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Review Article

An Over View of Recent Advances in Analytical Instrumentation.

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ABSTRACT

The major revolution in analytical chemistry was observed between the years 1920 and 1950. Within this period major changes in natural science were observed due to the advancement in the analytical instrument. Prior to 1920 analytical chemists determine the chemical composition of unknown substances by performing a series of chemical tests with known compounds and observing the kind of reaction they underwent. After 1950 different varieties of analytical instruments advised and were used by the chemical analyst for the determination of the chemical constitution of unknown compounds. Analytical instruments determine the chemical constitution by the decrementing physical properties of the constituent. Analytical instrumentation is the backbone of scientific research and the overall development of scientific research in many developing countries. Since from last many decades there is a tremendous advancement in the analytical instruments were done with the help of science and technology. Many problems related analysis and identification is solved with the help of advanced analytical instruments such as spectrophotometers, flame photometers, turbidimeters, colorimeter, mass spectrometer, NMR instrument, conductometer, potentiometer, polarography, atomic force microscope, X-ray, electron microscopy. Chromatography and distillation are widely used separation techniques in the various branches of science. In the present study, an overview of some widely used instruments and their application in the various branches of science were mentioned.

KEYWORD

Analytical instruments, spectrophotometers, flame photometers, chemical constitution.

1. INTRODUCTION

The major revolution in Analytical chemistry was observed between the years 1920 and 1950. Within this period major changes in natural science were observed due to the advances in the analytical instruments. Before 1920 analytical chemists determine the chemical composition of the unknown substances by performing a series of chemical tests by the treating with known compounds and observing the chemical change they underwent. After 1950 different varieties of analytical instruments invented and were used by the analytical chemist for the determination of the chemical constitution of unknown compounds by discriminating the physical properties of the chemical constituent [1]. In medical science, the body fluids are also analyzed by using different advanced instrumental methods such as urinalysis[2-3].

Davis Baird et al[4] described the revolution in analytical chemistry and instrumentation. Advances in the instrumentation were done to solve the many problems regarding the qualitative and quantitative analysis. Instrumental methods of analysis did not involve the changes in theory but change the practice of analytical chemistry. Instrumental analysis is depending upon the sample required for the analysis, the time necessary for the analysis and the precision/ accuracy with which trace quantities could be analyzed. Philosophers typically think of knowledge as a kind of belief. Instruments are not a kind of belief and hence cannot be a kind of knowledge. Philosophers express themselves in word, and so it is not surprising that they characterize scientific knowledge in the terms with which they are familiar.

Historically scientist's natural philosophers were born of philosophers. According to 'Ian Hacking's' modern science is the result of a collaboration of doing and thinking. The doing has always been understood in a subservient or instrumental role. 'Joseph Priestley' was interested in building new instruments to create new phenomena and thereby to express the fullness of nature. But Priestley is usually remembered as the suborn backward scientist who restricted Lavoisier's brilliant theoretical insights concerning, oxygen, phlogiston, and combustion.

The revolution in Analytical Chemistry is important with it we have widespread recognitions that building a new instrument can teach us about the world just a devising a new theory can.

Instrumentation emerges as a vehicle to carry knowledge.

1.1. Need for advances in Analytical Instrumentation

1. For the achievement of good accuracy and precision.
2. Analysis of very less quantity of analytical sample.
3. To reduce tedious time consuming analytical steps.
4. To reduce the quantity of working personnel.
5. To carry out analysis of less quantity of sample.
6. To analyze the trace quantity of elements.
7. The increased concern over the spread of viruses such as acquired immune deficiency syndrome (AIDS).
8. An intensified quest for new drugs by pharmaceutical companies.
9. A proliferation of environmental concerns and regulations.

10. Strong demand overseas for high-technology, high prolific instrument.

11. The environmental and pharmaceutical market offered the strongest growth domestically but demand from food processing biotechnology and chemical industries remained relatively healthy.

1.2. History of the development of Analytical instrumentation

In 1906 'John Muter's' described short manual of Analytical Chemistry for gravimetric and volumetric methods of analyses. Muter includes one eight-page chapter on alternative methods. He discusses analysis by circular polarization with saccharometer, spectrum analysis with Hempel's gas measuring apparatus. Rudimentary analytical instruments and measuring devices predate the birth of Christ. Naturalist Robert Boyle of England was credited with introducing the term "Analysis" in the chemical science in his book Sceptical Chemist published in 1661. In 1661 Isaac Newton conducted a light spectrum experiment that eventually led to the development of spectroscopy. Also in the seventeenth century, the first precise gravimetric analysis equipment for measuring specific gravity was believed to have been created by Friedreich Hoffman, a German physician, and chemist. Numerous key inventions and discoveries during the eighteenth century include the flame test for alkali metals, quantitative analysis techniques, and titrimetric analysis[5-8].

