(REVIEW ARTICLE)

A general overview on the extraction

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Abstract

To recover chemical compounds, a variety of extraction techniques have recently been devised. Extraction methods are widely used for component separation in numerous sectors and have a variety of applications. The basic principles behind several extraction methods, such as liquid-liquid extraction, solid phase extraction, solid liquid extraction, and supercritical extraction, are well explained. These include solvent selection, technique, benefits, drawbacks, and applications. Finally, a few extraction techniques are discussed, along with their applications, including Soxhlet, Pressurized Fluid, Ultrasonic, and Microwave extraction.

Keywords: Chemical compounds; Extraction methods; Liquid-liquid extraction; Solid phase extraction

1. Introduction

The extraction process divides the mixture into two phases, the solute-rich Extract Phase and the feed solvent-rich Raffinate Phase, by dissolving each component in the mixture with one or more solvents [1]. When the relative volatility is less than 1, the components of the mixture cannot be separated by distillation; in these cases, the extraction process is employed. Moreover, the extraction approach is employed when the distillation process is too costly [2]. Figure 1 shows the fundamental block diagram for the extraction process.
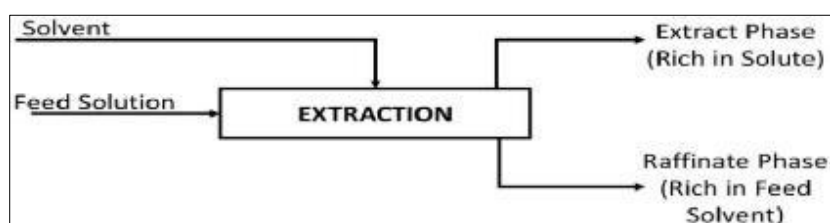

Figure 1 Extraction Block Diagram

During the extraction process, the combination of substances dissociates as each component is dissolved with one or more solvents. As a consequence, two phases are produced: the Raffinate Phase, which has a high solute content and the Extract Phase, which has a high feed solvent content [1]. The components of the combination cannot be separated by distillation when the relative volatility is 1; the extraction approach is used when the relative volatility is more than 1. Furthermore, if the distillation procedure is too expensive, the extraction method is employed [2]. Figure 1 shows the fundamental block diagram of the extraction process .Advanced extraction techniques include shake flask extraction, pressurized fluid extraction (PFE) or accelerated solvent extraction (ASE), supercritical fluid extraction (SFE),

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microwave aided extraction (MAE), ultrasonication assisted extraction (UAE), soxhlet extraction, soxtec extraction, and more.

2. Types of extraction

2.1. Liquid-Liquid Extraction

Solvent is another term for it. By coming into contact with a suitable insoluble liquid solvent that dissolves one or more of the components preferentially, the liquid mixture's constituents can be separated by the process of extraction [13]. Due to the uneven distribution of the components between the two immiscible liquids, the components of the solution may separate during this kind of action. In liquid extraction, there are two stages: the feed solution and the extraction solvent. One of the two liquids is removed more selectively when the feed and solvent come into contact with one another after mixing to create a homogenous combination [15].
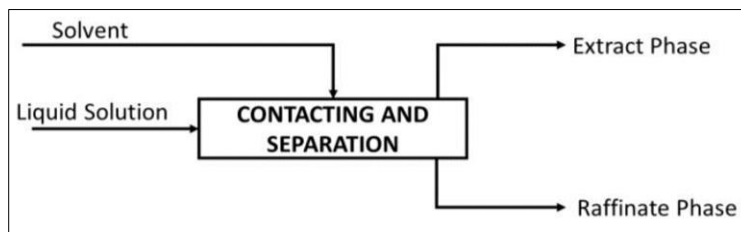

Figure 2 Diagram of the Liq-Liq Extraction Block

2.1.1. Notation Adopted

The solute that will diffuse between the two phases is C, the extraction solvent is B, and the feed solvent is A. Pure liquids that are highly insoluble are A and B.

F is the feed solution, which is made up of A and C, that will be extracted.

The letter E represents extract or extract phase.

[13–14] R is an acronym for Raffinate Phase or Raffinate.

Total Material Balance = Extract Phase (liq) + Raffinate Phase (liq) = Liquid Solution Solvent

$$F + B = E + R$$

2.1.2. For instance,

Water-based methanol extraction from LPG [14]

Two phases are created when an acetic acid solution in water comes into contact with a solvent, such ethyl acetate. The extract phase (also known as the "ester layer" or "organic layer") contains the majority of the acetic acid in ethyl acetate with some water, whereas the raffinate phase (also known as the "aqueous layer") contains

2.2. Selection of Solvent for Extraction

A solvent's density, dispersion coefficient, recoverability, and selectivity are among its characteristics that influence the choice. Selectivity, sometimes referred to as the separation factor, is the proportion of the extract phase's solute to feed solvent concentration to the raffinate phase's. It measures how well a solvent separates the constituents of a feed [16–19].

$$\beta = \frac{\frac{[Wt.\,fraction\,of\,C]}{[Wt.\,fraction\,of\,A]}\,(for\,E)}{\frac{[Wt.\,fraction\,of\,C]}{[Wt.\,fraction\,of\,A]}\,(for\,R)}$$

β>1 – Extraction is possible.

$\beta=1$ – Extraction not possible., This suggests that selectivity increases with the ease of separation. Recoverability: Solvents should not mix with the extracted solute to create a zoetrope, even if they may be recovered and used again by distillation. When relative volatility is large, recovery costs are low. Less latent heat of vaporization should also exist [16–19]. The distribution coefficient is the ratio of the solute concentrations in the extract and raffinate phases. It is represented by K [16–19]. CE/CR is equivalent to K. Higher Distribution Coefficient values are often favored since they indicate that a specific extraction task requires less solvent and fewer extraction stages. Density: Physical phase separation requires higher saturated liquid phase densities [16]. The solvent should be inexpensive and non-toxic.

