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A Study On Understading On Overview Of Raman Spectroscopy

Dr. Swati Goyal[1] ,Ms. Arti Mishra[2]

[1]*Research Supervisor (Chemistry), Dr. A.P.J. Abdul Kalam University, Indore (M.P.)*
[2]*Research Scholar (Chemistry), Dr. A.P.J. Abdul Kalam University, Indore (M.P.)*

Raman spectroscopy is a particularly potent instrument for material analysis that enables investigation of a wide variety of materials' properties. Since its inception, Raman spectroscopy has been used to examine several aspects of materials, including their carbonaceous and inorganic properties, and has been successful in revealing details about their phases, functions, and flaws. Additionally, methods like surface and tip enhanced Raman spectroscopy have broadened the range of applications for Raman analysis to include analytical and biological disciplines. Furthermore, Raman instrumentation's dependability and adaptability offer a promising means of doing on-site investigation for a variety of materials. We review the primary and most recent uses for the analysis of a wide range of materials, including carbonaceous materials, in this article since we are aware of the numerous popular applications of Raman spectroscopy.

Keywords: Raman spectroscopy; SERS; qualitative analysis; material characterization

INTRODUCTION

A well-liked method for analysing molecular structure, Raman spectroscopy is today regarded as an addition to infrared spectroscopy. The Raman effect, which was discovered by the Indian physicist Chandrasekhara Venkata Raman in 1928, serves as the foundation for Raman spectroscopy.

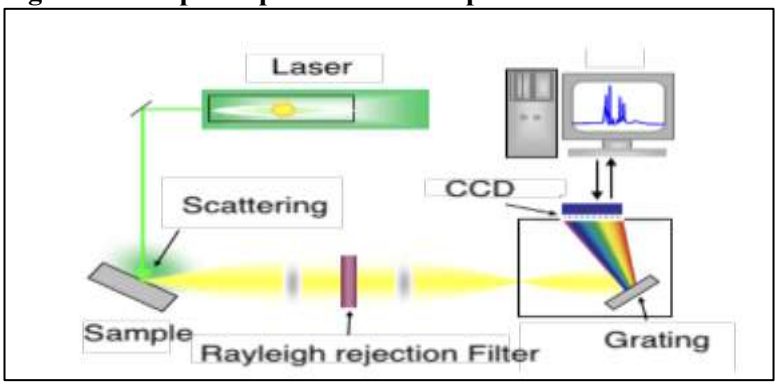
According to quantum physics, a molecule may move to a virtually higher energy level when it interacts with photons. There are several potential outcomes from this higher energy state. One possible result of this process is the production of a photon with a different energy level, which causes the molecule to vibrate at a lower energy level than it did in its initial condition. The Raman Shift is the term used to describe the energy difference between the incident photon and the scattered photon.

A high-intensity laser beam is used to excite the material, and the scattered light is then sent through a spectrometer to determine the Raman spectrum. The Raman Shift is the name for the energy differential between the incident light and the scattered light. The horizontal axis of the produced spectrum is the Raman shift wavenumber (cm1), and the vertical axis is the intensity of the scattered light.

Different materials have different vibrational modes, which results in distinctive Raman spectra for each substance. Raman spectroscopy is thus a practical method for material identification. The Raman spectra of gases and liquids and those obtained from solids (like crystals) differ significantly in one crucial way. When referring to gases and liquids, we discuss the various vibrational energies of the constituent molecules that make up the substance.

However, the molecules that make up crystals have a particular range of vibrational energy. As a result, the entire crystal lattice vibrates at a macroscopic level. Phonons are the name for these macroscopic vibrational modes.

Fig. Raman Spectrophotometer Setup



Source: (Jasco, 2021e)

PRINCIPLES

The molecule will be excited to some virtual state between the two states if the incident photon's energy is insufficient to excite it from the ground state to the low-Est electronic state. However, the excited molecule's electron must quickly return to the ground state because it cannot remain in the virtual state for very long. The wavelength of the photon released if the electron returns to its initial state—in this case, the ground state—becomes equal to that of the photon from the incident light. Rayleigh scattering is the name for this kind of scattering phenomenon.

However, it is also possible for the electron to enter a virtual state that is distinct from the one in which it is excited, leading to a difference in energy between the photons that are emitted and those that are incident. This causes a shift in the wavelength (and consequently an energy shift) of the emitted photon relative to the incident photon. This process is called Raman scattering. Stokes scattering is the process of scattering when the energy of the released photon is lower than the energy of the incident photon. Additionally, artistes scattering occurs when the incident photon has a higher energy than the emitted photon. (Barron and Agrawal, 2020; Laserna, 2014).

