

Innovative Approach of Spectroscopic Techniques in Chemical Analysis

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ABSTRACT: Spectroscopy is a general term used within analytical chemistry and some branches of physics that encompasses a wide range of analytical techniques involving probing atoms and molecules with radiation and seeing how they interact. Ordinarily, emission spectrochemical analysis is applied to the qualitative and quantitative determination of metallic elements, but it is not restricted to them. The method is among the most sensitive of all analytical methods: a few milligrams of a solid sample usually suffice for the detection of metallic elements present to the extent of a few parts per million or less. In addition, the method is capable of detecting several atomic species simultaneously, thus obviating chemical separations. In general, a molecule, part of a molecule or an individual atom can absorb, emit or transmit certain frequencies of radiation within the electromagnetic spectrum. Spectroscopy is the process of exposing a substance to some form of radiation, or gathering radiation emitted by the object, and then analyzing that radiation to gather information about the properties of the substance. Different kinds of radiation provide different kinds of information and are used to analyze different kinds of substances. The frequencies that are absorbed or transmitted can then give information on the structure and identity of sample being examined. In this paper is important as it is impossible to "see" atoms and molecules with the light visible to the human eye. The scale and use of spectroscopic techniques is huge and can be even used to obtain the chemical composition of stars and planets that are light years away and with more accurate, powerful and high resolution equipment it can be used in aspects of molecular biology.

KEYWORDS: Spectroscopy, Frequencies, Radiation, Chemical Analysis

I. INTRODUCTION

Usually it is not necessary to touch the object being studied, giving spectroscopy wide use in astronomy and astrophysics. Atoms and molecules, which follow the laws of quantum mechanics, are restricted to only certain energy levels. A particular amount of energy is required to lift an atom or molecule from one energy level to another, this is known as a transition. If there is too much or too little energy, the transition does not occur, but with just the right amount of energy, the transition will occur[1]. At the same time, this remarkable scientific technique can also provide information on atoms and molecules and on even the tinier particles that make up the atom. The relationship of these facts to spectroscopy may be shown by a musical analogy. A person with a trained ear can listen to a chord (several notes played at once) and say immediately what notes it consists of. Each note in the chord can be compared with a color. If we mix several colors together, we can make another color, which we might call a color chord. But while the musical version is easily perceived using the human senses to be a mixture of specific notes, the color version is not: it just looks like a new color.

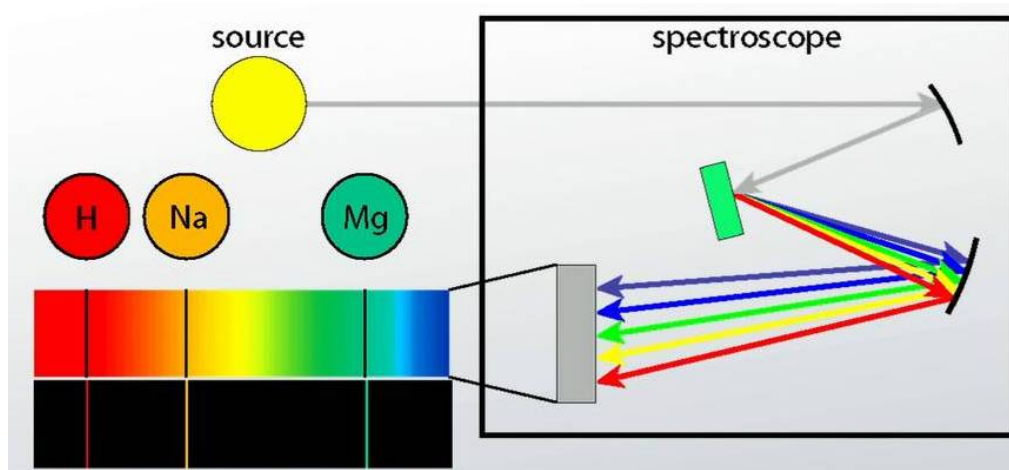


Fig.1. Spectroscopy Technique

As shown in Fig.1 spectroscopy permits the visual observation of spectra. Developed in the late nineteenth century, the term derives from two root words: the Latin spectrum, meaning “image” or “appearance,” and the Greek skopein, “to view.”