Table 1 Liquid-Liquid Extraction Solvents

Aqueous solvents	Water – Immiscible organic solvent
Basic solvent	Dichloromethane
Acidic solution	Diethyl ether
Water	Hexane, petroleum ether
High salts	Chloroform

Some applications for liquid-liquid extraction include the following: The pharmaceutical industry most effectively uses liquid extraction to recover active ingredients from fermentation broths and purify vitamin products; the petroleum refinery uses it to improve the quality of lubricant oil and to separate aromatics/aliphatic (BTX); the nuclear industry uses it to purify uranium; the food industry uses it extensively to decaffeinate coffee and tea and to separate essential oils (fragrances and flavors); and the petrochemical industry most likely uses it to separate olefins/paraffin and structural isomers [20–21].

2.3. Extraction in Solid Phase

Based on their physical and chemical characteristics, components from aqueous solutions can be isolated, enriched, and purified using the sample preparation technique known as solid phase extraction [24]. For a component to be adsorbed on the surface of a solid phase or sorbent before elution, the two must come into contact [28]. In comparison to the quantity of analysis in the sample, there is not much extract. In analytical labs, solid phase extraction is frequently utilized. It also tackles problems with the liquid-liquid extraction method, including poor phase separation, poor recovery, and large organic solvent waste. Expensive glassware is also necessary for liquid-liquid extraction [29]. A substance called a sorbent has the ability to absorb or adsorbed various fluids [25].

2.4. Various Packing Types for Solid Phase Extraction

The ideal packing for solid phase extraction is selected using a range of particle sizes. Table (2) lists the various packing techniques that are employed according to particle size [28].

Table 2 Particle size-based packing types

Type of Packing	Size of Particles	Phases
Alumina	Irregular particles, 60/325 Mesh	Adsorption Phase
Silica	40μm particles, 60 Å pores	Reversed Phase
		Ion Exchange Phase
		Normal Phase
Resin	(Spherical Particles) 80-160μm	Adsorption Phase
Florisil	Particles of 100/200 Mesh	Adsorption Phase
Graphitized Carbon		Adsorption Phase

In reversed phase, the stationary phase is non-polar (hydrophobic), whereas the moving phase is polar. Silica often has 8–18 carbons added to it. Silica C18 is non-polarizing. The polar molecules pass through the fixed phase more rapidly here, whereas the nonpolar molecules adhere to it. Working with the reversed phase is simple.

Additionally, this phase has a stationary phase that works with a wide variety of compounds and is hydrophobic. For the majority of organic analytes, it is an effective method of assessing retention time (70–80% of common analytes may be quantified in this manner). Additionally, it allows you to adjust parameters like pH, concentration, and organic liquid type.

In the realm of chromatography, reversed phase gives you more possibilities [29]. The following are the applications: removing pesticides from washing water used to make olive oil, extracting CCl4 from drinking water, and Before drinking, adding photo-inhibitors to drinks

In the normal phase, silica particles are densely packed in the column (Fig. 3). Silica has a polar charge. Here, the non-polar molecules flow through it more quickly while the polar ones stick to it. Compounds that do not separate well with water can be added to the usual phase. This level is for materials that either do not dissolve in water or may break down in it. One of the primary functions of normal phase is the separation of isomers [29].
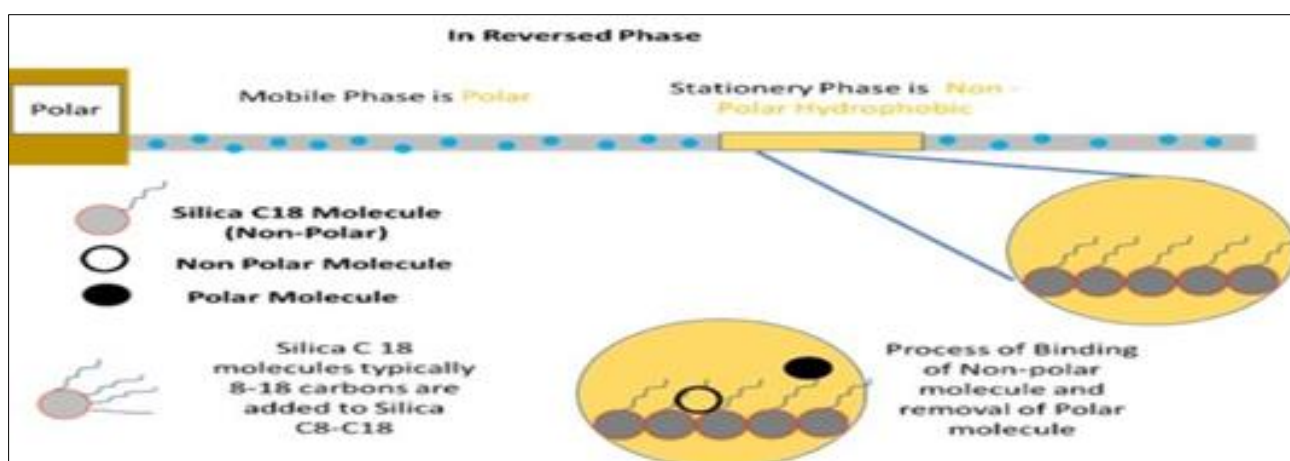

