



Characterization Techniques: A tool to understand Nanoparticles behavior

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Abstract:

For academics and industries, developing materials with dimensions less than 100 nm has been a breakthrough field. Nanoparticles typically display distinctive characteristics that set them apart from their bulk counterparts when their dimensions are shrunk to the nanoscale, making them particularly well-suited for use in electrical, chemical, and optical applications. These characteristics increase the appeal of nanoparticles for numerous applications while also making their characterization techniques more challenging. Finding the best characterisation methods that can analyse the properties of the nanoparticle is therefore a difficulty. In order to evaluate the qualities of nanoparticles, it is necessary to characterise them in addition to the synthesis and production procedures. For characterisation of nanoparticles and nanomaterials, several approaches can be used. This article will in-depth examine some of characterization techniques to understand different

properties of nanomaterial.

Keywords: Nanoparticles, Characterization tools, XRD, SEM, UV-Visible.

1 INTRODUCTION

The usage of nanoparticles in present day remedy has emerged as a trend that can't be avoided. Because of their several uses in fields which include delivery of drugs and identification of cancers and therapy [1, 2], particles of the order of 1 to 100 nm have drawn extra interest in latest years. As the shape, length, and morphology of nanoparticles diverge from the ones of bulk materials, their catalytic characteristics get better. Special types of metal nanoparticles, along with gold, silver, alloys, magnetic, and so forth, have various uses in a variety of industries (Fig. 1). The synthesis of nanoparticles can frequently be approached in certainly one of two approaches: top-down or bottom-up. A reducing agent is added to a chemical method to lessen metal ions to metallic nanoparticles, whereas physical operations use a ball milling technique and other mechanisms [3]. The electrochemical technique, micelle synthesis, discount technique, sonochemical technique, sol-gel technique, radiolytic method, coreduction approach, and sol-gel technique by using discount are in addition synthesis strategies [4].

The use of nanoparticles transforms clinical and biotechnology techniques, making them less difficult, more secure, extra lower priced, and portable. packages for nanoparticles can be determined in fields as various as organic labelling [9], the treatment of a few cancers [10], the usage of nanoparticles in numerous industries [6], the usage of nanoparticles in commonplace

products like apparel and cosmetics [7], optical devices, sensor era, and electronics [8], and using nanoparticles in regular products like apparel and cosmetics. In current years, interest has been interested in the specific functions of nanoparticles, consisting of their antibacterial interest and tolerance to severe warmth and oxidation situations [11].

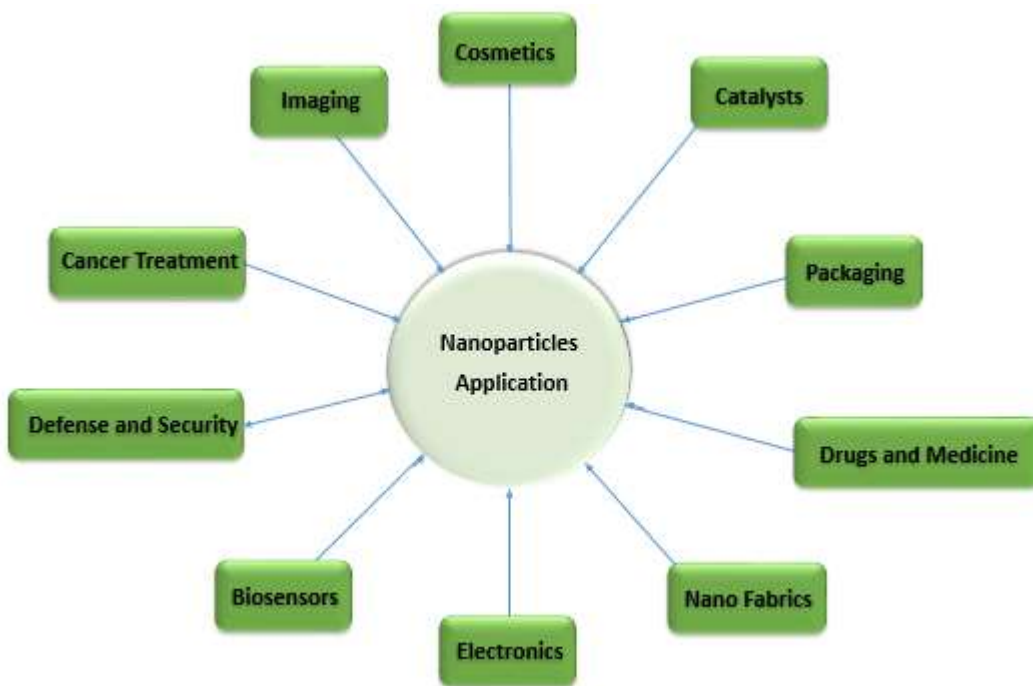


FIG. 1 Applications of nanoparticles.

