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EDITORIAL

Sustainability in (bio-)analytical chemistry

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We all live on this amazing planet, which, with available sunlight and abundant resources, offers more than enough to maintain life and livelihood. Nevertheless, how we continue to consume what the Earth provides will decide for what duration humanity will still be able to meet these ongoing needs. From analyzing contaminants in the environment to reducing the consumption of non-renewable chemicals required for analytical and bioanalytical techniques, chemists can and do play a major role in preserving resources for posterity. Thus, this topical collection highlights the significant and growing role of chemical and biochemical analysis in addressing key issues related to sustainability.

Sustainability is a major motivation for the use of renewable gases, a term used to describe gases that can be used as clean energy sources without producing additional emissions during combustion, thereby contributing to the decarbonization of the gas grid. Hydrogen and biomethane are the two main forms of renewable gases, which typically contain trace quantities of impurities that can impact the equipment and pipelines that they come in contact with. To ensure the quality of these gases requires close attention to the collection and transport of representative gas samples from the point of use to the analytical laboratory. The challenges and limitations of current methods for sampling renewable gases and related gases (e.g., carbon dioxide) are discussed in a critical review by Arrhenius, Francini, and Büker [1].

In the development of miniaturized electrochemical platforms for the in situ analytical monitoring of clinical, environmental, food, and forensic samples, it is crucial to pay attention to the sustainability of materials chosen to fabricate these devices, in order to decrease the amount and the impact of waste coming from their production and use. In the framework of a circular economy and an environmental footprint reduction, electrochemical sensor production technology must embrace innovative approaches based

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Our beloved colleague, María C. Moreno-Bondi, passed away unexpectedly during the publication process.

Published in the topical collection featuring *Sustainability in (Bio-) Analytical Chemistry*.

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on techniques and materials that can satisfy the needs of environmentally friendly and greener analytics. The work of Palchetti et al. [2] is fully in line with sustainable sensing and focuses on the use of electrochemical sensors based on sewage sludge derived biochar for the analysis of anthocyanins in berry fruits.

Hall and colleagues [3] address locally distributed manufacturing of sophisticated sensor components, where lowering cost of production, simplifying process protocols, and avoiding sophisticated laboratory equipment are critical design criteria. They hence developed a facile technique for the production of silica bead-coated polymerases that successfully carried out isothermal LAMP reactions just like the gold standard polymerases. Sustainability can hence be achieved through local production, avoiding shipping and reliance on distant manufacturers.

The work by Quintana et al. [4] reports the optimization of a gas chromatography–electron ionization–high-resolution mass spectrometry (GC-EI-HRMS) screening method and its application to the analysis of contaminants in coastal mussel samples and coastal/marine- and freshwater-deployed passive samplers. A total of 75 compounds were identified as the major contaminants, including plasticizers, pharmaceuticals, pesticides, PAHs, and fragrances, among others. The type of detected compound depended on the sample, although some of them were found both in water and mussel samples.

Rigano et al. [5] exploited the benefit of using miniaturized hand-portable HPLC instrumentation, and the "greenness" profile of the developed method was quantitatively estimated. The potential of the method for in situ (directly in-field) forensic investigations was shown for the determination of cannabinoids in hemp varieties.

The work by Wójtowicz et al. [6] demonstrated a sustainable approach for stability investigation of molecules of forensic and toxicological concern, based on SPME/LC-MS. The research focused on various popular psychotropic drugs and their metabolites and used vitreous humor and liver as alternative matrices. Besides the known principles of Green Analytical Chemistry, the method was also compliant to the White Analytical Chemistry principles, including the "red" and "blue" criteria demonstrating its practicability and fit-for-purpose.

The topic addressed by Zoccali et al. [7] regards the use and evaluation of hydrogen as a carrier gas, within the context of flow modulation comprehensive two-dimensional gas chromatography–time-of-flight mass spectrometry analysis, as a more sustainable alternative to helium. Especially as the cost of helium increases, hydrogen is an effective alternative because it can be produced using generators, which are safer and more cost effective than gas cylinders. This advance is all the more important due to the ongoing so-called helium shortage 4.0.

Bischoff et al. [8] combined in their article the use of synthetic data sets for supervised learning to generate photorealistic images of virtual protein crystals in suspension (PCS) through the use of ray tracing algorithms with experimental validation using high-resolution photomicrographs from stirred tank protein crystallization processes. By these means they achieved a broader application of crystallization as a purification method which is advantageous in biotechnological downstream processes as a sustainability challenge.

Finally, Chen and colleagues [9] reported a catalyst- and heat-free approach for fabrication of a core–shell magnetic nanocomposite. This highly crosslinked internal zwitterionic architecture had high adsorption capacity for glycoproteins.

We expect that the papers that form this topical collection will provide you with new insights into current work that connects (bio)chemical analysis and sustainability. The papers in this issue further emphasize the vital role that analytical chemists can play in making our Earth a better place. We hope that you will enjoy reading this topical collection as much as we did!

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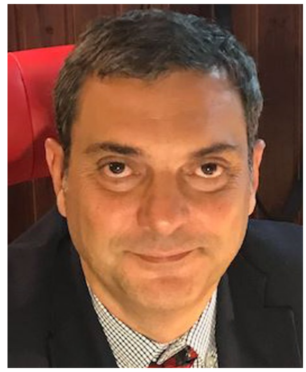

Luigi Mondello is Professor of Analytical Chemistry at the University of Messina, Italy. His research is focused on the development of multidimensional chromatographic instrumentation and software (GC × GC, LC × LC, LC-GC × GC, LC-GC-GC-GC-prep.), coupled to state-of-the-art MS, for the study of complex matrix constituents and contaminants. He is the author of more than 500 scientific papers and more than 1300 conference presentations, with an H-index of 69. *The Analytical Scientist* has included him in the Top Ten worldwide scientists in the field of separation science and he has received the HTC Award, COLACRO Medal, Silver Jubilee Medal, Liberti Medal, TASIAs, IFEAT Medal, GC × GC Lifetime Achievement, Golay Award, Robert Kellner Lecture, the Herbert J. Dutton Award, the Giovanni Dugo Medal, Prof. A. Waksmundzki Medal Award, and the Canneri Medal.

María C. Moreno-Bondi has been Professor of Analytical Chemistry at the Complutense University of Madrid (UCM), Spain, since 2008. Her current research interests lie in the development of luminescent optical sensors and biosensors, molecularly imprinted polymers, nanomaterials, phage-display techniques, epitope-mimicking peptides, recombinant antibodies, and their applications to food, clinical, and environmental analysis.

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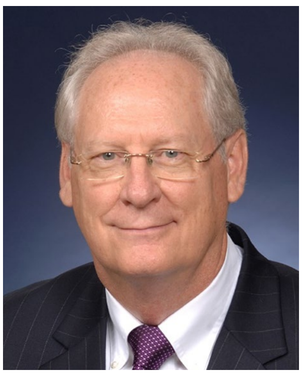

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