Figure 3 Reversed phase

It may be used, for instance, to extract fatty acids from shellfish extracts, separate molecular elements from the major components of soil organic matter, and quantify the level of chlorinated pesticides in fish extracts.
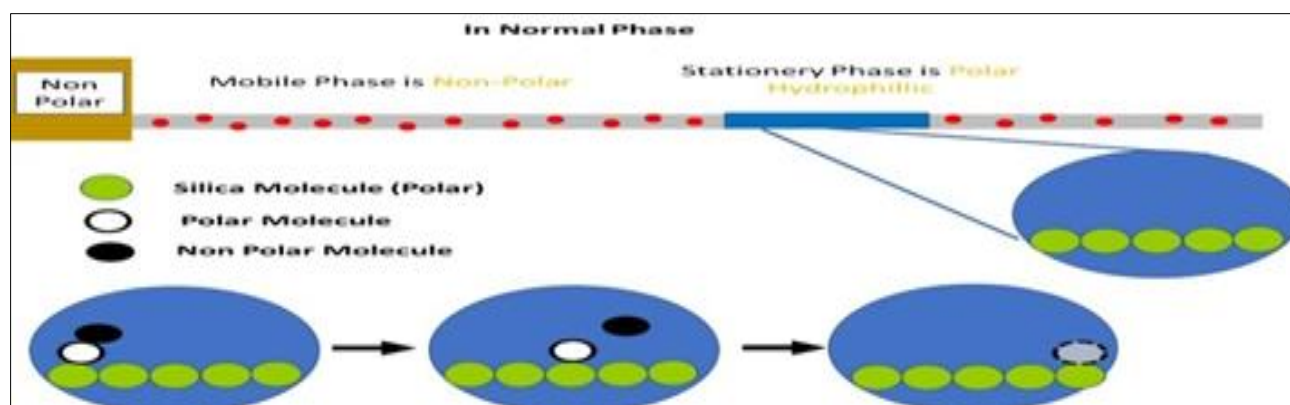

Figure 4 Reversed phase and Normal phase

2.5. Ion Exchange Phase

Ionic chemicals can be separated from polar or non-polar solvents via Ion Exchange Solid Phase Extraction when an oppositely charged ion exchange solvent is present. For the extraction of analyses with basic or acidic functional groups, ion exchange media are available in both cationic and anionic forms [37]. Depending on the kind of ionic group bound to the surface, ion exchange sorbents can be further divided into weak and strong exchangers. Acidic functional groups, such as sulphonic acid derivatives, are strong cation exchangers.

Surface functional groups of weak cation exchangers are neutral at low pH values but negatively charged at high pH values [29]. Applications include the formation of cationic selenium compounds seen in Brassica juncealeaf extracts and the isolation of protein components (amino acids) from liquid samples.

Figure 5 Ion Exchange

2.6. Selection of Solvent

Table 3 Solvents Frequently Used in Solid Phase Extraction

Polarity			Solvent	Miscible in Water
Non-polar	Strong Reversed Phase	Weak Normal Phase	Hexane	No
			Carbon tetrachloride	No
			Dichloromethane	No
↓		↓	Ethyl acetate	Poorly
	t		Acetone	Yes
		Strong Normal Phase	Methanol	Yes
			Acetic Acid	Yes
Polar	Weak Reversed Phase			

2.7. Steps involved in Solid Phase Extraction

The Solid Phase Extraction Operation is made up of these five steps:

First, moisten the sorbent. Step 2: Improve the sorbent. Inserting the sample is step three.

Step 4: Get rid of the disruption. Remove the analytes in step five.

Rinse the SPE tube with sorbent and fill it with adequate sorbent. The sorbent is then prepared by adding the solvent or buffer. The data must then be loaded. The sample is forced through the sorbent material using a pusher or vacuum. Following this stage, a solvent is used to remove the unnecessary material by elution, which is the process of separating one substance from another. This aids in obtaining the desired sample. Lastly, the required sample is extracted from the sorbent using the elute liquid [37].
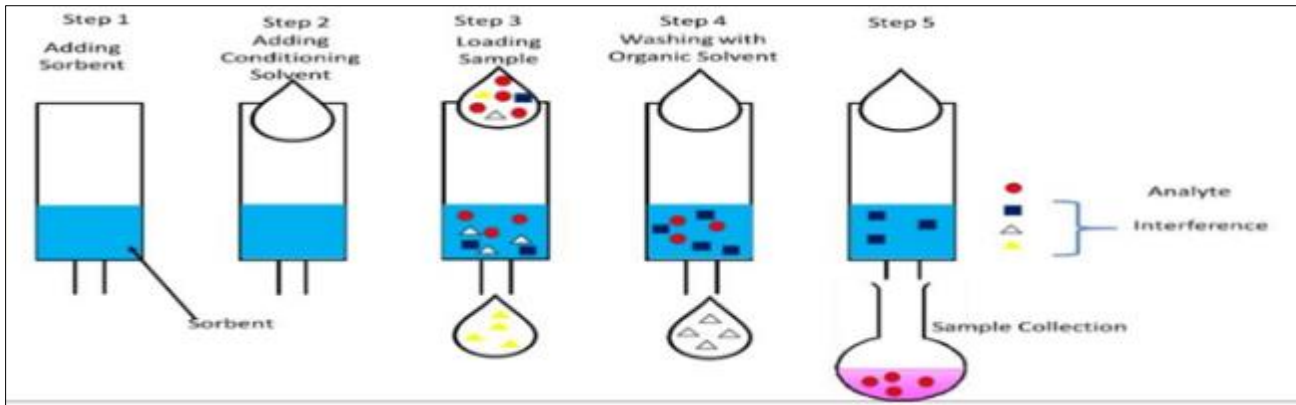
Figure 6 Steps involved in solid phase Extraction

3. Leaching (solid-liquid extraction)

The process of removing components from a combination of solids by combining the particles with a liquid that dissolves them is known as solid-liquid extraction, or leaching [30]. Leaching is a technique that may be used to separate an insoluble solid from a liquid substance it is combined with, or it can be used to create a concentrated solution of a valuable solid material. When you prepare coffee in your daily life, leaching is evident. In this instance, the ground coffee is submerged in water to separate the soluble and insoluble components [31].

