separations

Editorial

The Pivotal Role of Chemistry in Research and Development

Victoria Samanidou [1,*], George Zachariadis [1], Michael A. Terzidis [2] and Adamantini Paraskevopoulou [3]

[1] Laboratory of Analytical Chemistry, School of Chemistry, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece; zacharia@chem.auth.gr
[2] Department of Nutritional Sciences and Dietetics, International Hellenic University, Sindos Campus, 57400 Thessaloniki, Greece; mterzidis@ihu.gr
[3] Laboratory of Food Chemistry and Technology, School of Chemistry, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece; adparask@chem.auth.gr
* Correspondence: samanidu@chem.auth.gr

Citation: Samanidou, V.; Zachariadis, G.; Terzidis, M.A.; Paraskevopoulou, A. The Pivotal Role of Chemistry in Research and Development. *Separations* **2022**, *9*, 4. https://doi.org/10.3390/separations9010004

Received: 16 December 2021
Accepted: 20 December 2021
Published: 23 December 2021

Undoubtedly, all pivotal advances in a great number of scientific fields rely on advances in chemistry. Thus, the latter plays a key role in understanding the findings of numerous topics.

Of course, we are not bringing to light an unknown fact; actually, we are stating the obvious. However, it seems that even us chemists need to remind ourselves sometimes of how important our science is. A plethora of applications proves this fact, and this Special Issue on the "Research as Development Perspective" aims to highlight exactly this.

Just to mention a few of them, I list some examples that underline the importance of chemistry in technological advances.

Who can deny that testing new materials in dentistry needs the combination of the fundamentals of material science and the tools provided by analytical chemistry [1,2]?

Metabolomics provides information on the metabolic disorders that underlie disease, thus leading to the discovery of new therapeutic targets, or biomarkers that may be used as diagnostic tools [3–5].

The answer to criminal cases is typically hidden in the traces and clues used in forensics [6,7].

The study of the authenticity of paintings by famous artists needs a combination of spectroscopic techniques. Archaeologists use the tools provided in archaeometry, a combination of mathematics, physics and chemistry, to date archeological findings [8].

History uses chemical techniques to prove or overturn historical data. For example, tooth isotope analysis recently proved ancient historians wrong. According to a study using strontium and oxygen isotopic analysis, it was suggested that it was foreign mercenaries in 480 BC instead of Greek soldiers who helped a city in ancient Greece defeat its enemies [9].

The Olympic games use advances in anti-doping control to prevent or detect doping during sport events [10].

Pandemic situations, such as the one we are currently experiencing, have been faced through chemical or biochemical applications in a wide range of products, from antiseptic agents to vaccines or even the diagnosis of the disease [11].

Geologists use the science of geochemistry to examine the distribution of chemical elements in rocks and minerals [12].

Food sciences and technology, food and feed authenticity/adulteration, food aroma profiling, quality control and assurance are based on chemical studies [13–18]. The changes occurring in foods during processing and storage, and the mechanisms and influencing factors involved, are fully explained by chemical reactions/interactions between food components [19–21]. Gastronomy, and more specifically molecular cuisine, is based on chemical processes [22].

Polymer science and nanomaterials are products of the combination of the application of physicochemical principles and experimental results in a chemical laboratory.

Environmental sciences with regard to the protection of the environment and sustainability sources all use advances in chemistry, as well as in interdisciplinary studies. The monitoring of environmental pollution, e.g., by controlling toxic thallium species, and environmental technology take advantage of this cornerstone scientific field [23,24].

Metallurgy utilizes physical and chemical studies of the behavior of metallic elements, their inter-metallic compounds, and the alloys and their applications in several domains [25].

Cosmetology and the discovery of drugs either for human or veterinary medicine use analytical methods to examine the quality of products, while all clinical trial results necessary for drug approval are derived from bioanalytics [26].

Chemistry also plays a central role in the discovery of new compounds, and the synthesis of natural products, drugs and other pharmaceutical products with significant scientific, societal and environmental impact [27,28].

Additionally, these are only a few examples. The multidisciplinary role of chemistry is reflected in all important advances from research groups in every technological progress, proving that chemistry is the key issue in continuous scientific progress.

