The following manuscript was accepted for publication in Pharmaceutical Sciences. It is assigned to an issue after technical editing, formatting for publication and author proofing Citation: de la Guardia M, Garrigues S. Analytical Research Based On the Use of Low Cost Instrumentation, Pharm. Sci. 2019, doi:10.15171/PS.2019.13

Editorial

Analytical Research Based On the Use of Low Cost Instrumentation

Miguel de la Guardia* and Salvador Garrigues

Department of Analytical Chemistry, University of Valencia, 50 Dr. Moliner Street, Research Building, 46100 Burjassot, Valencia, Spain

(*) Corresponding author: miguel.delaguardia@uv.es

Green Analytical Chemistry and poor chemistry.

One of the side effects of the development of Green Analytical Chemistry (GAC) has been a drastic reduction of method costs, it is based on the reduction of analytical steps and sample treatments, miniaturization and automation of procedure together with on-line waste treatment and reduction of energy consumes. So, one of the reasons of the success of GAC is the fact that to be environmentally friendly makes also to be economically sustainable and this point has been gratefully acknowledge on both, industrial and academical laboratories [1-4].

The development of direct analytical methods has improved the use of portable instrumentation and application of vanguard analytical strategies based on fast screening methods thus offering new possibilities for point-of-care measurements and the use of chemometric models to extract as much as possible analytical information from crude signals. That, together with the advances in informatics, image, and communication technologies has changed the analytical practices and moved the analytical chemists out of their laboratories to obtain analytical information in a fast and cheap way.

Use of low cost instrumentation.

To be innovative in research, funding and imagination are required. Without instrument it is impossible to obtain data and also without ideas, only application notes can be produced. In this sense, the sustainability of prototypes of new high performance instruments is a guarantee to obtain data suitable to be accepted in the prestigious journals. However, also by using a lot of imagination it is possible to do an innovative research.

Sample preparation is one of the areas which requires less money and that can be developed by looking at the surrounding tools in the common life to move to the laboratory.

The pioneering work of Abu-Samra, Morris and Koirtyohann in 1975 opened the way for the use of domestic microwave ovens for sample digestion[5] and also, at the end of nineties, we demonstrated that domestic microwave ovens could be used in the laboratory to extract organic compounds[6] and to do a fast on-line digestion of samples[7], dry ashing of samples[8], also evidencing the possibility to obtain free cholesterol from its esters present in fat samples[9]. So, it was evidenced the versatility of domestic microwave ovens to be employed in the analytical laboratories. On the other hand, studies made at the end of the last century improved extraction and reaction steps by using ultrasound water-bath[10].

In recent years we have proposed the use of hard cup espresso machine to extract organic contaminants from solid samples[11] being confirmed that the use of a temperature around 72ºC degrees and a pressure of 19 bars can provide quantitative extraction of target analytes in only few seconds.

Nowadays, the use of photo cameras and smartphones together with chemometric models permit to obtain general parameters[12] and specific characteristics of samples without using reagent and not damaging the studied products. Once again, we are in front of a low cost tool which, additionally, is available all around the world and thus, it is not astonishing that smartphone can be moved from our daily life to our analytical methods.

The aforementioned examples are just few drops of the new advancements in low cost instrumental which have been also developed in the self-construction of instruments based on cheap components as light emitting diodes[13] and easy available detectors in many fields from environmental to clinical studies. In this sense the generalized use of microfluidics [14], lateral flow systems[15] and, in general, sensors[16], offer portable fast, relatively low cost and robust media for diagnostics and decision making concerning environmental studies.

Based on the use of low-cost instrumentation it is possible to be innovative in analytical chemistry research and, at the same time, to provide easy available tools all around the world

for both, professionals and not specialized citizens, and that opens the door for a new paradigm of analytical chemistry.

Democratic Analytical Chemistry.

GAC is, basically, an environmentally ethics approach but, at the same time, it could extend the benefits of analytical methods to societies with a reduced level of development.

There are in the literature some precedents which evidenced that, based on simple chemometric tools and direct measurements of infrared spectra on middle[17] and near wavenumber range[18] it is possible to made the determination of many analytes in sera in far areas of poor countries in which there is no availability of clinical robots no stable power supplies. So, we are convinced that this is the starting point of a new paradigm of our discipline; which we could call Democratic Analytical Chemistry (DAC).