1.2. Spectrum management is the process of regulating the use of radio frequencies to promote efficient use and gain a net social benefit. The term radio spectrum typically refers to the full frequency range from 3 kHz to 300 GHz that may be used for wireless communication[2]. Increasing demand for services such as mobile telephones and many others has required changes in the philosophy of spectrum management. Demand for wireless broadband has soared due to technological innovation, such as 3G and 4G mobile services, and the rapid expansion of wireless internet services[3].

In a simple spectroscopy, light rays enter through a slit and are forced to be parallel by a collimating lens. A prism then disperses the light, which is then focused by a lens. In this system red is dispersed the least, violet most. Instruments that record spectral images on photographic plates or in computer memory, spectrographs, are found on most large telescopes. The most experienced color expert can't tell what colors went into it simply by looking. What is needed is an instrument that has the capacity to analyze or separate out the different colors in the mixture (elements in the color's spectrum)[4].

II. TYPES OF SPECTROSCOPY BY ENERGY LEVEL

The electromagnetic spectrum stretches from low energy (low frequency) radio waves to high energy (high frequency) X-rays or gamma rays. Different levels of energy have different effects on atoms and molecules, for example lower energies affect only molecular vibrations, higher energies directly affect electrons[5]. If, instead of using an eyepiece or recording device, we use a photoelectric cell to measure how much of each color appears, the instrument is called a spectrometer (from the Greek metron, “measure”). In this case, however, the prism is rotated so that only a narrow portion of the spectrum is received by the detector at any time. In some cases, the whole operation is done automatically, and the results are fed to a recording spectrophotometer, which prints a complete record of the spectrum. Such devices are used widely in analytical labs to both identify and quantify substances in solution.

As such, types of spectroscopy can be ordered according to the energy levels that they probe. That's not to say that higher is better, of course, thorough chemical analysis requires the full range of the spectrum to be used[6].

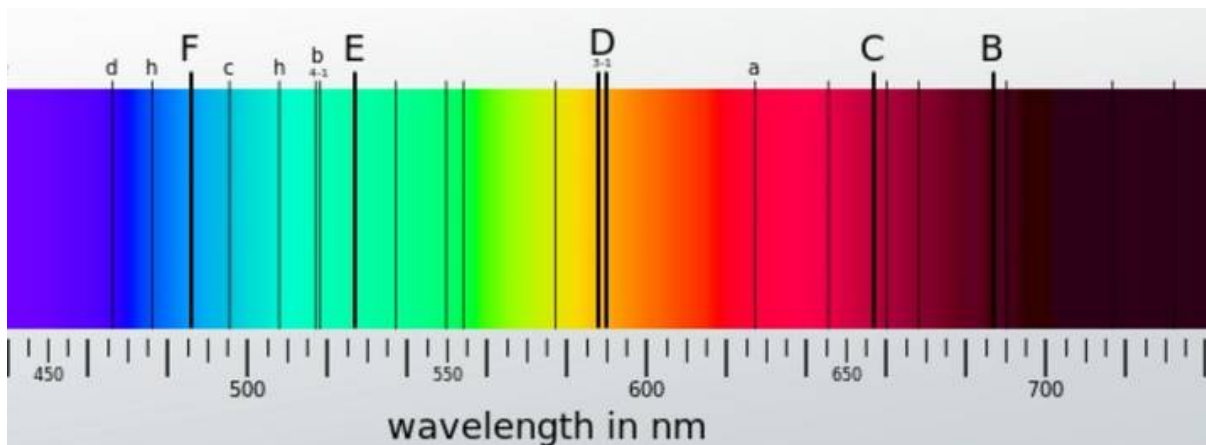


Fig.2. Electromagnetic spectrum

As shown in Fig.2 Electromagnetic spectrum, the entire distribution of electromagnetic radiation according to frequency or wavelength. Although all electromagnetic waves travel at the speed of light in a vacuum, they do so at a wide range of frequencies, wavelengths, and photon energies. The electromagnetic spectrum comprises the span of all electromagnetic radiation and consists of many sub ranges, commonly referred to as portions, such as visible light or ultraviolet radiation.