Four paradigms are described so far in this Special Issue, as described below:

Tsiasioti et al., in their paper: "Study of the Oxidative Forced Degradation of Glutathione in Its Nutraceutical Formulations Using Zone Fluidics and Green Liquid Chromatograph", report the results of their investigation of the oxidative forced degradation of glutathione in nutraceutical formulations by two validated analytical methods. The first is based on the reaction of glutathione with *o*-phthalaldehyde through an automated zone fluidics flow platform and fluorimetric detection ($\lambda_{ex}/\lambda_{em}$ = 340/425 nm). The second is based on the separation of glutathione and its oxidation product by a green reversed-phase HPLC method coupled with direct UV detection, at 210 nm. A solution of 3% *w/v* H_2O_2 provided the fast oxidation of more than 95% of glutathione to yield oxidized glutathione in a time period of 180 min. The mechanism of the oxidation was proved to follow pseudo-first-order kinetics. The k, t_{90} and $t_{1/2}$ values were calculated [15].

Tsanaktsidou and Zachariadis, in their manuscript "Titanium and Chromium Determination in Feedstuffs Using ICP-AES Technique", present the determination of Ti and Cr in dry animal feeds using wet acid digestion and inductively coupled plasma–atomic emission spectrometry (ICP–AES), in order to use these metals as digestibility markers. A radiofrequency power of 1350 W and a nebulizer argon flow of 0.8 L/min were selected. The limits of detection were between 11.4 and 16.1 µg/g for titanium and between 10.7 and 38.2 µg/g for chromium. The recovery values for the aqueous solutions were 89.5–103.9% (titanium) and 85.3–104.2% (chromium), with relative standard deviations (RSD%) under 2.1% and standard errors under 2.32%, demonstrating that the method offered good accuracy and repeatability. Six different samples of commercially available feedstuffs (two cat foods, two dog foods, and two poultry foods) were analyzed and the levels of investigated metals were found to be in the ranges of 0.10 g/kg and <LOD for chromium and titanium, respectively (dog foods); 0.10–0.18 g/kg, 0.70 g/kg for chromium and titanium, respectively (cat foods); and 0.07 g/kg, 0.82–1.35 g/kg for chromium and titanium, respectively (poultry foods) [14].

Kazantzi and Anthemidis, in their manuscript entitled "An On-Line Flow-Injection Sorbent Extraction System Coupled with Flame Atomic Absorption Spectrometry for Thallium Determination Using a PTFE Turning-Packed Column", present a novel time-based flow-injection–solid-phase extraction system (FI–SPE) coupled with flame atomic absorption spectrometry (FAAS) for the automatic on-line preconcentration and determination of thallium. The efficiency of poly-tetrafluoroethylene (PTFE) turnings packed into a column as sorbent material was investigated for thallium extraction. Total thallium was determined by oxidizing thallium(I) to thallium(III), adding bromine in acidic solution. The formed $[TlBr_4]^-$ anionic bromo complex was retained onto the PTFE turnings by on-line mixing with sodium diethyl dithiocarbamate (DDTC). The preconcentrated Tl(III)–DDTC complex was then effectively eluted with methyl isobutyl ketone (MIBK) and introduced into the flame atomizer for measurement and quantification. The column proved to be effective, stable, and reproducible, with a long lifetime. The enrichment factor was 105 for 60 s preconcentration time, and the sampling frequency 40 h^{-1}. The detection limit was 1.93 μg L^{-1}, and the relative standard deviation (RSD) was 3.2% at 50.0 μg L^{-1} concentration. The accuracy of the proposed method was estimated by analyzing certified reference materials and environmental and biological samples [23].

Marinou et al., in their manuscript entitled "Development of a High Pressure Liquid Chromatography with Diode Array Detection Method for the Determination of Four Tetracycline Residues in Milk by Using QuEChERS Dispersive Extraction", QuEChERS (quick, easy, cheap, effective, rugged and safe) dispersive extraction was applied for the extraction of tetracyclines (oxytetracycline, tetracycline, chlorotetracycline and doxycycline) from milk. Target analytes were determined by an accurate and sensitive chromatographic analytical method, which was validated in terms of a 2002/6572/EC decision. The analytes were separated on an Orbit $100C_4$ (5 μm, 250 × 4.0 mm) analytical column under a gradient mobile phase composed of a mixture of 0.01 M oxalic acid, 10^{-4} M Na_2EDTA and acetonitrile. For the extraction of isolated compounds from sorbent, a methanol and 0.01 M oxalic acid mixture (1:1 v/v) was used, leading to relative recovery rates from 83.07% to 106.3% at concentration levels in the range 100–200 μg/kg. The within-laboratory reproducibility, expressed as relative standard deviation, was <15.5%. Decision limits ranged between 100.3 μg/kg and 105.6 μg/kg, and the detection capability varied between 100.6 μg/kg and 109.7 μg/kg. Ruggedness was evaluated by following the Youden approach, in terms of milk mass, sorbent mass, centrifugation time, vortex time, type and volume of organic solvents and evaporation temperature [16].