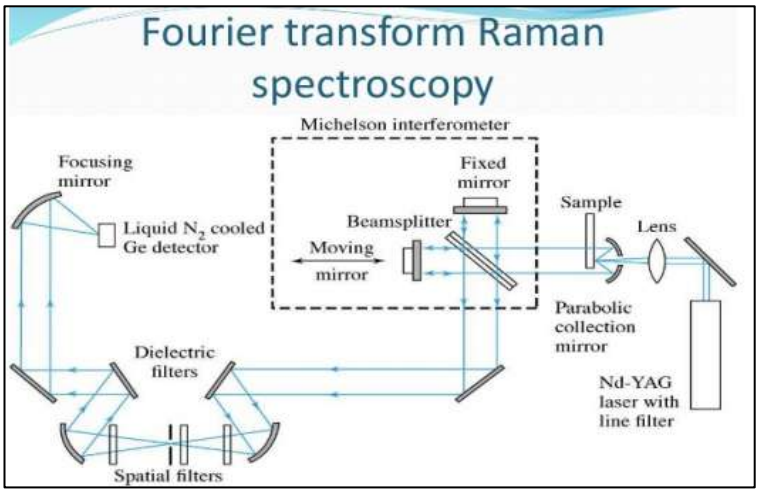
CONFIGURATION OF RAMAN SPECTROPHOTOMETERS

The Raman effect is based on light scattering, which includes inelastic (Raman) scattering at different wavelengths caused by molecular vibrations as well as elastic (Rayleigh) scattering at the same wavelength as the input light. About a million times less strong than Rayleigh scattering is Raman scattering. Therefore, it is necessary to prevent the Rayleigh scattering from outweighing the weaker Raman scattering in order to acquire Raman spectra. For this reason, high-intensity laser beams are used to excite samples, and the scattered light is then sent through a spectrometer to analyse the Raman spectra. The Raman Shift is the name for the energy differential between the incident light and the scattered light. The intensity of the

scattered light is shown vertically and the wavenumber is represented horizontally in the resulting spectrum.

The significantly higher intensity of the Rayleigh scattering and the low intensity of the inelastic scattering are the two main experimental issues with Raman spectroscopy. This fact has hindered the development of Raman spectroscopy in a number of ways.

FIGURE: FOURIER TRANSFORM RAMAN SPECTROSCOPY



Source: (Bavishi, 2021b)

By adding two or three dispersion stages to the monochromator, this issue has been resolved. By 1940, the first spectrophotometer with a double monochromator built in was on the market, and double and triple monochromators are still employed often today. At Raman shifts of just a few cm1, these systems may lower the amount of Rayleigh scatter by 10 or more orders of magnitude. The creation of high efficiency holographic notch filters for Rayleigh light rejection as a result of the search for alternatives has considerably increased the brightness of the Raman experiment by eliminating the need for additional dispersion stages. The optical components of a Raman Spectrometer must be perfectly matched and optimised because Raman Scattering is a modest effect.

LITERATURE REVIEW

A laser light source, a diffraction grating for dispersing Raman scattered light, an optical filter for rejecting Rayleigh scattered light, and a CCD for detecting the dispersed light at various wavelengths are all components of a Raman spectrophotometer system. (Long, 2002; McCreery, 2005).

Raman investigations can provide information about the composition, structure, and stability of co-ordination molecules. Inline Raman spectroscopy is being utilised to track crystallisation processes to uncover reaction mechanisms and kinetics. This data, when combined with analysis tools, provides educated reaction interpretation and optimisation. (Laitinen, 1980; Smith et al., 2016).

Raman spectra are similar to IR spectra in that they feature functional group detection zones and fingerprint sections that allow specific compound identification. However, Raman Spectra provide more information about specific types of organic substances than infrared spectra. (Clark, 2000).

Raman spectroscopy has been widely used to study biological systems. The benefits of this approach include a short sample requirement, spectrum detail, low sensitivity to water interference, and conformational and environmental sensitivity. (WOLTHUIS et al., 1999).

Han Infrared Spectra. As a result, peak overlap in mixes is less frequent, and quantitative measurements are more straightforward. Furthermore, Raman sampling equipment are not susceptible to moisture assault, and little amounts of water in a sample do not interfere. Nowadays, Raman Spectroscopy is frequently employed for Raman imaging and Raman Microscopy. (Schlucker et al., 2003).

Rayleigh in 1871, Einstein in 1910, and others had long investigated light scattering by various media, but no change in wavelength had been detected (with the exception of some specialised types of scattering in the X-ray spectral region observed by Compton). Raman spectroscopy began in the first quarter of the twentieth century, when an Austrian quantum physicist named Adolf Smekal predicted theoretically, in 1923, the scattering of monochromatic photons with a change in frequency. (Smekal, 1923).

With this backdrop, many scientists were intrigued by the concept of inelastic scattering, which was initially published in Calcutta by C.V. Raman and his co-worker K.S Krishnan in 1928, and almost simultaneously in Moscow by Landsberg and Mandelstam. Two years later, Raman was awarded the Nobel Prize in Physics for the discovery that retains his name to this day (Goodstein, 2014).

Raman and Krishnan employed filtered sunlight as a radiation source in their early studies (as did Grigory Landsberg and Leonid Mandelstam in inorganic crystals) and observed Raman lines in nearly sixty liquids and gases. They saw the scattering light optically by using a set of compensating-coloured filters to increase optical sensitivity. In 1929, a more conclusive spectrum of carbon tetrachloride with both the Stokes and anti-Stokes lines photographed using 435.83 nm mercury excitation was published. (Long, 2002).

