Brazilian Journal of Analytical Chemistry
2020, Volume 7, Issue 28, pp 8-10
doi: 10.30744/brjac.2179-3425.point-of-view-crtarley-N28

POINT OF VIEW

Analytical Chemistry and Materials Science: The Perfect Symbiosis to Improve Existing or New Methods

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A simple definition of analytical chemistry is a difficult task due to its broad scope in science. However, one of the most accepted definitions is “the art and science of determining the composition and structure of matter, by using knowledge of chemistry, statistics, computers and instrumentation” [1]. Of course, misleading definitions can be found by some scientists, which suggests that analytical chemistry is the simple application of chemical knowledge. If this is true, any chemist who makes qualitative and quantitative measurements can be considered an analytical chemist, a honest mistake. Hence, analytical chemistry may also be defined as what analytical chemists do, i.e., studies are performed to develop new analytical methods or to improve already established methods in order to solve analytical problems with different kinds of samples with outstanding precision, accuracy, detectability, selectivity, low cost, and less time.

Over the years, new analytical methods and techniques have been based on chemistry concepts and instrumentation involving optical, electrochemical, and separation phenomena. Classical colorimetric methods, analytical methods using bare electrodes, such as mercury, gold, carbon, and platinum, and atomic spectroanalytical techniques have been widely exploited by analytical chemists. However, until recently, analytical difficulties and challenges hold on, such as chemical speciation studies, analysis of biological samples without matrix effects, enantiomeric analysis, and analysis without sample pretreatment, which require deeper and broader knowledge of the analytical chemist. In this sense, connecting materials science research with analytical chemistry has increased, and this is key to improving new or existing techniques for overcoming analytical challenges [2,3]. Notwithstanding, in my opinion, analytical chemists should expand their knowledge in materials science to avoid mere application without scientific rigor. The ability to control the physico-chemical properties of materials by studying different synthesis processes, as well as minimum knowledge of characterisation tools, are highly recommended for better insight into the structure and applicabiltiy of materials for analytical purposes. Considering that the analyses are carried out at the molecular level, the physico-chemical nature of elements, the material morphology, and the kind of interface of materials as signal transducer of sensors or in chromatography stationary phases facilting selective partition also are parameters that play a crucial role to overall performance of analytical techniques. Additionally, it is highly necessary to understand a set of techniques, such as Fourier Transform-Infrared (FT-IR), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), X-ray Diffraction, Thermogravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), Nuclear Magnetic Resonance (NMR), X-ray Photoelectron Spectroscopy (XPS), Atomic Force Microscopy (AFM), elemental analysis, porosimetry, etc.

Cite: Tarley, C. R. T. Analytical Chemistry and Materials Science: The Perfect Symbiosis to Improve Existing or New Methods. *Braz. J. Anal. Chem.,* 2020, *7* (28), pp 8-10. doi: http://dx.doi.org/10.30744/brjac.2179-3425.point-of-view-crtarley-N28

In Brazil, the number of research groups composed of analytical chemists developing stationary phases for chromatographic applications, new material-based optical and electrochemical electrodes, and solid-phase-extraction-based methods has been increasing. A wide range of materials can be cited, such as carbon-based nanomaterials, including carbon nanotubes, black carbon, and graphene; metallic nanoparticles; chemically imprinted polymers; hybrid materials; metallic quantum dots; carbon quantum dots; magnetic particles; metal–organic frameworks; and others. Several successful studies have been carried out by Brazilian analytical chemists for the analysis of complex samples. In the study reported by Barbosa et al. [4], oxidised carbon nanotubes covered with layers of bovine serum albumin, so-called restricted-access carbon nanotubes (RACNTs), were employed to preconcentrate Pb^{2+} directly from untreated human blood serum while excluding all serum proteins, with further metal determination by Thermospray Flame Furnace Atomic Absorption Spectrometry (TS-FF-AAS). Suquila and Tarley [5] synthesised restricted-access copper-imprinted poly(allylthiourea) for the preconcentration of Cu^{2+} from milk samples using an Flow Injection Analysis-Flame Absorption Atomic Spectrometry (FIA-FAAS) system. Such methods, which were the first to show the development of restricted-access adsorbents for metal ions, are characterised by minimal sample manipulation, cost-effectiveness, and simplicity. Wong and co-workers used a graphite pencil electrode modified with palladium nanoparticles (PdNPs) for the simultaneous determination of tryptophan, carbendazim, and direct yellow 50 in environmental and biological samples [6]. The PdNPs improved the simultaneous and sensitive determination of analytes in environmental and clinical samples. Studies focused on the synthesis of hybrid monolith columns for capillary liquid chromatography, with good mechanical properties, stability in a wide pH range, and little swelling effect, have been reported [7]. Carbon dots synthesised from citrate have been used as a fluorescent probe for quercetin determination in tea and beer samples [8]. Simplicity, high selectivity towards possible interferences that could affect the analysis in real samples, and high sample throughput were the highlights of the proposed method. These examples show that different classifications of materials have triggered the development of new analyses with outstanding analytical performance, and Brazililan scientists have greatly contributed to the development of new knowledge.

In conclusion, in my opinion, it seems clear that materials science must be greatly exploited as a frontier of chemical and analytical chemistry knowledge, but commonly, and as expected, analytical chemists have been the protagonists. Thus, by being a multidisciplinary science, collaborative studies involving material scientists and analytical chemists should be encouraged.

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