Why democratic? Because it makes available the methods to all societies in spite of their degree of development and permits to obtain data from simple measurements with low cost instruments. Additionally, social networks and smartphones permits a rapid diffusion of obtained data and thus, as indicated in Figure 1, the concept of democratic analytical chemistry concerns both, benefits and data production. So, we must be optimistics on the future trends in this way. However, this new approach is not free from troubles and, as it is indicated in Table 1, the lack of representativity of some obtained measurements, together with unexperience data obtention, false data distribution, misuse of true results and irresponsible distribution of non-rigorous ones could provide the introduction of fake data through internet. It would damage dramatically the prestige of our discipline and contribute to misinformation of the whole population.

So, as a final conclusion we would like to encourage the analytical chemists and analytical method users to extreme their efforts in education and, specifically in analytical chemistry education, together with the improvement of self-control and policy of data distributed through internet. It must be based on a critical attitude and verification of data found in the social network and involves a high level of social responsibility. Take into account that democracy is one of the best social conquests but it is not at all free of threats and thus the benefits of a democratic analytical chemistry will strongly depend on our ethical behavior.

References

[1] Koel M, Kaljurand M, Green Analytical Chemistry. RSC Publishing; 2010.

[2] de la Guardia M, Armenta S, Green Analytical Chemistry: Theory & Practice, in Comprehensive Analytical Chemistry series, vol. 57. Elsevier; 2011.

[3] de la Guardia M, Garrigues S (Eds.) Handbook of Green Analytical Chemistry. John Wiley & Sons; 2012.

[4] de la Guardia M, Garrigues S (Eds.) Challenges in Green Analytical Chemistry. RSC Publishing; 2011.

[5] Abu-Samra A, Morris JS, Koirtyohann SR, Wet ashing of some biological samples in a microwave oven. Anal Chem. 1975;47(8):1475-7. DOI: 10.1021/ac60358a013

[6] Pastor A, Vazquez E, Ciscar R, de la Guardia M, Efficiency of the microwave-assisted extraction of hydrocarbons and pesticides from sediments. Anal Chim Acta. 1997;344(3):241-9. DOI: 10.1016/S0003-2670(97)00012-3

[7] Carbonell V, de la Guardia M, Salvador A, Burguera JL, Burguera M, Online microwave-oven digestion flame atomic-absorption analysis of solid samples. Anal Chim Acta. 1990;238(2):417-21. DOI: 10.1016/S0003-2670(00)80568-1

[8] Morales-Rubio A, Salvador A, de la Guardia M, Microwave muffle furnace assisted decomposition of vegetable samples for flame atomic spectrometric determination of Ca, Mg, K, Fe, Mn and Zn. Fresenius J Anal Chem. 1992;342(4-5):452-56. DOI: 10.1007/BF00322206

[9] Pineiro-Avila G, Salvador A, de la Guardia M, Microwave-assisted saponification of animal greases for cholesterol determination. Anal Chim Acta. 1998;371(2-3):297-303. DOI: 10.1016/S0003-2670(98)00350-X

[10] Salisova M, Toma S, Mason TJ, Comparison of conventional and ultrasonically assisted extractions of pharmaceutically active compounds from Salvia officinalis. Ultrason Sonochem. 1997;4(2):131-4. DOI: 10.1016/S1350-4177(97)00032-1

[11] Armenta S, de la Guardia M, Esteve-Turrillas FA, Hard Cap Espresso Machines in Analytical Chemistry: What Else?. Anal Chem. 2016;88(12):6570-6. DOI: 10.1021/acs.analchem.6b01400

[12] Dowlati M, Mohtasebi SS, Omid M, Razavi SH, Jamzad M, de la Guardia M, Freshness assessment of gilthead sea bream (Sparus aurata) by machine vision based on gill and eye color changes. J Food Eng. 2013;119(2):277-87. DOI: 10.1016/j.jfoodeng.2013.05.023

[13] Rocha FRP, Rodenas-Torralba E, Reis BF, Morales-Rubio A, de la Guardia M, A portable and low cost equipment for flow injection chemiluminescence measurements. Talanta, 2005;67(4):673-7. DOI: 10.1016/j.talanta.2005.03.021

[14] Mark D, Haeberle S, Roth G, von Stetten F, Zengerle R, Microfluidic lab-on-a-chip platforms: requirements, characteristics and applications. Chem Soc Rev. 2010;39(3):1153-82. DOI: 10.1039/b820557b

