# Green Chemistry and Its Implementation in Pharmaceutical Analysis

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***Abstract:*** ***As stated in this abstract, the objective of green chemistry is to reduce the amount of chemical pollutants discharged into the environment. Green chemistry's potential to produce safer specialized chemicals and improved chemical industry procedures are also covered. Green chemistry (GC), which was founded on 12 concepts in 1998, seeks to minimize the use of dangerous substances in chemical reactions and products. With an emphasis on direct analytical techniques that involve little or no sample preparation—"the most polluting" step—and research that either minimized the use of hazardous solvents or substituted them with safer, more environmentally friendly solvents, this review outlines the application of GAC principles in pharmaceutical analysis. High-pressure liquid chromatography (HPLC) generates enormous amounts of dangerous organic waste. It is necessary to optimize analytical methods for speed, accuracy, sensitivity, reproducibility, and versatility***

***Index Terms- Chemicals, Green Chemistry, HPLC, Pharmaceutical analysis***

## I. INTRODUCTION

Paul Anastas defines "Green Chemistry" as "the design of chemical products and processes that are more environmentally benign," fulfilling criteria for reducing negative impacts on the environment and human health. Green chemistry is independent of novel technologies such as fluorous phase chemistry, biotransformation, microwave chemistry, supercritical fluids(Jessop PG L. W., 2008 )., ionic liquids, or biotransformation. Green chemistry lies not in the methods employed, but in the purpose and outcome of technical application. A chemical process that is reliable, effective, and economical is probably considered to have good process chemistry. Potential improvements in terms of environmental performance are always shown by the same process when it is more closely investigated in relation to the twelve principles of Green Chemistry.

## II. WHAT IS GREEN CHEMISTRY

Green chemistry is the design of chemical goods and procedures that reduce or do away with the use of or production of dangerous substances. Green chemistry applies to a chemical product's entire life cycle, including design, manufacturing, usage, and disposal.

- Prevents contamination at the molecular level.
- Implements creative scientific solutions to real-world environmental concerns.
- Design chemical products and processes to decrease their inherent dangers.

## III. PRINCIPLES OF GREEN CHEMISTRY

- Garbage minimization: Eliminating waste creation is always preferable to dealing with it after it has been created.
- Safe chemical design: Involves taking great care to ensure that the chemicals are as non-toxic to people and the environment as feasible while creating goods with a specified purpose.
- Real-time analysis integration: Methods and analytical approaches must be developed to the extent that they can supply real-time data for their supervision. This allows the individuals involved to halt or regulate the process before hazardous or damaging substances are produced.
- Atom economy: Synthetic procedures and methods that employ green chemistry as a means of production must constantly aim to maximize the use of raw materials and their integration into the finished product. To reduce the amount of waste produced by any operation, this needs to be adhered to strictly.
- Integration of Catalysis: The use of chemical catalysts and catalytic reagents must be promoted in order to lower the energy

requirements of the chemical processes in the process.

- ❖ Renewable feedstock incorporation: It is imperative to prioritize the utilization of renewable raw materials and feedstock over non-renewable resource usage.
- ❖ Safe solvent and accessory design: Processes should try to avoid using auxiliaries as much as attainable. They must be optimized to be as non-hazardous as feasible, even in situations where their deployment is imperative.
- ❖ Design of secure solvents and auxiliaries: Process auxiliaries should be used as little as possible. They should be designed to be as safe as possible, even in situations where they are unavoidably necessary to use.
- ❖ Preventing the production of hazardous chemicals: Toxic substances that pose risks to human health can be synthesized through reactions and processes that need to be optimized. This will help avoid the development of such substances.
- ❖ Creating chemicals for degradation: Care must be taken to ensure that a chemical product is not a pollutant to the environment when it is being designed to fulfill a certain purpose. Ensuring that the chemical decomposes into non-toxic components is one way to do this.
- ❖ Safe chemistry integration to prevent mishaps: It's critical to ensure that the materials utilized in chemical processes are safe to employ while developing new ones. This can assist in averting some workplace mishaps, such fires and explosions. Moreover, this can contribute to creating a safer setting for the procedure to occur in.
- ❖ Energy efficiency: It is imperative to reduce the process's energy usage as much as possible.