3.1. Mechanism of Leaching

Leaching involves two steps which are as follows:

Contacting step

To dissolve the soluble solute in the solvent, the solid must come into contact with the liquid, which is the selective solvent. The solute diffuses into the main body of the solution after first dissolving from the solid's surface. The solid substance may develop holes as a result of this process, exposing additional surfaces to later solvent penetration [32].

3) The separation phase

separation of insoluble phases, that is, physically separating the liquid phase from the solid phase by filtering, settling, etc.

3.2. Methods of Operation

3.2.1. Single Stage Leaching (Crosscurrent) Consider a theoretical extraction stage.

F –mass of A+C in solids to be leached.

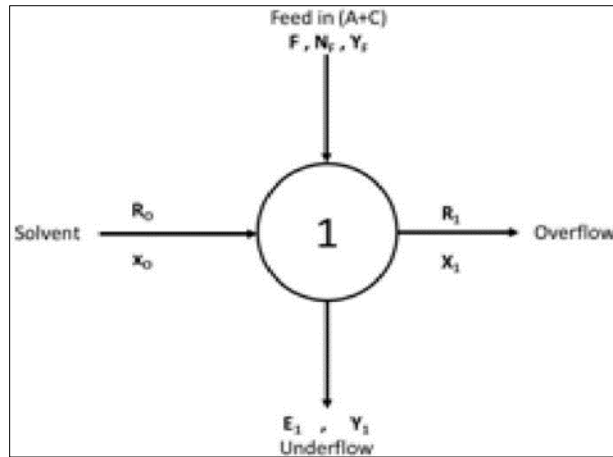YF – mass of C per mass of A+C in solids to be leached.

Ro – mass solution A+ C in leaching solvent.

Xo – mass of C / mass of A+C in leaching solvent.

E1 – mass A+C in leached solid

Y1 – mass C/mass of A+C in leached solids.

R1 – mass solution A+C in overflow.

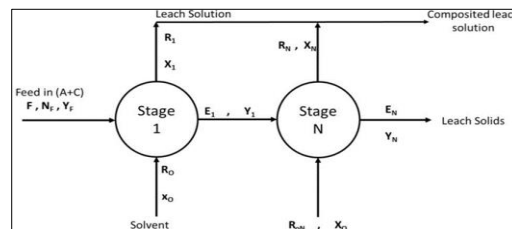X1 – mass C / mass A+C in the leach solution (overflow) Overall Material Balance

$$F + Ro = R1 + E1$$

Component Material Balance

$$F * YF + Ro * XO = R1 * X1 + E1 * Y1$$

Multistage Crosscurrent Leaching

Material Balance for stage 1 is similar to single stage Material Balance.

Material Balance of Stage N, Overall Material Balance, $E_{N-1} + RON = EN + RN$

Component Material Balance,

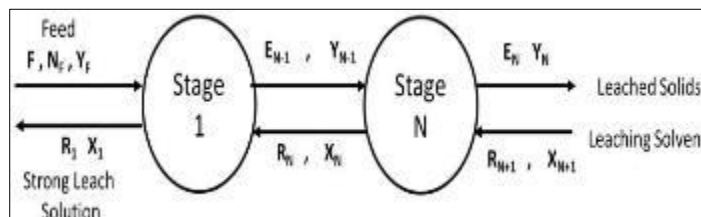$E_{N-1} * Y_{N-1} + RON * XO = EN * YN + RN * XN$

Multistage Countercurrent Leaching

Material Balance for N stage,

Overall Material Balance,

$E_{N-1} + R_{N+1} = EN + RN$

Component Material Balance,

EN-1*YN-1+RN+1*XN+1= EN *YN + RN *XN

Hot water may be used to extract sugar from sugar beets, while hexane or petroleum ether can be used as a solvent to extract oils from oilseeds such as soy beans. extracting tannin from tea leaves with water; extracting fragrance from flowers; In the drug industry, the roots, leaves, and stems of plants are used to produce compounds that resemble medication, such as fine medicines [34–36].

Extraction of Supercritical Fluids

This kind of extraction removes a portion from a matrix with the aid of a liquid. However, in this instance, the fluid is Supercritical Fluid. Supercritical Fluid Extraction (SCF) is often used to extract materials from solids, but it may also be used to extract materials from liquids. This type of extraction is used in analytical labs to prepare data for testing. More generally, it is employed to remove undesirable compounds (decaffeination) from the oil stream [38, 37]. In this extraction method, supercritical fluids are combined with certain sorted substances or compounds. A mobile phase results from this. The solvating properties of the mobile phase improve the situation when the temperature and pressure are near the critical temperature and pressure [39]. The supercritical fluid is: These fluids are too heavy to be compressed. The distribution of fluid pressure vs temperature is seen in Figure 7. In supercritical fluids, the temperature is higher and the pressure is higher than at the critical point. These fluids have a wide range of densities and flow very swiftly at high temperatures. Consequently, the characteristics related to density can be altered. A common liquid used in the decaffeination process is carbon dioxide. In contrast, water is employed as a supercritical fluid in the production of electricity [41, 42].
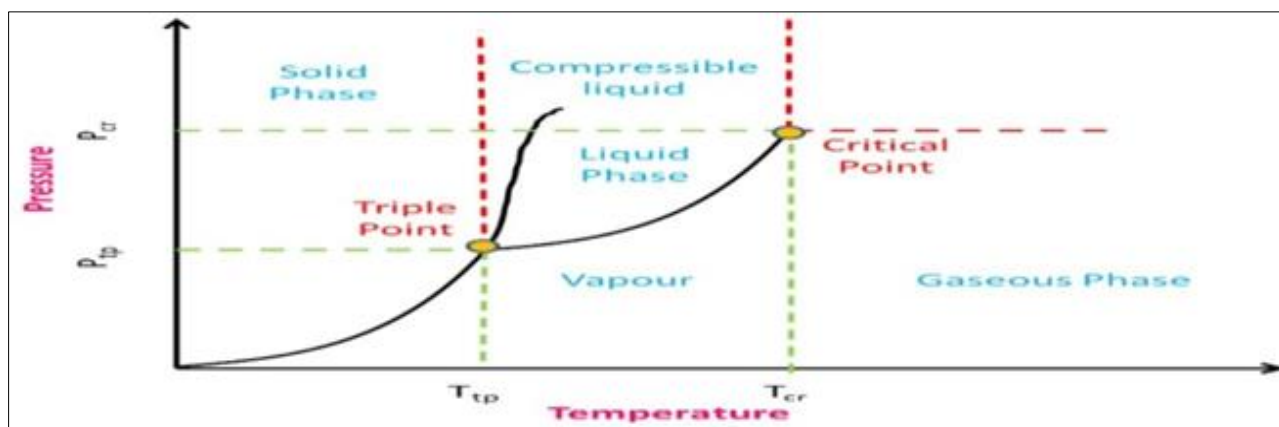