[15] Sajid M, Kawde AN, Daud M, Designs, formats and applications of lateral flow assay: A literature review. J Saudi Chem Soc. 2015;19(6):689-705. DOI: 10.1016/j.jscs.2014.09.001

[16] Kassal P, Steinberg MD, Steinberg IM, Wireless chemical sensors and biosensors: A review. Sens Actuator B-Chem. 2018;266:228-45. DOI: 10.1016/j.snb.2018.03.074

[17] Perez-Guaita D, Sanchez-Illana A, Ventura-Gayete J, Garrigues S, de la Guardia M, Chemometric determination of lipidic parameters in serum using ATR measurements of dryfilms of solvent extracts. Analyst. 2014;139(1):170-8. DOI: 10.1039/c3an01057k

[18] García-García JL, Pérez-Guaita D, Ventura-Gayete J, Garrigues S, de la Guardia M, Determination of biochemical parameters in human serum by near-infrared spectroscopy, Anal Methods. 2014;6(12):3982-3989. DOI: 10.1039/c3ay42198h

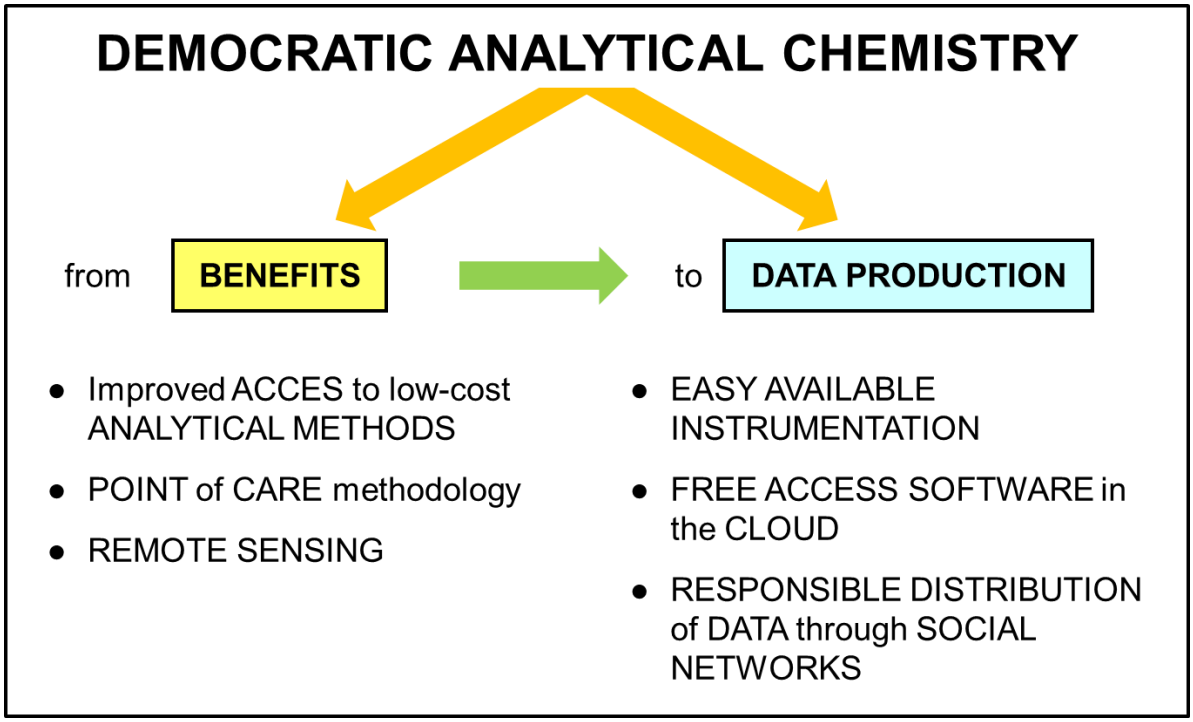

Figure 1. Concept of Democratic Analytical Chemistry

Table 1. Risks of Democratic Analytical Chemistry and the ways to avoid their bad effects.

Risk	Corrective action
Lack of representative data	Importance of analytical chemistry education
Unexperienced data acquisition	Improved education
False data distribution	Self control & policy
Misuse of true data	Critical attitude of data receptors
Irresponsible distribution of non-rigorous data	Social responsibility