Franco Rasetti observed the first Raman spectra in gases in 1929. Between 1930 and 1934, Czechoslovak scientist George Placzek steadily developed the pioneering hypothesis of the Raman Effect. It's worth noting that at the time, Raman spectra could be acquired using much simpler equipment than infrared observations. As a result, by the end of the 1930s, scientists working on IR group frequency analysis had to frequently rely on Raman data collections for reference material, because Raman spectra were frequently far more extensive and better categorised than matching IR data. (Mehra and Rechenberg, 2000).

The rich legacy of this period's efforts in IR spectroscopy and Raman studies culminated in the formalisation of a sound and working model of molecular vibration dynamics, laying the groundwork for Raman scattering as a predictive and interpretative class of spectroscopy. At the moment, at least 25 Raman spectroscopy variations have been produced. The typical goal is to improve sensitivity (e.g., surface-enhanced Raman), spatial resolution (Raman microscopy), or gather very precise information (resonance Raman). (Laserna, 2014).

OBJECTIVES

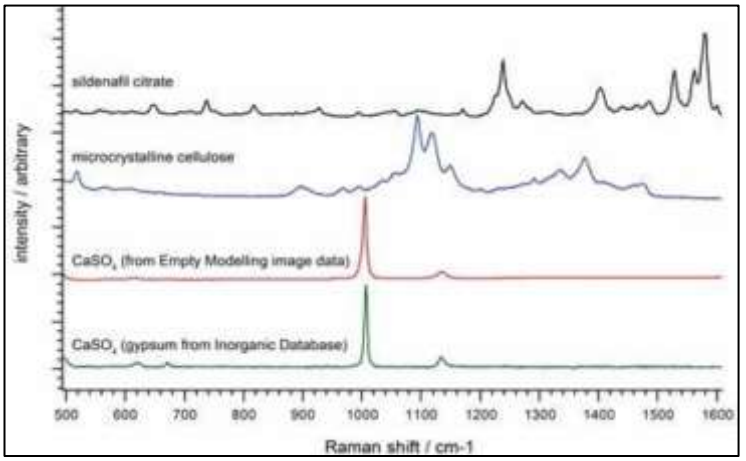
- To examine the need of conceptual overview of Raman spectroscopy
- To study the in-depth concept of Raman spectroscopy
- To study the role of Raman spectroscopy

RESEARCH METHODOLOGY

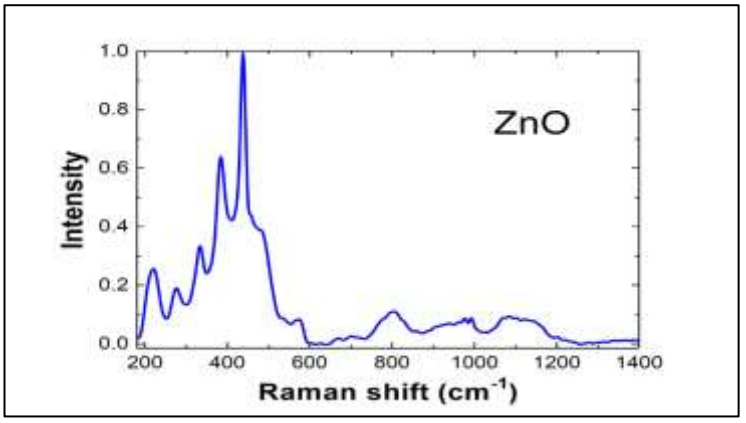
Conceptual research effort has served as the foundation for the study. A thorough analysis was done. In order to comprehend the depth of the concept behind the conceptual overview of Raman spectroscopy the values that Raman spectroscopy upholds, and the significance of Raman spectroscopy, this article analyses the legal factors associated to conceptual overview of Raman spectroscopy

The topic's many facets have been identified using secondary data and investigations from earlier academics. The preparation of the literature review and introduction used articles, research paper publications, and other online resources.

FINDINGS AND DISCUSSION



Source: https://www.renishaw.nl/nl/raman-spectra-explained--25807



Source: https://ramanlife.com/library/zinc-oxide/

CONCLUSION

Raman spectroscopy is a very powerful and polyhedral tool that could be used for the investigation of many fields and many more materials. As we discussed, Raman is useful for advanced materials science and real-life applications, always providing a deep and meaningful insight into the properties and arrangement of the sample analysed. Considering the decreasing cost of Raman instruments and their portability, the spread of on-field Raman analysis will mark a new game changing event establishing the advanced materials characterization as a routine analysis.

Raman spectroscopy is well recognized as an analytical tool for the discrimination of similar substances. Therefore, it can be used not only for the identification of adulterants but also for providing quantitative results. Since that time of invention, Raman Spectroscopy has been utilized for a vast array of applications from medical diagnostics to material science and reaction analysis. Raman Spectroscopy allows the user to collect the vibrational signature of a molecule, giving insight into how it is put together, as well as how it interacts with other molecules around it. And the technique and the instruments associated with it are getting more precise and accurate day by day, with the advancement of science.

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