Figure 7 Pressure versus Temperature profile for Supercritical fluids

3.3. Solvents used in Supercritical Extraction

Table 4 The critical properties of the solvents are mentioned in the Table (4),[38]

Solvents	Molecular Weight (g/mol)	Critical Temperature (C⍰)	Critical Pressure (atm)	Critical Density (Kg/m3)
CO2	44.01	31.2	73	467.6
CH4	16.04	-82.6	45	162.7
Ethylene (C_2H_4)	28.05	9.2	50	214
CH_3OH	32.04	240.2	81	281
Acetone (C_3H_6O)	58.08	235	46.3	273

The procedure of using the Supercritical Fluid Extraction Method is simple. Only a third to a quarter of the time required for a typical extraction is required for a rapid extraction, which takes 30 to 60 minutes each sample. This approach captures the extract in a trap column and eliminates trace quantities of pesticides. The minimal extract can also be separated using the trap column. Following each set of procedures, the pipes and trap column are cleaned. This maintains the column as clear and obstruction-free as possible. Carbon dioxide is utilized as an extraction solvent for SCF extraction. It is inexpensive and quite clean. This procedure is safe and environmentally friendly since carbon dioxide doesn't burn. The properties of SFFs fall in between those of a pure liquid and a gas. For this reason, they are often referred to as "dense gases" or "compressible liquids" [42].

Property changes for a SCF

- He densities of liquids are 100–1000 times higher than those of gases.
- Higher diffusivities (10-3 and 10-4 cm2/s) than liquids.
- Strong solvating ability.
- Surface tension is decreased.
- Low viscosity—between 10 and 100 times lower than that of liquids.
- Gases have great penetrating power because of their compressibility features. SCF extraction has the benefit of being able to get rid of organic solvents, which lowers storage concerns.

Chemicals that don't change significantly can also be extracted and cleaned using this technique. Low operating temperatures (too hot) might potentially cause it to malfunction. Additionally, the solvent may be fully separated from the extract and raffinate phases via SCF extraction. The SCF extraction process is efficient and flexible when co-solvents and co-solutes are used. [39]. There are some problems. lengthy time (SCF quickly enters the solid, whereas solutes diffuse from the solid into the SCF); In order to reduce energy expenditures, the solvent must be compressed via intricate recycling procedures. The absence of basics makes scale impossible; model of solutes in SCF based on molecules; Cleaning will take a long time, and maintaining pressure in SCF is difficult [39]. Oleoresins, spice oil, perfumes, and flavored items may all be obtained from natural sources using the SCF extraction process. In addition, it is used to dry aerogels, color textiles, create normal and ultrafine particles, and extract caffeine from tea and coffee. Extremely precise metal components are cleaned using the SCF extraction process.

3.4. Extraction techniques

Pressurized liquid/fluid extraction, enzyme aided extraction, Soxhlet extraction, mechano-chemical assisted extraction, heat flux extraction, ultrasonic assisted extraction, microwave assisted extraction, and many more are among the several extraction technique kinds. Some of them are discussed in greater detail here [43].

3.4.1. Microwave Assisted Extraction Method

Principle

Two fields that oscillate at right angles to one another make up electromagnetic waves. These two types of fields are the magnetic and electric fields. These kinds of waves are employed to transport information or energy. Electromagnetic waves are absorbed by the substance and converted into thermal energy. Microwave power is this. The frequency range of microwaves is 300 MHz to 300 GHz. Ions are not produced by these radiation waves [43]. Electric energy is transformed into heat by two processes: dipole rotation and ionic conduction [44]. Ionic conduction is the movement of ions caused by an electric field in the presence of an electromagnetic field [45]. The sign of the electric field changes with the ions' direction. This stops the ion transport by causing molecules to collide. This causes friction, which raises the temperature of the solution. Polar molecules with a dipole moment try to align themselves with an applied electric field. We refer to this as dipole rotation.Thermal energy is released as heat molecules return to their initial condition when the electric field relaxes. This energy release causes the solution to warm [46]. An electric field alters the behavior of polar molecules, as seen in Figure 8.
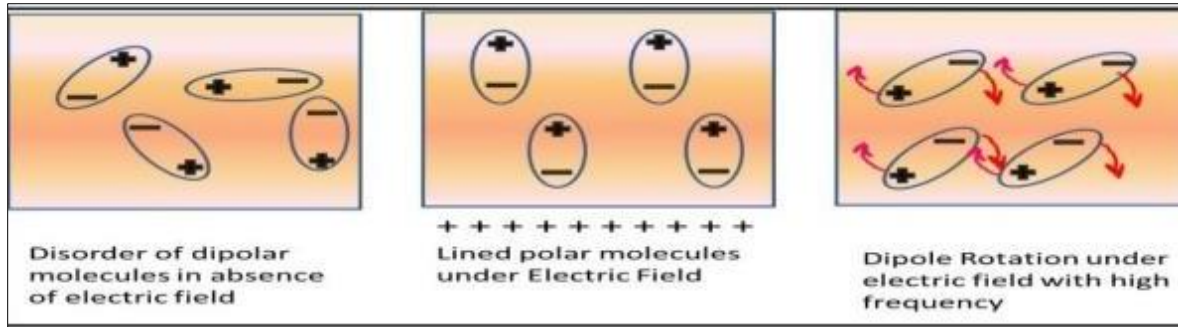
Figure 8 Dipole Rotation