Most instrumental methods before the eighteenth century yielded qualitative analysis. In the nineteenth century, however, French chemist Antoine Laurent Lavoisier unshared in quantitative analysis or the determination of the amounts and proportions of chemicals or elements in substance or gas. A breakthrough in analytical instrumentation and methods during the 1800s included electrochemical analysis methods and gas analysis. Besides, German chemist Gustav Robert Kirchhoff and Robert Bunsen introduced the first practical Spectroscope in 1859[9]. This important development led to the discovery of the new element. Spectrographic instrument improved greatly during the late 1800s and early 1900s with the introduction of mass spectrography [10], in 1919 flame photometry, in1928 and radiochemical method developed after world war-II.

The greatest innovations in the history of industry related to the development of chromatography, although first conceived in 1903, workable chromatography instrument was not built until the early 1940s. Gas chromatography and other advanced techniques that emerged during the 1950s significantly expanded the breadth of the analytical instrument industry. This pivotal innovation combined with steady market growth during the post-world war-II economic expansion resulted in healthy revenue gains for instrument manufactures the United States global technological led that it enjoyed throughout the 1960s and 1970s. The true instrumental method of analysis includes no reduction of data to normal pressure and temperature no corrections or computations, no references to correction factors or interpolation on monographic charts. There is more building an instrument that knowing the basic principle methods of analysis. This something more made the difference between instrumentation and analytical theory. Muller advocated a

science of instrumentation with its departments in universities. In November 1949 Muller wrote "is there a science of instrumentation[11].

Bunsen in 1860 invention of spectrochemical identification but the revolution in analytical chemistry is not simply the result of the development of spectrochemical methods. The revolution in advances in instrumentation is the development of physically-based instrumental methods would improve the abilities of the analytical chemists. 'Kuhn' has described the rise in importance of physics, as the second scientific revolution[12]. This second revolution must be a different sort of beast in Kuhn's mind. Ian Hacking has developed this idea further in his discussion if the probabilistic revolution. Hacking uses Hebert Butterfield's language: big revolutions are accompanied by a change in our sense of the texture of the world in a different fell for the world.

Instruments are providing a different texture of the world. In 1948 editorial in Analytical Chemistry, Walter Murphy describes and addresses, H.V. Chirchill were modern objective methods of analysis are identified with instrumental methods of analysis. This is a general phenomenon obstetrician used to use a variety of low tech hands-on means to follow the development of a fetus. Now in many cases, an obstetrician is more likely to be touching the transducer of an ultrasound imaging instrument than that belly of pregnant women. Ultrasound provides, as I have been told the objective gold standard with which follows fetal development. Instrumentation has become one of the important standards for objectivity and in so doing it has become one important channel for the expression and development of scientific knowledge[13].

Major technological trends in the mid-1990s include the proliferation of combined equipment such as single units that integrated both chromatograph and spectrometer functions smaller instruments particularly portable environmental field equipment increased quality, precision, and growth information system and robotics was evidenced by rising installations of laboratory information management system(LIMS), as well as growing demand for automated sample preparation system for biopharmaceutical applications. A new system introduces in 1993, for example, handled multi sample preparation tasks was operated by windows based personal computer software for easy use. Several other automation and robotics systems offered by companies such as CRS plus Inc. and Zymark Inc. were aimed at relatively inexperienced user that wanted to conduct complex sample preparations and analysis.

Similarly, manufacturers were also introducing easier to use chromatography and mass spectrometry devices advanced systems automatically optimized and turned themselves during operations, thereby eliminating much of the practice and guesswork associated with conventional instruments. Besides, many newer instruments combined up to three major functions into one unit. In 1997 MEMS also known as micro-electrochemical systems began to make their appearance with the promise of an impact as profound as the microchip many small American companies are bringing new MEMS applications to the market. In December 1999 Beckman Coulter and third-wave technologies announced a high throughout automation platform that provides researchers access to an automated nucleic acid analysis platform for SNP (single nucleotide polymorphism) SNPs have differences in genetic codes that account for variations

among people and are believed to determine susceptibility to many diseases and individual responsiveness to treatment.