Figure 1: 12 Principles of green chemistry

The impact of green chemistry on the environment and Green chemistry

Green chemistry yields significant cost benefits by minimizing the amount of resources required for analytical processes, including solvents, solutions, water, and organic compounds, as well as their storage. In pharmaceutical analysis, waste can be converted to clean waste by using GAC to replace dangerous chemicals with safe, environmentally favorable substitutes (Tobiszewski M, 2012). In order to return pharmaceutical analysis leftovers to the environment with minimal negative consequences, recycling and pre-treatment are necessary. Recycling, whether done offline or online, is therefore necessary and has the extra advantage of recovering costly and dangerous chemicals. Recyclable materials shouldn't, however, compromise methodology precision and accuracy or lower sample throughput. Conversely, pharmaceutical activities affect the populace on various fronts and in various ways. Drug preparation involves the use of reagents, solvents, operators, and patient-affecting techniques (Płotka J, 2013).

Chromatographic methods and their implementation in green chemistry:

The two primary forms of chromatography are liquid chromatography (LC) and gas chromatography (GC). Analytical or preparative uses are possible for both varieties. Compounds that are volatile and semi-volatile can be analyzed using GC. Green chemistry principles can be applied to gas chromatography (GC) by minimizing the number of solvents used, forgoing pre-treatment during the sample preparation step, and choosing the most environmentally safe carrier solvent—typically helium (He) due to its advantageous chromatographic properties, which include high optimum linear velocity, non-toxicity, non-flammability, inertness, and safety during handling (de Marco BA, 2019).

## IV. HAZARDOUSCHEMICALS EXPELLED FROM VARIOUS PHARMA COMPANIES

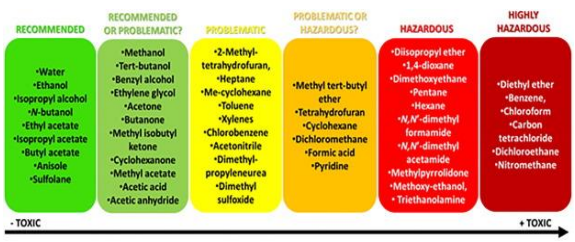


Figure 2 : Toxic ranges of various chemicals

| Chemicals - Toxic levels |
|---|
| Solvents |
| 1 . Methanol (MeOH) - 100-200ppm(0.1-0.2%) |
| 2. Acetonitrile(ACN) - 50-100 ppm(0.05-0.1%) |
| 3. Dichloromethane (DCM) - 50-100ppm(0.05-0.1%) |
| 4.Toluene - 50-100 ppm (0.05-0.1%) |
| Heavy metals |
| 1.Lead(Pb) - 0.1-1.0 ppm (0.01-0.1%) |
| 2.Mercury(Hg) - 0.1-1.0 ppm (0.01-0.1%) |
| 3.Arsenic(As) - 0.1-1.0 ppm (0.01-0.1%) |
| 4.Cadmium(Cd) - 0.1-1.0 ppm (0.01-0.1%) |
| Volatile organic compounds |
| 1.Benzene - 0.1-1.0 ppm (0.01-0.1%) |
| 2.Ethylacetate - 50-100 ppm (0.05-0.1%) |
| Other hazardous chemicals |
| 1.Formaldehyde - 0.1-1.0 ppm (0.01-0.1%) |
| 2.1,4-Dioxane - 0.1-1.0 ppm (0.01-0.1%) |

Green analytical chemistry

It is clear that, in terms of apparatus, some analytical techniques are regarded as being more ecologically friendly than others. Flow Injection Analysis (FIA) is one such method that is favored over conventional High Performance Liquid Chromatography (HPLC). Sequential Injection Analysis (SIA), Capillary Electrophoresis (CE), and Capillary Electrochromatography (CEC) are other techniques that have been suggested as the environmentally friendly substitute for analytical chemistry techniques that rely on organic solvents.