Additionally, biological processes can be used to create nanoparticles. Biochemical techniques mostly deal with microorganism- and green synthesis-based processes [12, 13]. Synthesis based on microorganisms is time-consuming and delicate. The metabolites of the secondary order in the extracts of plant aid in the procedure by serving as the reducing agent. For the manufacture of extracts, nearly all parts of the plant have been found to have

positive results.

Characterization is essential to confirming the nanoscale of the produced particles. In the field of material learning, "characterization" denotes to the wide and across-the-board methods used to investigate the structure and physical characteristics of a physical material. To understand the material scientifically, one must first understand this fundamental mechanism. Characterization refers to the methods used to investigate the microscopic and material qualities, i.e., any procedure involving the investigation of materials, such as mechanical evaluation, thermal evaluation, and computation of density. Methods that are used for characterization have been researched for decades, to this there are a lot of new methods that have been added that seem to be more sophisticated. The primary objective of characterization is for the evaluation of how effective an approach is enables us to evaluate the effectiveness of the approach and provides information on the composition and material structures. Certain approaches are qualitative, while others can be quantitative.

This episode will highlight popular and useful methods for characterizing nano-particles (Fig. 2). Main goal of this episode is offering a hypothetical and hands-on explanation of the techniques useful for characterizing a wide array of materials. The applications of the different methods, preparation of samples, and the outcomes expected are the main areas of focus for our team. You will learn how to apply the optimal method for a specific material in this way.

Transmission-electron microscope (TEM) analysis, atomic-force microscope (AFM), Raman spectroscope, scanning-tunnelling microscope (STM), and energy-dispersive X-ray analysis (EDAX) are a few instances of

the types of analyses that can be done.

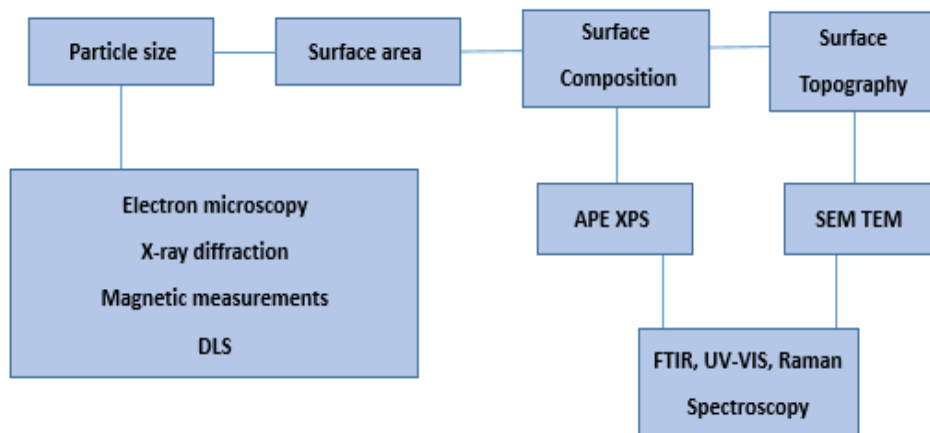


FIG. 2 Common techniques for nanoparticle characterization.

Some more techniques for understanding the properties of materials are X-ray diffraction (XRD), X-ray photo-electron spectroscopy (XPS), Fourier-transform infrared spectroscopy (FT-IR), ultra-violet visible spectrometer (UV-vis), zeta potential analysis, and dynamic light-scattering (DLS). Here, we go into great detail about the fundamental ideas and mechanisms underlying the techniques.