1.3. Advanced Analytical instrumental Techniques: their Invention and Applications

1. **Spectroanalysis (Spectroscope)**
   In1840s Robert Wilhelm Bunsen (1811-1899) introduced sector analysis and the concept of molar extinction coefficient this led to the development of the spectroscope in 1860 was established for detecting the various spectrogenic pigments in blood further this is used for determination of constituent in chemical composition[14-15].
2. **Colorimetry (Colorimeter)**
   Introduction of colorimetry marked a major turning point in analytical development the first colorimeter designed by Jules Dubosq (1817-1886) in France, became available in 1854 and was used initially to measure caramel in syrup Dubosq colorimeter was first visual colorimeter. There are three types of colorimeter versions namely the Plunger, the wedge, and the dilution type. In the plunger colorimeter, the intensity of the color of either standard or unknown was varied by changing the depth of solution that was inversely proportional to their depth when the color-matched. In wedge type of colorimeter was then moved up and down until the color intensity matched of unknown. In the case of the dilution type of colorimeter, the unknown solution was diluted until it matched the standard. Another colorimeter was introduced by Joseph Lovibond in 1890. Which is used for standardizing the color of the beer[16].
3. **Photometer**
   Introduction of photoelectrical cells that subjective very ability in colorimetry was removed. The early photoelectric colorimeters such as the sheared and Stanford filter photometers are designed in 1933, the Evelyn photometer of 1936 and the Leitzphotometer dated 1937, used colored filters to isolate narrow range wavelengths. Further advancement in technology led to the development of a spectrophotometer. The use of prism or diffraction grating in these instruments enabled the measurement of optical densities in a continuous sequence over the whole range of the spectrum. The first spectrophotometer was invented by Beckman DU described by Carey and Beckman in 1941. This is used for measuring optical densities in both the ultra-violet and infrared region.
4. **Bunsen Burner**
   The Bunsen burner is a type of widely used heating device in laboratories; it was designed by British Chemist and physicist Michel Faraday (1791-1867). It was invented by Robert Bunsen in 1855. The Bunsen burner was a short vertical tube of metal perforated at the bottom to admit air and connected to a gas source. The flow of air was controlled by an adjustable collar on the tube.

5. **Absorption and Emission Spectroscopy**
   Emission spectroscopy is introduced by John Frederick William Herschel in the 1820s. This technique is used to identify elements using the characteristic spectra of their free atoms. Similarly, in 1802 William Hyde Wollaston (1766-1826) to be the result of absorption by gases although it was not until 1860 that this phenomenon could be fully explained by Robert Bunsen and Gustav Robert Kirchhoff (1824-1827). This was the first example of absorption spectroscopy. Emission spectroscopy was thus finally translated into an analytical tool in 1929 when Henrik Gumar Lundgardh (1888-1969) introduced the flame photometer which was used to estimate certain elements.
6. **Electrophoresis**
   The moving boundary electrophoresis apparatus is devised in 1937 by Arne Wilhelm Tiselius and used for the study of proteins. It consists of rectangular sectional quartz U-tube provided with an optical system that displaces the migration proteins in the electrical field.
7. **Electroanalytical Techniques**
   The glass pH electrode was discovered in 1909 by Max Cremer (1865-9935) which is used for the measurement of pH. In 1912 Karl Albert Hasselbalch and Christen Lundsgaard used hydrogen electrode for the measurement of pH. In 1954 by Richard Stow basically, this was a pH electrode covered by a thin electrolyte layer separated from the sample by an insulating carbon dioxide permeable membrane usually made up of Teflon[17].
8. **Polarography**
   The polarography was invented by Leland C Clark in1953 to the accurate and easy determination of oxygen tension in liquid. The previous method using dropping- mercury electrode polarography which is pioneered in 1925 by Jaroslav Heyrovsky (1890-1967) and improved upon in 1942 by Henry Knocoler Beecher (1904-1976).
9. **Chromatography**
   The chromatography was devised by Russian botanist Mikhail Tsvett (1872-1919). As an absorption chromatography as long ago as 1906 for the separation of plant pigment into their constituents. Results into the number of color bands on his column of calcium carbonate were due to the absorption of chemicals[18]. Ion-exchange chromatography was introduced in 1936 by Adams Holmes and used for the separation of ions. Partition chromatography was developed by Archer Jon Porter Martin and Richard Laurence Millington Synge in 1941. Paper chromatography was introduced in 1944 by AJP Martin and coworkers used to separate amino acid. Thin Layer chromatography was introduced in the early 1950 century by Mottier and his colleagues the technique and apparatus were developed by E Stahl in 1965. In 1952 AT James and AJP Martin developed gas-liquid chromatography to achieve better separation of volatile fatty acids[19].

