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A REVIEW ON INTRODUCTION TO ANALYTICAL CHEMISTRY AND APPLICATIONS OF VARIOUS ANALYTICAL TECHNIQUES

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ABSTRACT

Analytical chemistry studies and uses instruments and methods to separate, identify and quantify matter. Qualitative analysis identifies analytes, while quantitative analysis determines the numerical amount or concentration. It has been important since the early days of the chemistry, providing methods for determining which elements and chemicals are present in the object in the question. The first instrumental analysis was flame emissive spectrometry developed by Robert Bunsen and Gustav Kirchhoff who discovered rubidium (Rb) and cesium (cs) in 1860. In this review we will know about the introduction to analytical chemistry and its applications.

KEYWORDS: Analytical chemistry, analytes, flame emissive spectrometry, Robert Bunsen. rubidium. cesium.

INTRODUCTION

Analytical chemistry plays an important role in the measurement of drugs and metabolites in the field of pharmaceutical sciences. Analytical chemists assess the chemical structure and nature of substances. Their skills are needed for a variety of purposes including drug development, forensic analysis and toxicology. Analytical chemistry is an important tier of environmental protection and has been traditionally linked to compliance and exposure monitoring activities (or) environmental contaminants.

Classification of Analytical Techniques

The analytical method is a generic process combining the power of scientific method with the use of formal process to solve any type of problem.

- Classical methods
- Instrumental methods

Classical methods

- Classical methods/ instrumental methods/ earliest methods of analysis, relied mainly on chemical properties of analytes.
- Analytes are treated with reagents to form products that could be identified. Gravimetric and titrimetric methods were used for quantitative analysis.

Examples:

- Formation of precipitate and measurement of mass.
- Oxidation of analyte and detection of endpoint via the change of color of the analyte.
- Neutralization of the analyte and detection of endpoint using acid-base indicator.
- Complexation of analyte and use of metallochromic indicators to detect endpoint.

Instrumental methods

- Instrumental methods largely rely on physical properties of the analyte, thus generally are not destructive.
- They are not necessarily more sensitive.
- Separation methods
  - Chromatography
  - Electrophoretic

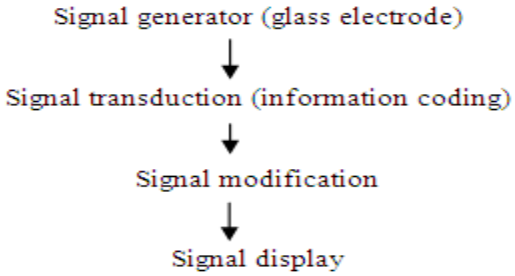
Classification of instrumental methods based on properties

Characteristic properties	Instrumental methods
Emission of radiation	Emission spectroscopy (x-ray, uv, visible, electron, auger) Fluorescence Phosphorescence Luminescence (x-ray, uv, visible)
Absorption of radiation	Spectro photometry and photometry (x-ray, uv, visible), Photo acoustic spectroscopy, Nuclear magnetic resonance, Electro spin resonance spectroscopy.
Scattering of radiation	Turbidimetry, Nephelometry, Raman spectroscopy
Refraction of radiation	Refractometry, Interferometry

Diffraction of radiation	x-ray, Electron diffraction methods
Rotation of radiation	Polarimetry, Optical rotatory dispersion, Circular dichroism
Electric potential	Potentiometer, Chrono potentiometer
Electric charge	Coulometer
Electric current	Polarography, Amperometry
Electrical resistance	Conductometer
Mass	Gravimetric (quartz crystal microbalance)
Mass-to-charge ratio	Mass spectrometer
Rate of reaction	Kinetic methods
Thermal characteristics	Thermal gravimetric, Titrimetry, DSC, DTA, Thermal conductometric methods.

Measurment Process and Domain

Measurment Process



Information is encoded, processed, transferred, decoded and displayed.[1]

Applications of various analytical techniques

Spectroscopic techniques

- Fat and fatty acids are important quality parameters of daily food characterizing their nutritional values. Conventional methods for determining fats and fatty acids content of dairy foods are time consuming, laborious, destructive to samples and often requiring use of hazard solvents, which makes it impossible for real time and online measurements. The spectroscopic techniques based on near-infrared spectroscopy (NIRS), Raman spectroscopy, Nuclear magnetic resonance (NMR), have been studied extensively for fat and fatty acids analysis of daily foods.[2]
- Proteins are essential nutrients required for various body functions and normal human life. Diverse modification techniques are usually employed to improve their performance in food products. Protein modification is essential for obtaining optimal functionalities. The relationship between protein conformation and functionality is described by Fourier transform infrared, Raman spectroscopy, circular dichroism, fluorescence, ultraviolet spectroscopy are introduced for monitoring conformational changes that occur during physical, chemical or enzymatic modification of proteins.[3]
- A standoff laser spectroscopy sensor based on a broad band tunable external cavity quantum cascade laser (ECQLL) and a piezo electric effect based detector was developed for simultaneous detection of multiple chemicals. This technique is used for the detection of leak plumes in security fields.[4]
- Paper was the main material for recording cultural achievements all over the world. Paper is mostly made from cellulose with small amount of organic and inorganic additives, which allow its identification and characterization and may also contribute to its degradation.
  The following are the spectroscopic techniques used for paper characterization and conservation are Fourier transform infrared spectroscopy, Raman spectroscopy, nuclear magnetic resonance spectroscopy, x-ray, laser-based spectroscopy, inductively coupled mass spectrometry.[5]
- Nuts and dried fruits contain rich nutrients and are thus highly vulnerable to contamination with toxigenic fungi and aflatoxins because of poor weather, processing and storage conditions. The current developments and applications are frequently used for food safety testing techniques.
  The techniques used are near infrared spectroscopy (NIRS), mid-infrared spectroscopy (MIRS), conventional imaging techniques like color imaging (CI), and hyper spectral imaging (HIS), and fluorescence spectroscopy and imaging.[6]
- Recent advances in nanotechnology have opened a lot of new possibilities for nanomaterial application in wide variety of industrial, pharmaceutical, medicinal and environmental applications. Characterization of nanomaterials using FTIR micro spectroscopy, scanning probe microscopy was also used.[7]
- Spectroscopy also focuses on some ancient pottery shreds. Analytical characterization using Fourier transform infrared spectroscopy (FTIR), x-ray diffraction (XRD), and differential scanning colorimetric coupled with thermo gravimetric

analysis. It also identifies the mineralogical composition of pottery samples.