III. DIFFRACTION GRATING

In optics, a diffraction grating as shown in fig 3. is an optical component with a periodic structure that splits and diffracts light into several beams travelling in different directions. The emerging coloration is a form of structural coloration[7]. The directions of these beams depend on the spacing of the grating and the wavelength of the light so that the grating acts as the dispersive element. Because of this, gratings are commonly used in monochromators and spectrometers. For practical applications, gratings generally have ridges or rulings on their

surface rather than dark lines. Such gratings can be either transmissive or reflective. Gratings that modulate the phase rather than the amplitude of the incident light are also produced, frequently using holography. The various portions bear different names based on differences in behaviour in the emission, transmission, and absorption of the corresponding waves and also based on their different practical applications. There are no precise accepted boundaries between any of these contiguous portions, so the ranges tend to overlap[8]. The entire electromagnetic spectrum, from the lowest to the highest frequency (longest to shortest wavelength), includes all radio waves (e.g., commercial radio and television, microwaves, radar), infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays. Nearly all frequencies and wavelengths of electromagnetic radiation can be used for spectroscopy.

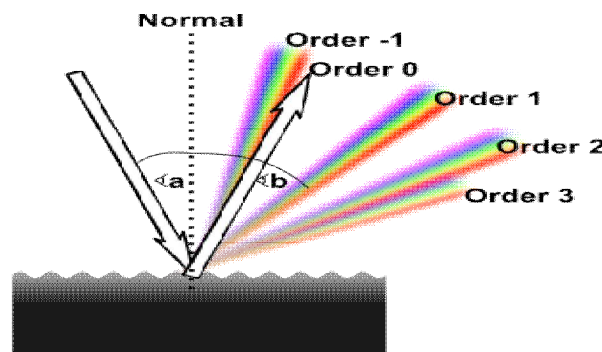


Fig.3. Diffraction Grating

What made this discovery possible was Fraunhofer's development of a different kind of dispersion device, the diffraction grating, a transparent or opaque plate inscribed with thousands of fine lines per inch. These lines break up the light rays as a prism does, but much more evenly. The result is a spectrum that displays a definite geometrical relationship between the position of the spectral line and its corresponding wavelength (e.g., a separation of 1 nm per mm on a photographic plate). Grating spectroscopes made direct determinations of absolute wavelength possible. This proved particularly useful later in the century, when scientists began to use spectroscopy to unravel the properties of atoms and molecules. Also, diffraction gratings allow much greater dispersion of light; that is, the wavelengths are spread further apart. This facilitates observation and was perhaps the most important factor in Fraunhofer's work. Prism spectroscopes are commonly used in schools and demonstrations because of their simplicity, low cost, and impressively bright spectra. Radio waves, infrared rays, visible light, ultraviolet rays, X-rays, and gamma rays are all types of electromagnetic radiation. Radio waves have the longest wavelength, and gamma rays have the shortest wavelength.

IV. CHEMICAL ANALYSIS

Spectroscopy's many guises have proved indispensable for research and analysis in all areas of chemistry as well as a variety of other scientific and technical areas. In analytical applications, spectroscopy can fingerprint (uniquely identify) a material by disclosing what elements it contains, and in what proportions[9]. During this early period of spectroscopy, interest was largely confined to the chemical and physical properties of matter and with correlating and charting the lines of various elements. Some 30 new elements were discovered in this way. A few were even named for the brilliant spectral lines they provided: thallium (green), rubidium (red), cesium (blue), and indium (indigo). Fraunhofer had an even greater scientific discovery within his grasp, but did not perceive that under the proper circumstances each element produced its own characteristic set of lines and that these lines are as unique to it as fingerprints are to humans. Quantitative analysis by emission spectroscopy depends upon the fact that the quantity of light (*i.e.*, the intensity) emitted at a given wavelength is proportional to the number of atoms vaporized and excited. The quantity of a given element is usually determined by a comparative method—that is, the intensity of the radiation emitted at a selected wavelength by the sample is compared with the intensity of the radiation emitted by a standard of known composition[10]. Other spectrochemical methods useful in elemental analysis are atomic absorption spectrometry and atomic fluorescence spectrometry.