The two organic solvents most frequently used in HPLC are methanol and acetonitrile. The latter requires a costly, specific chemical technique to detoxify it due to its toxicity. The latter is dangerous to people and has detrimental effects on the ecosystem. Replacing separation procedures makes them more environmentally friendly. There are two ways to view the relationship between green chemistry and analytical chemistry.

Green chemistry is controlled and justified by the study of analytical chemistry. However, chemical analysis techniques produce waste and need energy, reagents, and solvents. Anastas and Warner's(Anastas PT, 2000). proposed green chemistry concepts are closely tied to analytical chemistry, with the most significant of these being prevention of waste generation; safer solvents and auxiliaries; design for energy efficiency; safer chemistry to minimize the potential of chemical accidents

Analytical chemistry can thus be the subject of a green chemistry approach, much like other branches of chemistry and chemical technology, and it also becomes an object of application of green chemistry concepts. J. Namiesnick coined the phrase "green analytical chemistry" in(J. N. , 2001)(de la Guardia M, 2012 ). discussing several facets of environmentally friendly analytical chemistry.

## V. GREEN ANALYTICAL METHODOLOGIES

The study of GAC techniques includes several tactics to reduce or completely do away with the use of hazardous materials as well as the production of garbage. As the primary emphasis has been on creating new strategies to reduce the number of side goods and to swap out hazardous solvents.

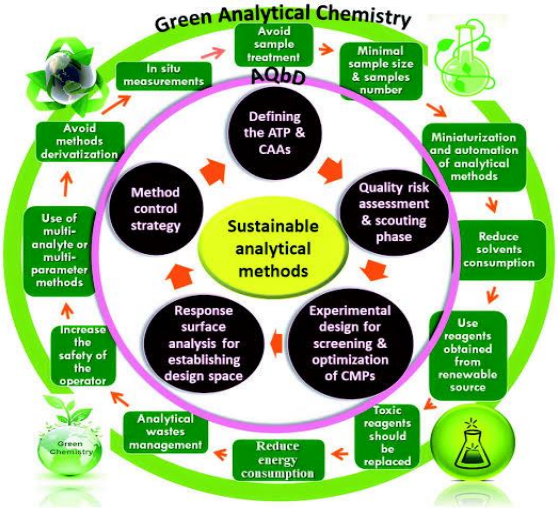


Figure 3 : Green analytical chemistry

1. Screening Methodologies :-It is evident that one of the GAC's goals is to minimize the quantity of samples that require traditional, non-environmentally friendly analysis. Approachable techniques as well as to lessen the waste produced as a consequence. However, this reduction in the number of samples for analysis needs to be done in a safe setting.

From this angle, It's noteworthy to bring up immunoassays (IAs), which were initially created for surveillance blood insulin levels in 1960 and are typically used to ascertain in clinical chemistry medicines, viruses, and hormones in biology samples. The most popular technique for IA is the immunosorbent enzyme-linked ELISA assay. The primary benefit of those analytical screenings based

on biology methods is the total substitution of aqueous media using organic solvents and the resulting decrease in hazardous waste.

- Atomic emission spectrometry (ICP-AES) and inductively coupled plasma X-ray fluorescence, which offer superior qualitative or semiquantitative results without the need for pretreatment mass spectrometry, or ICP-MS are the most perceptive, discerning methods pertaining to several elements identification of many elements within the identical sample.
- Ion-mobility spectrometry (IMS) is typically utilized for explosives screening at airports and the identification of products of pyrolysis, identifying substances for the defense sector, such as agents of war, and tracking the emissions from stack gases in business.

2. Replacement of Toxic Reagents :- By automating and reducing flow-based procedures and replacing polluted reagents with non-toxic ones, greener analytical methods have become feasible. Leaf extract from guavas has been utilized as an new natural reagent substitute for the FI measurement of Fe without the requirement for additional cleansing.