TGA was applied in order to study the dehydration of hygroscopic water and decomposition of carboxyl group in the powdered pottery samples during heating.[8]

- Non- proliferation of nuclear materials is important in nuclear power industry and fuel cycle factories. It requires technologies capable of measuring and assessing the radiation signatures of fission events. The neutron energy information allows characterization of nuclear materials and nuclear sources. The plastic scintillator EJ-299-33A was studied as a fast neutron detector.[9]
- Stand- off , insitu, laser induced breakdown spectroscopy (LIBS) offers a rapid, safe and cost effective method for discrimination of radioactive waste material, arising during the operation of nuclear planta and from decommissioning activities.

  Graphite has been extensively used as a moderator material in many nuclear reactors. A new analysis workflow comprising the examination of spectral characteristics, multi variate analysis and molecular isotopic spectroscopy is proposed to enable rapid segregation of graphite from a heterogeneous waste stream.
- Plastic pollution is ubiquitous in aquatic environments and its potential impacts to wildlife and humans present a growing global concern. The challenges faced in this field largely relate to the methodological and analytical limitations associated with studying plastic debris at low concentrations. The radio tracing techniques are used for assessing the micro plastic at realistic concentration.[10]

Chromatographic Techniques

- Micro extraction techniques are widely applied for sample preparation to gas chromatographic analysis of target compounds in samples with a complex matrix recently, needle-based micro extraction techniques have been developed in order to improve the performance of the extraction .due to small size, needle devices may be applied for work place exposure monitoring.[11]
- Excipients are pharmacologically inert substances; still they are integral and significant ingredients of a pharmaceutical formulation. Their amount and concentration level along with the active pharmaceutical ingredients of utmost importance to decide the pharmacokinetics and stability of a dosage form. They include capillary electrophoresis, static head space capillary gas chromatography, gel permeationchromatography. Chemometric techniques in quality control of pharmaceutical excipients.[12]
- Parabens have been widely used as antimicrobial preservatives in food, drugs and cosmetics for over 60 years determining this with the help of LC-MS/MS Techniques mainly in milk of lactating women.

These compounds in human milk is important because of breast milk plays an important role in infants growth and in neurocongnitive development. State of the art of the chromatographic techniques that is available for the analysis of parabens in the breast milk samples.[13]

- Plasmid DNA Vaccines have gained tremendous attentions in the last few decades as a modern approach of vaccination. The techniques include affinity chromatography hydrophobic interaction chromatography, ion exchange chromatography, ion exchange chromatography and miscellaneous chromatographic methods.[14]
- Various chromatographic techniques such as size exclusion, ion exchange, hydrophobic interaction and affinity chromatography. These developments in the chromatographic techniques lead to the isolation of inclusion bodies, solubulisation and refolding to obtain bioactive protein.[15]
- A Newly developed thin layer chromatographic (TLC) method coupled with fluorescence detection for specific determination of febuxostat (FEB) was designed. Here the determination of the studied drug in real human plasma and urine sample in presence of its metabolites.[16]
- Chromatographic method is used for the quality control of drug derived from herbs.
- Chromatographic method, in combination with chemo metrics, are usually developed and applied throughout the food chain to verify the nature or origin of food, with both targeted (metabolomics) and non-targeted (profiling) approaches.[17]
- The full analytical characterization of therapeutic monoclonal antibodies requires a large variety of complementary information that can be obtained by chromatographic methods. Other techniques such as reverse phase liquid chromatography (RPLC) and hydrophilic interaction chromatography (HILIC) are also used.[18]
- Gas chromatography - mass spectrometer technique was used for the determination of homocysteine thiolactone in human urine.[19]

Electro Analytical Techniques

Conductometry

Some water insoluble or sparingly soluble substances such as Agcl, Baso4, they cannot determine their solubility by any chemical method. So extremely, small solubility of a substance can however be determined with the help of conductance measurement. Determining ionic product of water and basicity of an acid .it is used to measure the progress of chemical reaction .conduct metric titration is carried out in order to measure the electrical conductivity of the reaction mixture.

Potentiometry

It is used to determine the total organic carbon content of soil. It is one of the widely used methods to determine the content of certain ions in a solution, but have not been widely applied to the analysis of soil samples. They are useful in titration with non-aqueous solvents.

Polarography

This technical is useful to determine

- Hormones
- Antibiotics
- Alkaloids
- Dissolved O_2 and peroxides
- Trace metals
- Metal containing drugs
- Antiseptics and insecticides
- Vitamins
- Blood serum and cancer diagnosis

Amperometry

- Food analysis. L-ascorbic acid content was analyzed in fruit juices and effervescent tablets, by a biosensor

Thermo analytical methods

- It is commonly used method for analytical and enthalpy change determination. The application of these techniques includes also the determination of reaction stoichiometry and the determination of any of the thermodynamic quantities of Δh, Δg, and Δs.
- Aromatic sulfonic acid and amides are converted by $NaClO_4$ to monochloroamines in neutral or alkaline solutions, by making use of this technique.[20]

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