2 MICROSCOPY-BASED NANOPARTICLE CHARACTERIZATION

With adequate resolution, optical/ophthalmic microscope permits the reflection of materials in micrometre scales. Further resolution in optical microscopes is challenging to achieve because to aberrations and limited wavelength. As a result, technologies for further techniques for imaging including SEM, AFM, STM and TEM have progressed for identifying materials of submicron size. Despite having different principles, these approaches result in images that are greatly amplified. Through various

imaging methods, nanoparticles can be seen. In the material that follows, the fundamental operating principles of the approaches are described in depth.

2.1 PRINCIPLES AND MECHANISM OF SCANNING ELECTRON MICROSCOPE

A beam of electrons, as opposed to a beam of light such as an optical/ophthalmic microscopy, is pointed at the specimen in scanning electron microscopy (SEM) [15]. At the top of the device an electron gun is mounted, shooting a beam which is greatly concentrated. Two of the primary forms of electron gun's are thermionic and field emission guns. The former creates a robust electric arena that rips electrons from atoms, while the latter heats the filament until the electrons start to stream away.

Electron beams that have high-energy emanating from SEM will scan the surface of the specimen [16]. Since SEM employed waves of light waves for producing a enlarged image, they vary from traditional light microscopes in this regard. The specimen surface reacts to the electron beam as it hits it in a scanning electron microscope (SEM).

There are three different kinds of electrons, including Auger electrons, ancillary/secondary electrons, and backscattered electrons, which get freed once the incident beam of electrons forays the specimen. X-rays are also produced. The primary or backscattered electrons as well as the ancillary electrons are employed in SEM. Using ancillary electrons; the creation of images of superior resolution is done by SEM creates high-resolution images that expose particulars that have minute dimensions (1 - 5 nm). Characteristic X-rays are employed via a method called EDX to determine the composition of the elements. This method similarly creates the image using backscattered electrons.

2.1.1 Preparing the specimen for SEM analysis

Samples that are properly prepared will allow accurate SEM analysis. Because metals have the naturally ability of electrical conductivity on exposure to electrons, no preparation is necessary. The nonmetals must, however, be prepared using a sputter coater [17].

A small layer of conductive substance, typically gold, is applied to the specimen. Gold is obtained through aid of argon and an electric arena. The electric field takes an electron out of argon, resulting in ions that are positively charged. The gold foil's negative charge pulls these ions' positive charges. Atoms of gold atoms are unconfined by ions of argon and get deposited on the sample; a thin layer is coated on the sample resulting in a conductive layer. Environmental SEM (ESEM) that is operated at lower voltages is useful for imaging samples that are not non-conducting [18].

In cases of conventional SEM, removal of water is extremely crucial since, in a pressure of vacuum, the molecules of water tend to vaporize, obstructing the electron beams and reducing image clarity. Modern SEMS can function without a complete vacuum. These tools create images with reduced resolution, but they allow for the examination of a wide range of samples that were previously inaccessible, which is essential for industrial and similar fields.

2.2 ENERGY DISPERSIVE X-RAY ANALYSIS

By examining near-surface elements and estimating the elemental percentage at several spaces, the technique provides a general charting of the specimen.

2.2.1 Basic principle

Along with SEM, EDAX is engaged. The X-rays will emit the energy from the conducting sample as a result of a beam of electrons which has energy of 10 to 20 keV striking its exterior layer depends on the material being studied. Since the generation of X-rays in the region is just about 2 μm deep, EDX does not qualify as a superficial science approach. One can see an image of individual element in the specimen by mobilizing the beam of electrons across the specimen. As a result of low intensities of X-ray, image acquisition usually requires several hours of time [15].

When the nanoparticles near and at the surface include certain heavy metal ions, the quantities or compositions of those particles could be estimated by means of the EDX. For instance, EDX makes it simple to spot surface-bound nanoparticles of silver (Ag), gold (Au), and palladium (Pd). By means of EDX, it is difficult to find lower atomic number elements.

2.3 ATOMIC FORCE MICROSCOPY (AFM)

AFM is an effective as well as flexible microscopic technique that examines samples at the scales of nanometer [19]. It captures a three-dimensional topographical image and offers different surface measures to cater to the requirements of engineers and researchers. AFM requires less sample preparation than other imaging methods and can produce pictures with atomic resolution and resolution height information. It can be utilized in polymer nanocomposites to analyze surface texture and assess surface roughness on a variety of materials. Additionally, it can be classified as a non-destructive technique through a extraordinary three-dimensional resolution.

