in the field of micro and nano materials. While the review by D. Pérez and J. Orozco elegantly presents the state of the art of the technology, the original articles present consolidated works within this technology and, some of them, works with great future potential for the implementation of this technology.

The different challenges expected to build a wearable device are depicted in the various papers of this Topical Collection, such as, material properties, sample, sensitivity, and integration.

> Challenge 1. Material: which is the right material that will generate similar analytical performance under different mechanical stress?

The potential of wearables to be implemented within the device highly depends on the substrate, and the capability to withhold the various movements of the body while the user is wearing it. The paper from Song et al. describes the implementation of flexible polypyrrole composites within the electrochemical to detect carcinoembryonic antigen. The sensor needs to accommodate the diversity of shapes/sizes of our body and the environment of our daily routines. Thus, the materials used for diverse bio- or chemical wearable sensors are a central part of the research in this topic.

> Challenge 2. Sample: how to measure complex biological samples?

Human body secretes different biofluids including sweat, saliva, or urine. Boobphahom et al. describe the potential of wearable technology to detect norepinephrine in urine using a combination of $TiO_2$/MXene-polyvinyl alcohol/graphene oxide materials on the carbon electrode. The integration of this sensor in a pantyliner (adsorbant pad) demonstrates the initial capabilities of interfacing these technologies. However, for samples such as urine, interferences from proteins are still a huge challenge and still require centrifugation of proteins and dilution steps.

Other samples are more difficult to access and require a minimal invasion to the skin, as described by R. Antiochia's group. Her team developed a microneedle-based nano porous gold electrochemical sensor for continuous and real-time detection of different catecholamines: dopamine, epinephrine, and norepinephrine, in interstitial fluid. Initial models using gel skin model demonstrate the great potential for these platforms as wearable sensors.

> Challenge 3. Data collection: how to measure without wires?

Apart from the complexity in the real samples, some of the targets that are measured requires continuous detection and the user needs not only a non-invasive device but simple to use. Zhu's group focuses on using Prussian blue/graphene-based sensors integrated in head-bandages to detect glucose in human sweat using a cellphone as the data receiver including Bluetooth wireless tech.

> Challenge 4. Complete integration: how to integrate all components in a miniaturized sensor?

Xuan et al. describe a rime ice-inspired bismuth-based flexible sensor for zinc ion detection using sweat (human perspiration). The lower interference in sweat allows a direct measurement. Besides, the combination of flexible materials (PDMS) with nanomaterials (graphene) enables good analytical performance with the needs of wearables.

Jeerapan's group provides another elegant solution including, in a mouth guard, the sensing component to detect salivary thiocyanate, and providing solutions to mitigate biofouling using protective films.

In the examples of this Topical Collection, we include samples from urine, interstitial fluid, sweat to saliva for detection of a diverse number of markers (biological and chemical), which gives a general idea of the type of research on-going and still needed in the goal to get new readily available sensors.

Although we are aware that the literature on this topic goes far beyond the limits of this Topical Collection, we hope that our readers will gain new ideas for their current and future research and will consider *Microchimica Acta* as a new forum for the publication of their works in the field of design and development of wearable-type (bio)-sensors.

**Acknowledgements** We would like to acknowledge the work and support of the editorial team, Dr. Steffen Pauly (Springer Nature Chemistry Editorial Director), Dr. M. Prodomidis (Co-Editor in Chief), Senior and Associated Editors, Dr. Wolfgang Frenzel and Dr. Jolanta Oleksy-Frenzel (Managing Editors), and Dr. Beatriz Jurado Sanchez (Assistant Editor) for their invaluable support, and also to all the authors for their contributions and to the reviewers for helping us to maintain the high standards of the journal.

**Author contribution** Aida Martin, Associate Editor, *Microchimica Acta*
Alberto Escarpa, Editor in Chief, *Microchimica Acta*

## Declarations

**Conflict of interest** The authors declare no competing interests.