10. Radiochemical Techniques

In 1895 the cloud chamber was invented by Scottish physicist Charles Thomson Rees Wilson (1869-1959). In this instrument charged particles of gamma rays were passed through a glass container filled with moisture saturated air; the ionized atoms in the path of these rays or particles created vapors tracks which could easily be viewed utilizing cross lightning. The characteristic of these radiations could be assessed by studying the pattern of vapor tracks which could their behavior in magnetic fields. Spinthariscope invented by William Crooks in1903. In this device, the tiny light flash scintillation produced by the impingement of radioactive emission on a zinc sulphide screen could be viewed individually with a low power microscope. Rutherford and Wilhelm Hans Geiger (1882-1952) in 1908 these devices filed with inert gas are designed to capture and measure the ions produced by radiation entering the detector. In 1950 Kallmann also discovers the possibility of liquid scintillation counting when he observed that the solution of certain organic materials such as anthracene was efficient enough to serve as scintillator [20].

11. Mass Spectroscopy

Mass spectrometer was developed in 1919 by the British Physicist and Nobel Laureate Frances William Aston (1877-1945) used for the determination of molar mass and molecular ion peak of an unknown compound.

Similarly, the other numbers of instruments are devised such as NMR Spectroscopy, Atomic Force Microscopy, Electron microscopy, Conductometry, Potentiometriy, Turbidometry, coulometry which are used in the chemical analysis.

2. CONCLUSION

There is the number of advanced instruments and techniques that were advised from time to time in a field of Analytical Chemistry which turns great revolution in the natural Science and respected branches of science. Due to Advancement in analytical instrumentation, one can achieve the greatest accuracy and precision in qualitative and quantitative analysis. With the advancement in analytical instrumentation which is benefited every branch of science such as medical science, environmental science, pharmaceuticals, and industries which are direct benefits society?

3. REFERENCES

1. Skoog, D. A., Holler, F. J., & Nieman, T. A. (2003). *Principes d'analyse instrumentale*. De Boeck Supérieur.
2. Baird, G. Urinary Deposits, Their Diagnosis, Pathology and Therapeutic indications, 2nd edn London; 1846.
3. Bush, R.B. Urine is a harlot or liar JAMA 1969; 208; 131-4.

4. Baird, D. (1993). Analytical chemistry and the 'big'scientific instrumentation revolution. *Annals of Science*, *50*(3), 267-290.
5. Clark, B.L. (1947). Editorial; "what is Analysis?" Industrial and Engineering Chemistry, Analytical Edition, 19, 822.
6. W.C. Mccrone, 'Editorial: The role of Analyst" Analytical Chemistry, 20(1948), 2-3.
7. Ostwald, W. The Scientific Foundation of Analytical Chemistry, Translated by McGowan (London, 1895; First German edition, 1894).
8. Ewing, G.W. Instrumental Methods of Chemical Analysis, Third Edition (New York, 1969; first Edition1954) p-1.
9. Kirchhoff, G.R., Bunsen, R.W.E. Chemishe Analyse Durch Spectra Beabachtumgen Leipzing; Engelmann; 1860.
10. Hasler, M.F. 'The Practice of Arc Spectrochemistry with a Grating Spectrograph'; in Harrison1938.
11. Muller, R. 'Monthly Column; Instrumentation in Analysis; Industrial and Engineering Chemistry, Analytical Edition, 18 (1946) 25A-26A.
12. Brush, S. The History of Modern Scientific Revolution; 1800-1950(Ames, Iowa, 1988).
13. Murphy, W. 'Editorial; Modern Objectivity in Analysis' Analytical Chemistry, 20(1948), p-187.
14. Olukoga, A. O., Bolodeoku, J., & Donaldson, D. (1997). Laboratory instrumentation in clinical biochemistry: an historical perspective. *Journal of the Royal Society of Medicine*, *90*(10), 570-577.
15. Walker, J.T. 'The Spectrograph as an Aid in Criminal Investigation'; In Harrison (1939) p-1-5.
16. Skeggs, L. T. (1957). An automatic method for colorimetric analysis. *American journal of clinical pathology*, *28*, 311-322.
17. MacInnes, D.A., Belcher, D.A. Durable glass electrode, IndEngChem Anal Ed1933; 5; 199-200.
18. Lines, J.G. 'A Chronicle of Development of Clinical Chemistry'. IFFC Newsletter 1977; 18; 3-9.
19. Ettre, L. S., & Zlatkis, A. (2011). *75 years of chromatography: a historical dialogue*. Elsevier.
20. Hine, G. J. (1977). The inception of photoelectric scintillation detection commemorated after three decades.