Author Contributions: Conceptualization, V.S.; writing—original draft preparation, V.S., G.Z., M.A.T. and A.P.; writing—review and editing, V.S., G.Z., M.A.T. and A.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Kerezoudi, C.; Samanidou, V.F.; Palaghias, G. Nanobiomaterials in restorative dentistry. In *Nanobiomaterials in Dentistry: Applications of Nanobiomaterials*; William Andrew Publishing: Norwich, NY, USA, 2016; pp. 107–132. [CrossRef]
2. Mourouzis, P.; Andreasidou, E.; Samanidou, V.; Tolidis, K. Short-term and long-term release of monomers from newly developed resin-modified ceramics and composite resin CAD-CAM blocks. *J. Prosthet. Dent.* **2019**, *123*, 339–348. [CrossRef] [PubMed]
3. Clish, C.B. Metabolomics: An emerging but powerful tool for precision medicine. *Mol. Case Stud.* **2015**, *1*, a000588. [CrossRef] [PubMed]
4. Chatgilialoglu, C.; Ferreri, C.; Geacintov, N.E.; Krokidis, M.G.; Liu, Y.; Masi, A.; Shafirovich, V.; Terzidis, M.A.; Tsegay, P.S. 5′,8-Cyclopurine Lesions in DNA Damage: Chemical, Analytical, Biological, and Diagnostic Significance. *Cells* **2019**, *8*, 513. [CrossRef]
5. Terzidis, M.A.; Chatgilialoglu, C. An ameliorative protocol for the quantification of purine 5′,8-cyclo-2′-deoxynucleosides in oxidized DNA. *Front. Chem.* **2015**, *3*, 47. [CrossRef] [PubMed]
6. Kovatsi, L.; Fragou, D.; Samanidou, V.; Njau, S.; Kouidou, S. Drugs of Abuse: Epigenetic Mechanisms in Toxicity and Addiction. *Curr. Med. Chem.* **2011**, *18*, 1765–1774.
7. Samanidou, V.; Kovatsi, L.; Fragou, D.; Rentifis, K. Novel strategies for sample preparation in forensic toxicology. *Bioanalysis* **2011**, *3*, 2019–2046. [CrossRef]
8. Katsifas, C.S.; Touloumzidou, A.; Zachariadis, G.A. Compositional study of bronze vessels from the Derveni tombs of central Macedonia of the fourth century bce using energy-dispersive micro-X-ray fluorescence (EDμXRF) spectrometry: Bronze vessels from the Derveni tombs of central Macedonia. *Archaeometry* **2019**, *61*, 1313–1332. [CrossRef]
9. Reinberger, K.L.; Reitsema, L.J.; Kyle, B.; Vassallo, S.; Kamenov, G.; Krigbaum, J. Isotopic evidence for geographic heterogeneity in Ancient Greek military forces. *PLoS ONE* **2021**, *16*, e0248803. [CrossRef]
10. Brun, E.M.; Puchades, R.; Maquieira, A. Analytical methods for anti-doping control in sport: Anabolic steroids with 4, 9, 11-triene structure in urine. *TrAC Trends Anal. Chem.* **2011**, *30*, 771–783. [CrossRef]