One method of doing away with harmful reagents has been suggested: using SPE in conjunction with FIA systems. A multi syringe FI (MSFI) technique that is time-based was created for automating sorbent separation from disks phenol isomers that have been nitro-substituted, then simultaneous online determination of specific species utilizing a diode array spectrophotometry. Target analytes were enriched online and removed using this approach. of matrix elements that could potentially interfere. An was used to elute the nitro phenol isomers. Alkaline solution and UV-vis spectrum measurements were logged. In order to deconvolve significantly overlapping spectra, regression models with many variables.

3. Minimization of Wastes :- Since it is challenging to substitute every hazardous reagent used in chemical analysis, lowering the amounts utilized is especially crucial. This is how multi commutation worksis advantageous in that it minimizes both reagent usage and the production of trash. It is possible to create multi commuted flow networks. Using replicable solenoid micropumps the tiny volumes of dissolved liquids, hence decreasing the automated methods' scale.

4. Recovery of Reagents :-Reagent recovery is a good means of reducing the adverse impacts of analytical procedures because it is an a crucial step in reaching zero emissions during study. Laboratory wastes are not thrown away immediately albeit they are handled offline, enter the environment. But this routine lengthens the running expenses of testing facilities and establishes a issue due to the buildup of poisonous leftovers. An environmentally friendly substitute for rubbish disposal, consequently online solvent recovery and hazardous or pricy reagents.

5. On-Line Decontamination of Wastes :-As previously mentioned in the context of GAC, particular attention should be given to evaluating the environmental impact of new strategies in addition to conventional objectives (e.g., precision, sensitivity, accuracy, and LODs). In 1994 saw the proposal of various flow techniques required more work to detoxify wastesproduced. In essence, online therapy for adding a disinfection stage is wastefulfollowing analytical measurement to produce a clean waste. In 1999, to detoxify wastes on-line, it was suggested using;Thermal degradation,Oxidative detoxification,Photo degradation, and Bio degradation.

6. Reagent-Free Methodologies:-The greatest choices for making analytical decisions more environmentally friendly may be those that rely on direct measurements of untreated samples. Utilizing FT-Raman spectroscopy, employed as a technique devoid of reagents. Mancozeb in agricultural chemicals was also identified using a solvent-free method called photo acoustic Fourier-transform infrared spectroscopy, or PAS-FT-IR. The approach comprised direct finding the transmittance spectra of solid specimens. Additional reagent-free techniques suggested is photo-induced mercury in the literature,creation of chemical or cold vapour (PI-CVG), which employs a reductant made of sample matrix.The new approach is predicated on the mercury reduction using wine ethanol radiation under UV light. The standard-addition method was employed to accomplish real sample analysis the aim of reagentfree.

Energy dispersion X-ray fluorescence, or "green" approach, cannot be used to directly ascertain the elemental makeup of a sample. But it's evident that these measurements entail no sample handling and is possible without producing wastes.(Armenta S, 2008).

Methodologies:-

1 )HPLC

2 )FTIR

1)HPLC in a green analytical way :-

By using environmentally friendly techniques, analysts can develop chromatographic techniques that work with standard HPLC equipment. Green analytical process (GAP) concepts must be incorporated into the creation of green chromatographic methods, and traditional HPLC methods must be converted into environmentally friendly alternatives, according to the pharmaceutical industry's development plan.

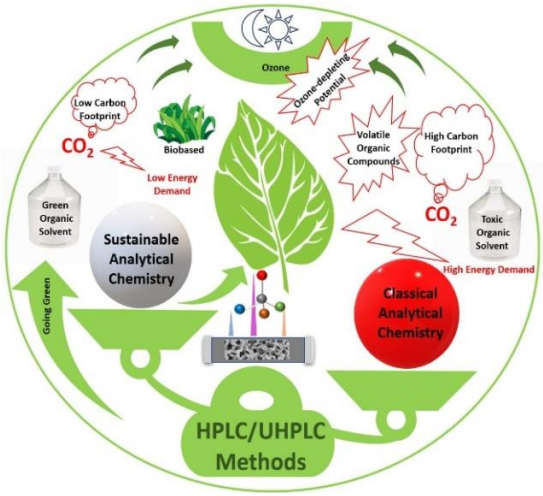


Figure 4: green chemistry in HPLC methods

Chromatographic techniques for applying GAC principles have become more sophisticated over time. The green analytical procedure index (GAPI) can be used to quantify the environmental impact of the entire analytical process, from sample collection to result.