4. The Microwave Extraction Process

Since dried plant material is utilized for extraction, some moisture is still present even though it has been dried.
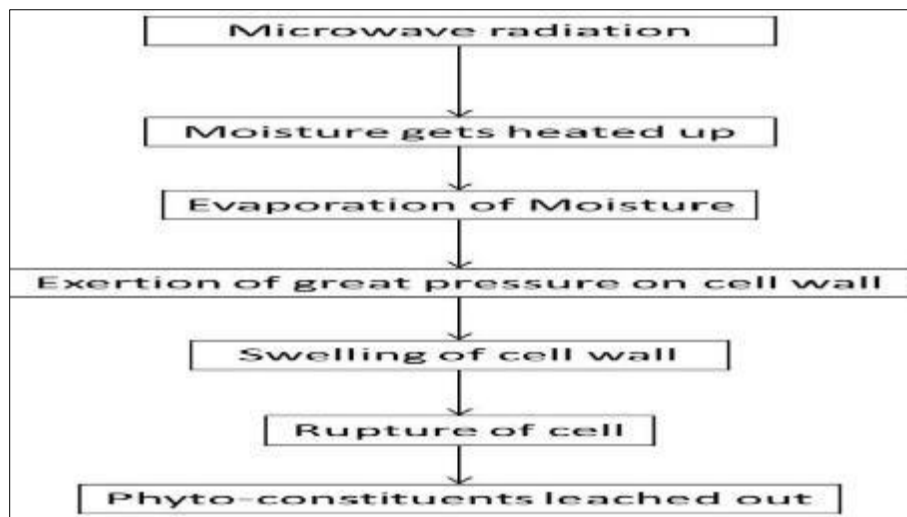

Figure 9 The Microwave Extraction Process

This moisture content is heated by the microwave event, which raises the internal pressure. The plant cell wall is under pressure, which causes the cell to enlarge. Should the pressure continue to rise, the cell will rupture. The solvent will then wash away the components inside the cell. Heating is more effective if the solvent is fully absorbed by the plant matrix. Focused microwave ovens, which treat just a small portion of the extraction vessel, and closed extraction vessels, which regulate the extraction, are the two types of equipment utilized in the microwave extraction process. Systems can be classified as either single-mode or multi-mode. The following image illustrates the processes involved in the microwave extraction procedure.

4.1. Factors influencing microwave extraction

- Solvent: A acceptable extraction rate is achieved by using the right solvents. The microwave extraction method uses a variety of solvents, including methanol, acetone, dichloromethane, gasoline ether, and others. Many liquids should be able to detect the analyte. The chromatographic processes and the extraction liquid should work together. The procedure is also affected by the fluid's dielectric properties and the quantity of solvent used. Therefore, maximizing this factor is the most important thing [48].
- Extraction time: When there are more analytes, their removal takes longer. After a specific period of time has elapsed for extraction or recovery, this also increases the likelihood of degradation; further extraction will result in the deterioration of crucial components. Different plant species require varying amounts of time to eradicate [48].
- Microwave power: The microwave should get just the correct amount of power—neither too much nor too little. This depends on the extraction's performance, which is determined by exposure duration and power. Experimenting to determine what works and what doesn't is the process of optimization [48].

- A matrix's characteristics: The extracted material's particle size ranges from 100µm to 2mm. The particles are smaller and the extraction is better when the surface area is larger. Both the grid's initial water level and its size have an impact on the procedure [48].
- Pressure and Temperature: The solubility increases and the solvent's surface tension and viscosity decrease as the solvent level rises. Due to the leaching of phytoconstituents into the material, the extraction recovery is high. Pressure is also a significant consideration because it is influenced by weather [48].

The application of the microwave extraction method

These are the substances that can be extracted with this technique [50]. The system is a modified home oven, and the volatile oils in the matrix include Mentha piperita and Thuja occidentalis. To aid in the extraction process, clear liquids are utilized. The system consists of an open and a closed vase, and the ethanol is produced from the leaves of Cyclocarya paliurus and Pistacia lentiscus. The extraction process requires 600W of power for an open tank. Citrus seninsus fruits serve as the matrix, while an open jar serves as the system.

The benefits and drawbacks of the microwave extraction method
The fact that microwave extraction requires less liquid and less time is its finest feature. Additionally, it recovers some of the solvent and is inexpensive to set up [49]. The main issue is that when the procedure is finished, there are still solid leftovers in the extractor. Therefore, additional procedures like centrifugation and filtration are required to facilitate the removal of the solid residue. It is not possible to process non-polar solutions. Additionally, volatile solvents cannot be used in this technique since they reduce the effectiveness of the microwave extraction approach [49].