11. Ruszkiewicz, D.M.; Sanders, D.; O'Brien, R.; Hempel, F.; Reed, M.J.; Riepe, A.C.; Bailie, K.; Brodrick, E.; Darnley, K.; Ellerkmann, R.; et al. Diagnosis of COVID-19 by analysis of breath with gas chromatography-ion mobility spectrometry-a feasibility study. *EClinicalMedicine* **2020**, *29*, 100609. [CrossRef] [PubMed]
12. Britannica, The Editors of Encyclopaedia. "Geochemistry". Encyclopedia Britannica. 21 March 2014. Available online: https://www.britannica.com/science/geochemistry (accessed on 20 May 2021).
13. Samanidou, V.; Karageorgou, E.; Kourti, P. The Role of HPLC in the Authenticity Control of Milk and Dairy Products. *Liquid Chromatography: Principles, Technology and Applications. Nova*. e-Book. 2013, pp. 173–206. Available online: https://novapublishers.com/catalog/product_info.php?products_id=41489&osCsid=1%2013af153ecad31d45dd1263372817705 (accessed on 16 December 2021).
14. Tsanaktsidou, E.; Zachariadis, G. Titanium and chromium determination in feedstuffs using ICP-AES Technique. *Separations* **2020**, *7*, 1. [CrossRef]
15. Tsiasioti, A.; Zacharis, C.K.; Zotou, A.-S.; Tzanavaras, P.D. Study of the Oxidative Forced Degradation of Glutathione in Its Nutraceutical Formulations Using Zone Fluidics and Green Liquid Chromatography. *Separations* **2020**, *7*, 16. [CrossRef]
16. Marinou, E.; Samanidou, V.F.; Papadoyannis, I.N. Development of a High Pressure Liquid Chromatography with Diode Array Detection Method for the Determination of Four Tetracycline Residues in Milk by Using QuEChERS Dispersive Extraction. *Separations* **2019**, *6*, 21. [CrossRef]
17. Zakidou, P.; Plati, F.; Matsakidou, A.; Varka, E.-M.; Blekas, G.; Paraskevopoulou, A. Single Origin Coffee Aroma: From Optimized Flavor Protocols and Coffee Customization to Instrumental Volatile Characterization and Chemometrics. *Molecules* **2021**, *26*, 4609. [CrossRef] [PubMed]
18. Kalogiouri, N.P.; Manousi, N.; Rosenberg, E.; Zachariadis, G.A.; Paraskevopoulou, A.; Samanidou, V. Exploring the volatile metabolome of conventional and organic walnut oils by solid-phase microextraction and analysis by GC-MS combined with chemometrics. *Food Chem.* **2021**, *363*, 130331. [CrossRef] [PubMed]
19. Roussi, Z.; Malhiac, C.; Fatouros, D.G.; Paraskevopoulou, A. Complex coacervates formation between gelatin and gum Arabic with different arabinogalactan protein fraction content and their characterization. *Food Hydrocoll.* **2019**, *96*, 577–588. [CrossRef]
20. Paraskevopoulou, A.; Rizou, T.; Kiosseoglou, V. Biscuits enriched with dietary fibre powder obtained from the water-extraction residue of maize milling by-product. *Plant Foods Hum. Nutr.* **2019**, *74*, 391–398. [CrossRef]
21. Paraskevopoulou, A.; Donsouzi, S.; Nikiforidis, C.V.; Kiosseoglou, V. Quality characteristics of egg-reduced pound cakes following WPI and emulsifier incorporation. *Food Res. Int.* **2015**, *69*, 72–79. [CrossRef]
22. This, H. The science of molecular gastronomy and the art of innovative cooking. *FEBS Lett.* **2019**, *593*, 887–891. [CrossRef]
23. Kazantzi, V.; Anthemidis, A. An On-Line Flow-Injection Sorbent Extraction System Coupled with Flame Atomic Absorption Spectrometry for Thallium Determination Using a PTFE Turning-Packed Column. *Separations* **2019**, *6*, 22. [CrossRef]
24. Rekos, K.; Kampouraki, Z.-C.; Sarafidis, C.; Samanidou, V.; Deliyanni, E. Graphene Oxide Based Magnetic Nanocomposites with Polymers as Effective Bisphenol—A Nanoadsorbents. *Materials* **2019**, *12*, 1987. [CrossRef] [PubMed]
25. Shewmon, P.G.; Lorig, C.H.; Gill, C.B.; Charles, J.A. Metallurgy. *Encyclopedia Britannica*. 26 December 2018. Available online: https://www.britannica.com/science/metallurgy (accessed on 20 May 2021).
26. Zacharis, C.K.; Tzanavaras, P.D. Determination of bisphosphonate active pharmaceutical ingredients in pharmaceuticals and biological material: A review of analytical methods. *J. Pharm. Biomed. Anal.* **2008**, *48*, 483–496. [CrossRef] [PubMed]
27. Kallitsakis, M.G.; Gioftsidou, D.K.; Tzani, M.A.; Angaridis, P.A.; Terzidis, M.A.; Lykakis, I.N. Selective C–H Allylic Oxygenation of Cycloalkenes and Terpenoids Photosensitized by [Cu (Xantphos)(neoc)] BF4. *J. Org. Chem.* **2021**, *86*, 13503–13513. [CrossRef] [PubMed]
28. Kallitsakis, M.G.; Ioannou, D.I.; Terzidis, M.A.; Kostakis, G.E.; Lykakis, I.N. Selective Photoinduced Reduction of Nitroarenes to N-Arylhydroxylamines. *Org. Lett.* **2020**, *22*, 4339–4343. [CrossRef] [PubMed]