The GAPI tool provides detailed information on investigated activities in addition to an instantly evident perspective for the user/read(J., 2018).

USE OF GREEN SOLVENTS IN HPLC

Eluents for the mobile phase of Reversed Phase-High Pressure Liquid Chromatography (RPHPLC) require a significant quantity of organic solvents.

The two chemical solvents that are most frequently utilized in the RP-HPLC mobile phase are acetonitrile cluster (ACN) and methanolic acid (MeOH). An alcohol that is poisonous and can harm the visual nerve is methanolic acid. There is a shortage of ACN because acrylonitrile decreases manufacturing by producing ACN as a byproduct.

When it comes to the mobile phase, organic solvents such as ethanol, acetone, ethyl acetate, glycerol, 2-propanol, and propylene carbonate (PC) are used as ecologically friendly substitutes for typical organic solvents. Compared to ACN and MeOH, EtOH is less toxic when inhaled and has a lower vapour pressure, making it more environmentally friendly and biodegradable. EtOH is the most preferred green substitute for MeOH and ACN in drug analysis RP-HPLC(Yabré M, 2018). A green aprotic reagent with high polarity, propylene carbonate can replace hazardous polar aprotic reagents. With its higher separation power in 2D LC and ability to replace acetonitrile, propylene carbonate is a viable alternative that offers more applications.

Glycerol is an organic solvent that is used as a mobile phase changer to quantify vitamin C and L-glutathione in tablets and in green chromatographic techniques to separate antiviral medications. Because of its low flammability and excellent stability, glycerol is a safe, non volatile diluent that is appropriate for environmentally friendly LC techniques.

USE OF PURE WATER IN HPLC

An environmentally favourable choice for the LC mobile phase is pure water. It is the most environmentally friendly solvent available.

Two techniques allow for the use of pure water as an LC elution solvent. When employing custom-pure water as the solvent for LC elution, the initial step is to raise the temperature in conjunction with stable stationary phases. Subcritical water chromatography (SCWC) or superheated water chromatography (SHWC) are the names given to this kind of chromatography.

The second one is based on utilizing clean water at normal temperature, which is less than 60°C(Bocian S, 2019).When using silica-based stationary phases, follow the instructions for aqueous liquid chromatography (PALC).

Figure 5: HPLC instrument

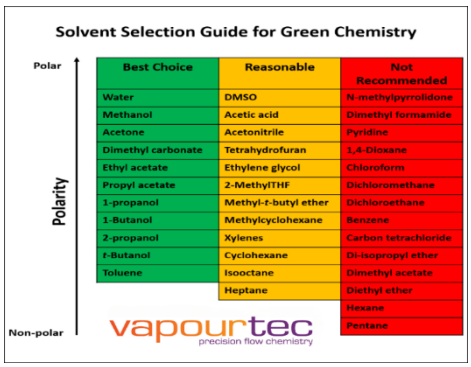


Figure 6: Solvent selection guide for green chemistry.

In order to separate polar chemicals, purified water was used as the mobile phase in a mixed-mode polar embedded column. The ion-exchange functional groups affixed to the terminal end of the long alkyl chains that make up this column's reverse phase and ion-exchange characteristics are generated from these chains.

USE OF SURFACTANTS IN HPLC

Surface tension is reduced by surfactants, which are bipolar compounds. When their concentration is low, they generate micelles.