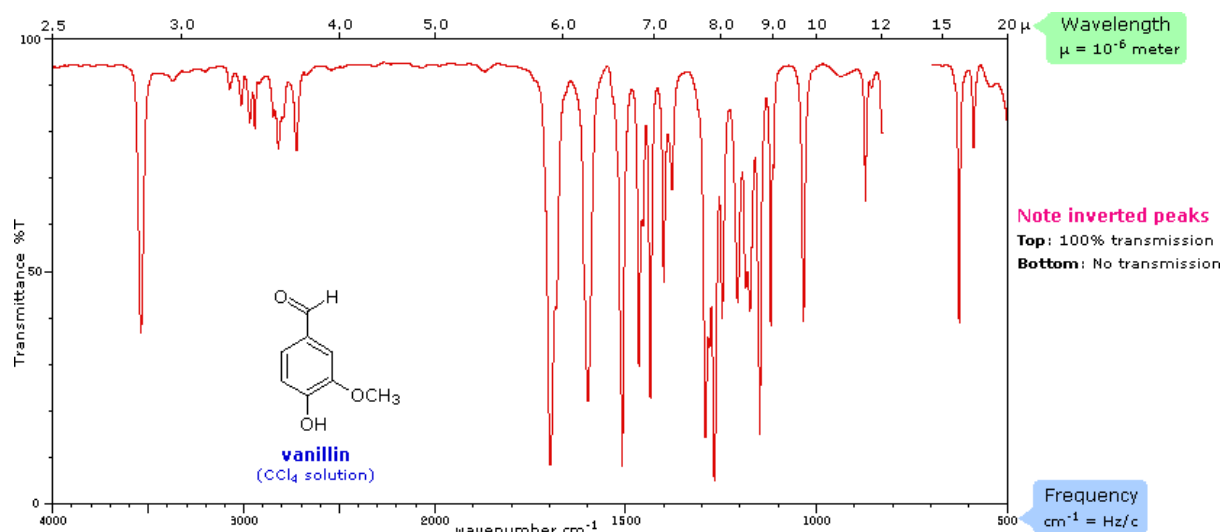


Fig.4. Spectrochemical analysis in vanillin

As shown in fig.4 example of Spectrochemical analysis, methods of chemical analysis that depend upon the measurement of the wavelength and the intensity of electromagnetic radiation. Its major use is in the determination of the arrangement of atoms and electrons in molecules of chemical compounds on the basis of the amounts of energy absorbed during changes in the structure or motion of the molecules[11]. In its restricted and more common usage two methods usually are implied: (1) ultraviolet (nonvisible) and visible emission spectroscopy and (2) ultraviolet, visible, and infrared absorption spectrophotometry. The wavelength dependence in the grating equation shows that the grating separates an incident polychromatic beam into its constituent wavelength components, i.e., it is dispersive. Each wavelength of input beam spectrum is sent into a different direction, producing a rainbow of colors under white light illumination. This is visually similar to the operation of a prism, although the mechanism is very different.

V. CONCLUSION

Ordinarily, emission spectrochemical analysis is applied to the qualitative and quantitative determination of metallic elements, but it is not restricted to them. The method is among the most sensitive of all analytical methods: a few milligrams of a solid sample usually suffice for the detection of metallic elements present to the extent of a few parts per million or less.

a physical method for the qualitative and quantitative determination of the atomic and molecular composition of a substance through study of the substance's spectrum. Molecular spectrochemical analysis determines the molecular composition of substances by molecular absorption, luminescence, or Raman spectra. In addition, the method is capable of detecting several atomic species simultaneously, thus obviating chemical separations. Both methods resemble the flame method of emission spectroscopy (*i.e.*, a method that uses flame as the energy source to excite atoms) in that a solution of the sample is usually vaporized into a flame of hydrogen or acetylene in air or oxygen. In addition, light of the same wavelength as that emitted by the desired element is passed through the flame[12]. A certain fraction of the light is absorbed by atoms that are in their ground electronic state. The quantity of radiation absorbed is proportional to the concentration of atoms in the flame in their ground state and, because thermal equilibrium exists, to the total concentration of that atomic species. The physical basis of spectrochemical analysis is atomic and molecular spectroscopy. Various types of spectrochemical analysis are distinguished according to the purposes of the analysis and the kind of spectra used (see). Atomic spectrochemical analysis determines the elemental composition of a sample by atomic or ionic emission and absorption spectra.

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