2.3.1 Surface sensing

AFM scans the sample's surface using a cantilever that has a pointed tip. The attractive force amongst the surfaces and ends causing a tiny deflection to be seen in the cantilever as the surface gets closer to it. Even though the beam is brought nearby to the superficial layer such that the ends touch it, the cantilever is deflected away from the surface due to stronger repulsive forces.

2.3.2 Detection method

A beam from the laser is required to detect the beam's displacement towards or away from the surface. A photosensitive photodiode will be used to track any tiny changes in the direction of the reflected beam that may result from the cantilever's deflection. The photodiode therefore captures the cantilever's deflection as AFM travels over an elevated surface.

2.3.3 Mechanism of Imaging

A photography of the specimens topmost surface is generated by scanning the region of interest with the beam of electrons. The properties or characteristics of the top surface of the specimen are tracked by the photodiode of the beam's deflection. AFM creates a precise topographic map of the surface characteristics by maintaining a consistent laser location by adjusting the tip height above the surface.

Review articles [20–22] have shown interest in the fundamental idea and use of AFM. AFM scanning can be done in three different ways: tapping, noncontact, and contact modes.

Touch mode: The end that is closest to the vicinity of the materials surface will scan the sample. The forces of repulsion can be generated at the surface of the material by focusing the beam against the sample by use of piezo-electric device. Images are created after evaluating the deflection of beam.

Non-contact mode: While the tip is hovering overhead the surface, the forces of attraction among the specimen and tip are closely observed and.

By means of a crystal of piezoelectric and the tapping mode, the beam oscillates at its resonance frequency to obtain high resolution. In cases where there is no contact between tip and surface, the beam starts oscillating as a result of the piezo motion. In order to evaluate the features of the sample, the oscillations are reduced when the beam starts to sporadically contact the superficial layer.

2.4 TRANSMISSION ELECTRON MICROSCOPY

When a beam of electron is focused incident on the specimen, it networks with the specimen and the electrons that are transmitted get enlarged and focus is dedicated towards the lens of the objective to generate an image.

2.4.1 Principle

The contrast between TEM images and light microscopic images is different. When the beam of electrons networks with the material, diffraction occurs instead of absorption. The diffraction strength changes depending on how the plane is positioned in relation to the beam of electrons. At some angles from the axis, the beam of electrons is considerably deflected, while at other angles transmission occurs. Containers/holders are designed so that the sample can be slanted to accomplish a specific deflection form. Using those electrons to create a evaluation photograph is called light field, and it

includes blocking the electrons that are deflected by way of the aperture while allowing the unscattered electrons to pass via. A dark field image is a type of image that is created using the deflected electrons.

2.4.2 Preparation of Sample for analysis

The specimen needs to be made into an extremely thin foil in order for the electron to pass through it [23]. Depositing a diluted sample having the specimen over support frames results in creation of materials with reduced dimensions. In a cryogenic ultra-microtome with a diamond knife, some samples are cut into thin films. The ideal samples are those that can tolerate the intense vacuum inside the device and are very thin [24].

2.5 HIGH-RESOLUTION TRANSMISSION ELECTRON MICROSCOPY (HR-TEM)

The atomic level crystallographic structure of a material can be imaged using the TEM imaging method known as electron microscopy. This does not produce images by absorption like traditional microscopy does; instead, it produces images through interfering in the plane of image plane. Independently, electrons engage through the material, the wave of electron wave travels over the system of imaging system and the transition of phase occurs and gets hampered.

Images that were captured aren't an exact replica of the structure of specimen. As a consequence of high resolutions it delivers, the technique is a valuable tool for studying the physical characteristics of materials at the nanoscale. This high resolution enables the imaging of crystal structures [25], crystal flaws, and discrete atoms [15].

2.6 SCANNING TUNNELING MICROSCOPY

With the use of this device, surface photographs with atomic-scale lateral resolution can be created. By the use of piezo-electric crystal and a tiny

probe, the superficial surface of the specimen that is conductive is scanned, and the subsequent tunnelling current is then monitored.