4.2. Soxhlet's extraction method

Solids and liquids are continuously extracted. Thumble is composed of a substance that functions similarly to filter paper in that it retains particulates while allowing only liquids to flow through. The solid stuff that has to be eliminated is placed here. The thimble is then placed into the extractor. The vapors then begin to boil as a result of the organic solvent being heated in reflux. The condenser condenses the rising vapors further, filling the thimble even more. Until all of the materials that must be removed from the masses have been removed, this procedure is repeated again [37]. The Soxhlet Extractor [54] is composed of the following tools:

4.3. Soxhlet Extractor

4.3.1. Mantle Heater (Electric)
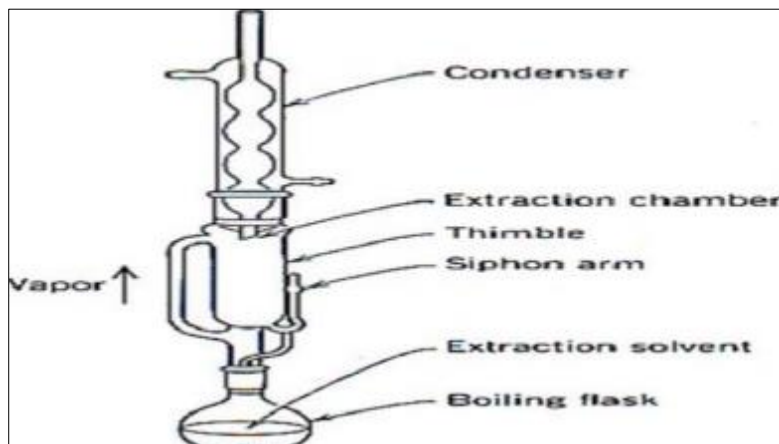
Water Condenser

Flash Evaporator

Figure 10 Soxhlet extraction apparatus

The solid material to be eliminated is placed in a thick filter paper thimble. After that, it is transferred into the Soxhlet extraction machine's main chamber. This equipment also includes a condenser. In a mantle heater, the heated vapor rises to the top of the room and is cooled by an attached condenser [54]. The solvent is recycled back into the cylinder by the condenser. Slowly, the heated solvent is injected back into the chamber containing the solid itemA pump arm automatically empties the Soxhlet extraction chamber once it is full. Until the desired amount of material is not removed,

these procedures are carried out several times each hour or daily [54].It is primarily utilized for solid-liquid extraction in a variety of fields, including food, medicine, and the environment. Many labs use this as a standard or reference method since it is the most widely used technique for extracting oil from various materials [37]. Among the system's advantages are its low cost, large solvent collection capacity, and ease of use and operation [37, 54]. Despite being a straightforward technique, Soxhlet extraction has several drawbacks. For instance, it takes a long time to dry and requires more liquid (200 ml) and time (8 hours). Furthermore, it cannot be mechanized. The heating medium should be as cool as possible in this method to prevent the solvent from boiling and the vapors from beginning to evaporate. This is another mistake. This will prevent the solvent from being squandered and the extracted solutes from degrading too fast [37,54].

4.4. Pressurized Liquid Extraction (PLE)

4.4.1. Principle

Pressurized liquid extraction requires a lot of pressure and heat. In these circumstances, the fluid maintains its liquid state. The temperature and pressure of the liquids are below the critical values [52]. This technique is also known as pressurized fluid extraction, pressured hot solvent extraction, and rapid solvent extraction. PLE is a quicker extraction technique than the standard approach. Compared to the conventional method, a significantly less quantity of solvents is required. When heated or subjected to extreme pressure, solvents change properties. Surface tension and viscosity decrease as mass transfer rates and test solubility increase. Extraction rates are increased when these factors occur.

4.4.2. Factors affecting PLE process

In addition to being environmentally safe, solvents should be carefully selected based on their particular requirements. Safe liquids such as ethanol, ethyl lactate, or d-limonene are ideal. The most environmentally friendly fluid available is water. Temperature and pressure are the most crucial factors in maintaining the solvent's liquid condition. The results remain mostly unchanged if the pressure increases above a specific threshold. Typically, a pressure of 5 to 10 MPa is used. After temperature and pressure, extraction time is another factor that requires consideration and improvement. The amount of time the solvent is in close contact with the matrix, once the extraction's temperature and pressure have been adjusted, is the effective extraction time. For example, extracting bioactive compounds from natural sources takes 5 to 20 minutes [51]. To determine the ideal value for this number, a variety of experiments should be conducted. The extraction's efficiency does not increase after the effective extraction period has passed. Numerous other aspects should also be considered, including the mass transfer rate, sample particle size, and so on [51, 52]. Dispersants are added to the extraction cell together with the sample. This improves the extraction yield and ensures that the liquid is distributed uniformly.

4.4.3. Equipment used of PLE process

Following are the equipment's used in Pressurized liquid extraction process:[51]