STM operates on the theory of quantum tunnelling. Electrons are capable of tunneling thru the vacuum between them as the surface of sample comes in contact with the tip of the conducting end when the sample surface makes contact with the conducting tip thanks to biasing. The confined density of the states at a level of Fermi of the specimen determines the tunnelling current at low voltages.

STM resolution standards include resolutions of lateral and depth of 0.1 and 0.01 nm respectively. Creation of images occur as the surface of sample and distance of tip are changed using a piezo-electric crystal, sustaining a constant value of current between both similar to the tip does a raster scan above the superficial surface while maintaining the force at the point. By mapping the tip height according to its function as a adjacent position over the surface of sample, the topography of the surface can be determined. STM can be applied in a variety of temperature ranges in liquids, gases, and both air and vacuum. Since the end must be razor-sharp and the exteriors must be spotless, the procedure can be difficult. In STM, tips of carbon nanotube are employed [26].

3 SPECTROSCOPY-BASED CHARACTERIZATIONTECHNIQUES

3.1 ULTRAVIOLET-VISIBLE SPECTROSCOPY

For the ultraviolet and seen place wavelengths, a deuterium or tungsten lamp, sample and reference beams, a detector, and a monochromator are the components of this method (Fig. 3). The UV spectrum can be received by means of exposing the sample to UV mild. Samples are introduced to the mild direction through cuvettes, which can be used to comprise samples and

are saved in the tool. Cuvettes may be constituted of glass, plastic, silica, or quartz cells. For absorbance experiments below 310 nm, plastic and glass cuvettes have to be utilized due to the fact they absorb wavelengths underneath that number. On the grounds that quartz cuvettes are obvious to wavelengths over one hundred eighty nm, they are applied for absorption measurements inside the UV range.

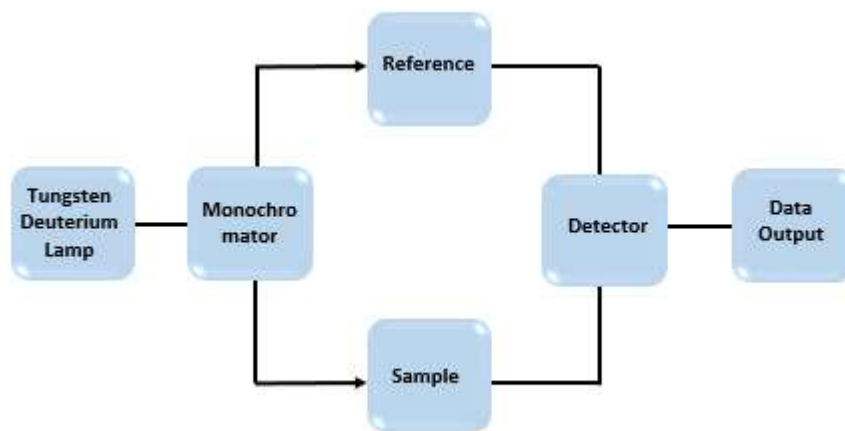


FIG. 3 UV-visible spectroscopy.

3.1.1 Principle and working

The reference beam is a beam that travels directly from the light source to the detector without a contact with the pattern. Due to the pattern beam's interactions with the pattern, the pattern is subjected to continuously various UV light. Whilst an electron is promoted to a higher molecular orbital by way of the wavelength this is emitted, electricity is absorbed. The detector maintains track of the distinction in beam strengths between the pattern and reference beams. The pattern's maximum stage of absorption dictates the

wavelength [27]. A discrepancy in the intensities shows that the reference beam is more excessive than the sample, and the corresponding wavelength is displayed as having a high ultraviolet absorbance. The UV-seen spectrum describes the reflectance or absorbance spectra in this spectrum.

A part of light can get absorbed when it passes through the solution, but the remaining light will continue to travel through it. Transmittance is the measure of how much light at a specific wavelength enters and leaves a sample. The term "absorbance" refers to the transmittance's negative logarithm.

The Beer-Lambert Act A sample's absorbance at given wavelength is linearly related to concentration of absorbing material, the path length, and the absorptivity, or $A = cl$, where A represents absorbance or the absorptivity, c represents the concentration, and l represents the length of the path.

The radiations that are incident ought to be homochromatic, and the absorbing material ought to be uniform and incapable of scattering the light.

Because of their surface plasmon resonance (SPR), nanoparticles of metals that have diameters of orders less than 100 nm can effectively scatter optical light. The conduction electrons within the metal are collectively vibrating at this frequency. The composition of the material, surroundings, form, and size of the material all has an impact at the plasmon resonance's bandwidth, significance, and wavelength peak. For instance, silver debris has a plasmon resonance top with 420–500 nm absorption. Within the case of silver nanoparticles, the plasmon absorption's position and form are influenced via the particle size and the dielectric medium [28]. As the particle length grows, metal nanoparticles' absorption spectra may shift

closer to longer wavelengths [29, 30].

3.2 RAMAN SPECTROSCOPY

Raman spectroscopy, a spectroscopic approach that studies rotational, vibrational, and other modes of a gadget, uses Raman scattering or inelastic scattering of monochromatic laser light. A power shift that follows from the phonons' interaction with the laser mild reveals records approximately the machine's phonons' modes.

Generally, the sample is illuminated the use of a laser beam. A lens is used to acquire the electromagnetic radiation from the laser struck spot earlier than it is dispatched via a collimator. The molecule will loosen up into a vibrationally excited kingdom after being aroused to an excited state from a ground nation. The Stokes Raman scattering is the end result of this. It's far known as antistokes Raman scattering if the molecule became already inside the vibrational state. For a molecule to display Raman scattering, its polarizability should change. In comparison to the Raman shift, that's based at the vibrational degree at play, the electricity of the Raman scattering is dependent on the change in polarizability. Suppressed Raman spectroscopy, surface better Raman spectroscopy, and resonance Raman spectroscopy are examples of superior Raman spectroscopy.

3.2 FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

FTIR analysis uses infrared light for scanning specimen with an objective of identifying the type of material whether it is polymeric, inorganic or organic. An exchange within the material composition is really indicated by way of

changes inside the different pattern of absorption bands. Unknown materials can be identified and characterized using FTIR. It can also be used to find additives, identify decomposition, and characterize oxidation.

Fig. 4 indicates a schematic diagram of FTIR. A source, sample mobile, detector, amplifier, A/D convertor, and pc are all common components of an FTIR spectrometer. After passing through the interferometer, radiation from the sources reaches the detector. The A/D convertor and amplifier amplifies the signal, converts it to a digital signal, and then transfers it to the pc to carry out the Fourier transform. The FTIR spectrometer's schematic is depicted in parent 4.

A sample is uncovered to infrared mild that ranges in wavelength from 10,000 to a hundred cm¹, a number of that is absorbed and a number of which passes thru. The pattern transforms the absorbed radiation into rotational or vibrational power. The final signal produced on the detector generally has a spectrum among 4000 and four hundred cm¹, which represents the molecular fingerprint of the substances. The reality that every molecule has a wonderful fingerprint makes FTIR a vital tool for identifying chemical substances [31].

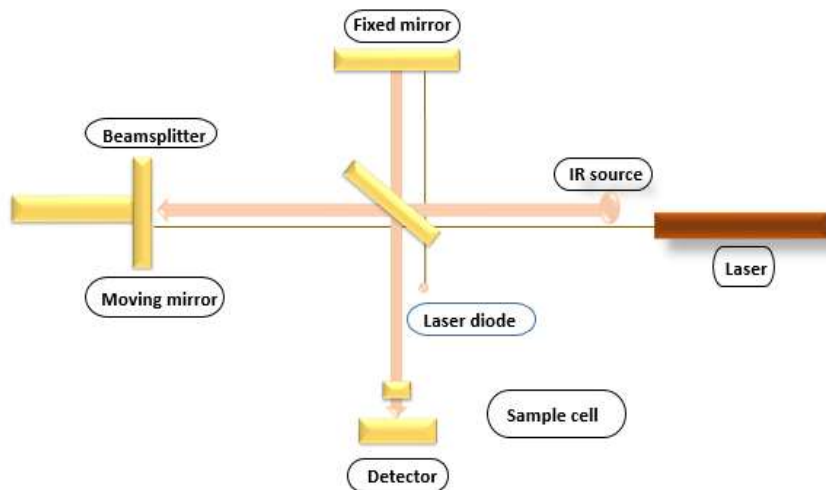


FIG. 4 Schematic diagram of FTIR.