- Pump
- Extraction cell
- Oven

4.4.4. A Collection tube or Collection vial

Solvent is introduced into the system using a pump. This pump shouldn't be harmed by the selected pressure. When the procedure is finished, the pump can also push or move the extract away. The extraction cell is where the extraction procedure is carried out. The cell operates at high pressure and contains on/off valves. The extraction cell is heated to the proper temperature in the oven. The maximum temperature at which it can function is around 200oC. The collecting tube receives the material once it has been removed from the extraction cell [51]. When extraction is ongoing, heating coils can also be utilized to warm liquids. After extraction, the liquid can alternatively be released using nitrogen. The materials used to make instruments are corrosive and resistant.
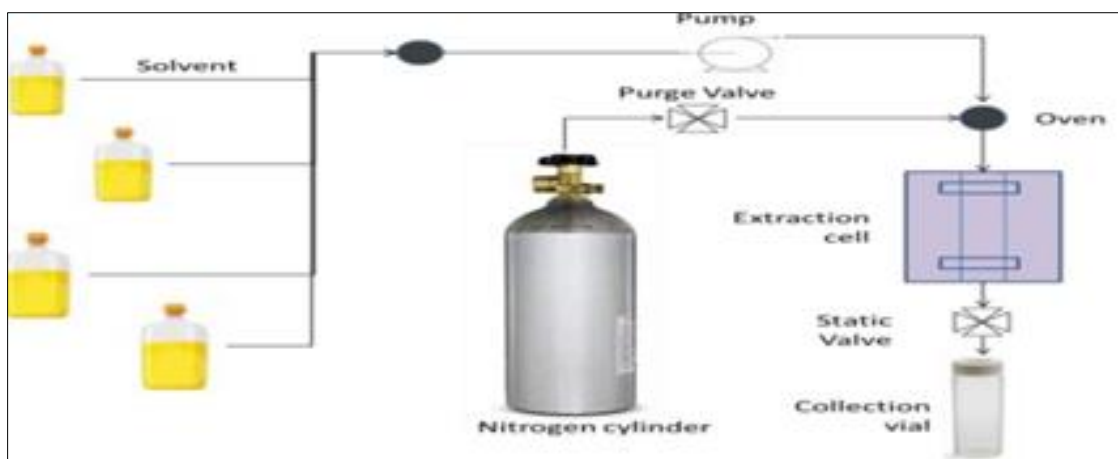
Figure 11 PLE process

4.5. Ultrasound extraction (sonication)

4.5.1. Principle

Ultrasound with frequencies between 20 kHz to 2000 kHz is used in this procedure; this causes cavitations and enhances the permeability of the cell. Ruwolfia root is extracted using this method, which is limited due to its expensive cost even though it is effective in many situations, such as the extraction of antioxidants and anthocyanins and in the field of nanotechnology.

4.5.2. Advantages and Disadvantage

Higher extraction yield, quicker kinetics, and lower operating temperatures—all of which enable the separation of chemicals that degrade readily at high temperatures—are just a few advantages of ultrasound extraction. Because they function effectively and need the fewest solvents feasible, little quantities of ingredients are utilized, increasing the production of the sample [43]. Active compounds can also be recovered and cleaned up using the ultrasonic extraction technique [43]. Compared to other novel extraction techniques, such as microwave-assisted extraction, the ultrasonic equipment is less costly and simpler to use. The fact that ultrasonic radiation (more than 20 kHz) can sometimes and severely damage the active ingredients of medicinal plants by generating free radicals that alter drug molecules in undesirable ways is one issue with these treatments.

4.6. Application

Cells are broken apart and sulfur is extracted from crude oil using ultrasound extraction. Additionally, sonication can initiate crystallization and even control polymorphism crystallization. This process is used to clean these materials as well as to produce biofuels, plant oil, and nanoparticles such as liposomes and nano emulsion from wastewater.

4.7. Comparisons Of Extraction Techniques

Various extraction techniques for recovering chemical components from solid samples are compared. The Soxhlet technique of extraction takes six to twenty-four hours to perform for a sample weighing around ten grams. As solvents, 150–300 milliliters of acetone and hexane are utilized, and acetone and dichloromethane (DCM) are combined in a 1:1 (vol/vol) ratio. For substances like methanol and toluene, the appropriate dosage is 1. In essence, this procedure is a set of sequential stages carried out for 10:1 samples (vol/vol). In this instance, the oil is removed via burning. This method is essentially carried out one step at a time, however if there are several components, they might be carried out simultaneously. The development of this technique is quick, and it doesn't require a lot of equipment or expertise from the user. However, compared to the Soxhlet Method, the Sonication procedure, also known as the Ultrasonic assisted Method, requires less time to extract. Each sample weighing between 2 and 30 grams requires 3 to 5 minutes of extraction time. In this instance, the quantity of each solvent mixture employed is the same. There are only a few solvents used—roughly 5–20 ml. The extraction techniques are then carried out using the ultrasonography approach. The ultrasonic extraction method may be applied to both continuous and batch operations. Similar to the Soxhlet Extraction method, the Sonication process is inexpensive, time-efficient, and skill-based to set up and operate. The solvent in the Supercritical Fluid Extraction process is carbon dioxide. It takes 30 to 60 minutes each sample to extract 1 to 10 grams of sample mass.

For extraction, ten to twenty milliliters of solvent are needed, along with pressure and heat. Only batch operations are carried out in this procedure. Because it takes longer to construct, costs more, and needs more talent, this approach is more challenging to utilize than the other two. Microwave-assisted extraction requires 50 minutes for up to 40 samples with a mass of 2–10 grams. There are around 25 to 45 milliliters of solvent utilized. Similar to Supercritical Fluid Extraction, this approach uses pressure and heat techniques. Up to 40 units can be extracted simultaneously using this method. Compared to other processes, this one takes a long time to develop.Instead, the cost of the instrument and operator skills are moderate. For a sample mass of 30 grams, the extraction period for pressurized fluid extraction is around 12 to 15 minutes. This technique uses a variety of liquid combinations in varying proportions. Here, extraction is accomplished with the aid of heating and pressurization, and around 25 milliliters of solvent are used. This approach uses both continuous and batch combinations. Low operator skills are needed, and the process development time and instrument cost are considerable.

5. Conclusion

Because it uses the appropriate solvent to separate the required components of a mix, the extraction process is an essential component of many businesses.Because the extraction process is so helpful in so many areas—chemicals, pharmaceuticals, wastewater treatment, polymers, petroleum, petrochemicals, food, metals, inorganics, nuclear, and more—it is difficult for any process to proceed without it. Depending on the characteristics of the elements that must be eliminated, it is crucial to thoroughly research the extraction techniques.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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