4. CHARACTERIZATION TECHNIQUES RELATED X-RAY

There are two techniques for determine techniques related to X-ray, they are XRD and XPS.

4.1 X-RAY DIFFRACTION

Using XRD analysis, the sample's crystallinity is identified. It can also be used to provide information other than just identity. If the sample is in combination shape, XRD styles can be utilized to calculate the ratios of the elements. The statistics analysis can also be used to decide the degree of crystallinity, departure of a sure element from its perfect composition, and its structural condition. A part of the beam is transmitted because of the interaction between the X-ray beam and the atomic planes, and the final component is absorbed, refracted, dispersed, and diffracted through the sample. Depending at the atomic configuration and kind of atoms, every element diffracts X-rays in a completely unique manner.

X-rays are electromagnetic energy with a shorter wavelength. X-rays are created when electrically charged debris with sufficient energy are decelerated. Electrons are interested in the metallic goal by an excessive voltage this is maintained between the electrodes. X-rays are produced on the effect spot and radiate in all guidelines. These produced X-rays are collimated and geared toward a pattern, which is a powder that has been finely powdered. The detector picks up X-rays, and then the alerts are either processed electrically or the use of a microcontroller. By changing the attitude between the supply, pattern, and detector, an X-ray or spectrograph experiment is received. When the X-ray strikes a crystal lattice, scattering takes location. Because it interferes with itself, a phenomenon called damaging interference, the most scattering is removed. Diffraction takes place while the scattering is in section with the scatterings from every other aircraft. Right here, constructive interference takes place while new wave fronts are created by means of combining the reflections. Every crystalline substance has a characteristic atomic shape that causes it to diffract the X-rays in a certain manner. The perspective of diffraction is calculated the use of Bragg's equation [32], that is given by using $d \sin \theta = n \lambda$, in which d is the distance between the planes, θ is the angle of prevalence, n is an integer, and λ is the wavelength of the beam.

The graded circle that is centered at the powder specimen on this technique's geometry has a radiation source and an X-ray detector at its circumference (Fig. 5). Both between the detector and the specimen as well as amongst the specimen and the source of X-ray are different slits. In addition to collimating the radiation and lowering background noise, this aids in minimizing dispersed radiation. The sample holder and detector are

connected to a goniometer in order that the rotation of the specimen and detector are 2:1 in proportion.

4.1 X-RAY PHOTOELECTRON SPECTROSCOPY

The analysis of surface of by spectroscopy is known as XPS is effective for estimating a material's elemental makeup [33]. A material that has been exposed to X-rays, which causes emission of electrons from the surface-level core orbitals of elements, is examined in an ultra-high vacuum. The measurements of kinetic energy in addition to the quantity of ejected electrons from the material surface produce the XPS spectra. Kinetic energy can be used to compute the electrons' binding energy, which represents the state of oxidation of the elements surface [34]. The proportion of the element is reflected in the electron numbers.

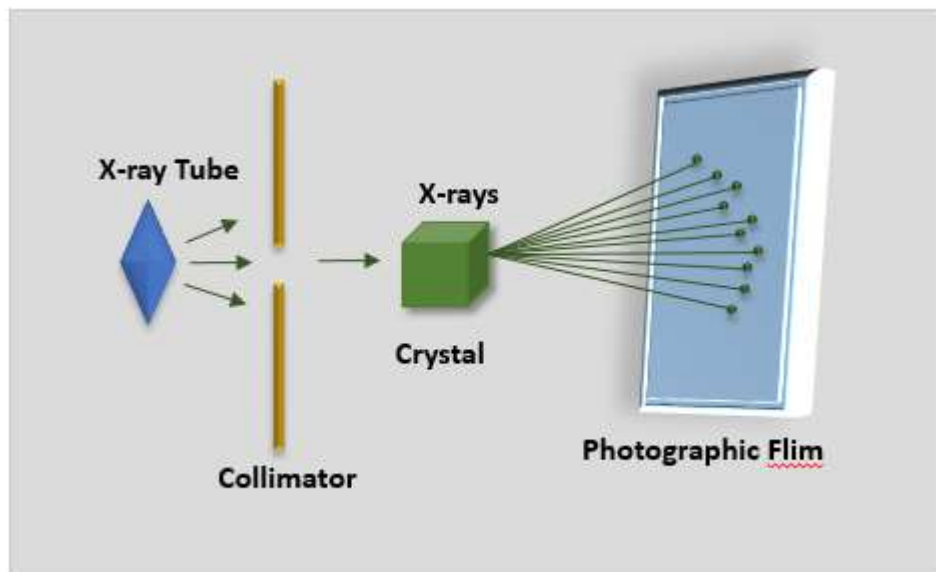


FIG. 5 X-ray diffraction set-up.

For the reason that the electricity of the X-ray used to excite the electron from a core orbital is thought, the binding strength may be computed the use of the subsequent components:

Here, binding is the power of the emitting electron, photon is the energy of the X-ray photons employed, kinetic is the kinetic electricity of the emitting electron, and is the work function.

Additionally, contaminants in the sample can be found using XPS.

5 DYNAMIC LIGHT SCATTERING

Using DLS, colloidal solutions and nanoparticles are characterized. DLS measures the scattered mild from a laser that passes through the colloidal answer. The evaluation of the scattered light's depth modulation as a function of time lets in us to decide the particle length.

5.1 DLS AUTOCORRELATIONFUNCTION

Truely, the time delay with which the function degrades is encouraged via the nanoparticle's charge of diffusion. Brownian motion is the idea for evaluation, wherein huge debris move greater slowly and scatter milder than small particles. The hydrodynamic diameter is decided from the time dependence of the scattering depth measurement and corresponds to the diameter of a hypothetical nonporous sphere that may diffuse on the equal charge because the particles being characterized. Moreover, it gives statistics at the nanoparticles' aggregated situation. Unaggregated responses have hydrodynamic diameters that are similar to or large than TEM length, whereas aggregated solutions have hydrodynamic diameters large than TEM size. The macromolecules' size and shape have an effect at the

hydrodynamic diameters [35].

6 ZETA POTENTIAL

Colloidal or nanoparticles in suspension can have a surface charge. The interaction between the electrical field and the charged particle causes a particle to begin moving as soon as the electrical area is delivered. The electric discipline, rate, and suspending medium all have an impact on the movement's speed and path. The Doppler shift inside the scattered mild is used to decide a particle's pace; the velocity proportional to the electric ability of the particle at the shear plane is referred to as the zeta ability. Consequently, the optical dimension of the particle's motion in an electric field may be utilized to calculate the zeta potential [36, 37]. Particle movement in a carried out electric subject is known as electrophoresis. In an answer with a recognized refractive index, pattern debris is suspended. Zeta capacity quantifies the price balance of colloidal particles by way of calculating the effective electric rate on a nanoparticle's floor. While a nanoparticle has a internet surface charge, the rate is screened by means of a higher attention of ions which might be negatively charged close to the nanoparticle's floor. The ion layer moves with the nanoparticle, and an electrical double layer is created by means of the layer of ions with opposing costs on pinnacle of it. Zeta ability is the difference in capability between the fluid layer containing dipolar ions and the bulk fluid in which the particle is suspended. Undoubtedly charged surfaces will bind to particles having a negative zeta potential, and vice versa. The zeta potential's size tells us something about the stability of the particle. The larger magnitude denotes greater stability brought on by stronger electrostatic attraction.

- In the 0–5 mV range, particle aggregation is most common.

- Particles with the lowest stability lie in the 5–20 mV range.
- Particles that are moderately stable lie between 20 and 40 mV.
- The range of highly stable particles is 40 mV and above.

The solution's pH is yet additional significant variable which can considerably effect the amount of control on the surface of nanoparticle. The isoelectric point is the pH at which it is possible to bring the surface charge to zero.

7 CONCLUSION

As a well-known topic, nanotechnology provides diverse applications in the bioscience sector as well as for environmental cleanup and energy production. Nanotechnology is fundamentally about synthesis, production, and manipulation. Nanoparticles are essential to the creation of more current, cutting-edge technology because they are today's main emphasis. Information characterization is crucial for regulated nanoparticle manufacturing and alertness. Nanotechnology has an exquisite deal of capacity for its futuristic method, but it's also motivated by way of matters like the advent of quicker, easier, extra effective, and strategies for materials characterization. For a deeper knowledge of particles and their properties, several methodologies must be combined.

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