Surfactants have various applications in analytical chemistry, including Micellar Liquid Chromatography (MLC). MLC is an effective method for becoming green with HPLC procedures since it is ecological, non-hazardous, and contains components with low concentrations of biological pollutants in the environment. The most common surfactants used as eluents in MLC are the cationic acetyl trimethyl ammonium bromide (CTAB), the anionic sodium dodecyl sulphate (SDS), and the non ionic polyoxyethylene-23-lauryl ether (Brij-35).The working column temperature should be greater than the Kraft point in order to decrease the retention duration and improve separation efficacy(Nasr ZA, 2021). Brij-35 lessens the negative charge that the anionic surfactant SDS leaves on the stationary phase's surface in order to keep the column's charge neutral.

2) A Green Tool for Drug Quantitative Analysis:

FTIR Spectrophotometry

Figure 7: FTIR Instrument.

Experiment on Amoxicillin:

Equipment: This spectrophotometric investigation was conducted using an FTIR Shimadzu (Kyoto, Japan) IR Prestige-21 model spectrophotometer.This equipment was linked to a computer to use the “IR Solution” program for analysis of the spectra. Development of calibration curves was performed using Microsoft Excel (2013). The following other equipment is also in use: Oven ECB 1.2Digital and H51 analytical balance.

Chemicals and Reagents: A Pharmaceutical Enterprise Amoxicillin reference standard (AMX RS), which has a purity of 98.9%, and amoxicillin (AMX) in a prescription dosage form of 500 mg per capsule. This pharmaceutical dosage form contains adjuvants such as magnesium stearate, sodium lauryl sulphate, and croscarmellose sodium, all of which were acquired from Sigma-Aldrich (São Paulo, Brazil). Additionally, analytical grade potassium bromide (KBr) was utilized.

Qualitative analysis: The spectrophotometer described in Equipment was used to carry out the procedure. A 150 mg pellet (at 2 mg/pellet) was produced by precisely weighing 2.0 mg of AMX RS and homogenizing it with 148.0 mg of KBr that had previously been ground into a powder and dried in an oven at 105° C to constant weight. This mixture was then compressed for 10 minutes using a mechanical press to produce a translucent pellet. The analysis was conducted in transmittance, and the spectrum was obtained using “IR Solution” software (Shimadzu, Kyoto, Japan). The same procedure was carried out with amoxicillin in capsules. Translucent pellets were obtained by compressing each combination for ten minutes using a mechanical press. This method was utilized to identify the best

spectral region (one free from adjuvant interference) to be employed in the quantitative analysis. The spectral region included in the study was from 4000 to 400 cm−1 (the mid-infrared region).

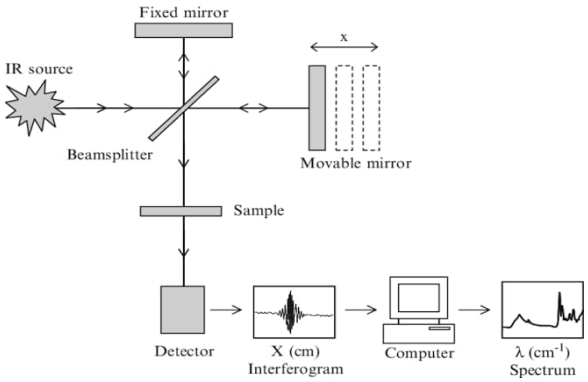


Figure 8: Block diagram of FTIR instrument

*Quantitative Analysis:*

A) Acquiring the Calibration Curve- The spectrophotometer listed in the "Equipment" section was used to carry out the method. As KBr pellets containing the medication, the samples were examined. Once the mid-infrared range (4000–400 cm−1) spectrum was obtained, the spectral region ranging from 1815.0 to 1736.0 cm−1 was chosen. This region corresponds to a distinctive band of the amoxicillin molecule (carbonyl), and its height was quantitatively assessed in terms of absorbance. Five amoxicillin concentrations were chosen for the analytic curve during the preliminary testing, as follows: mg/pellet of0.5,0.75,1.0, 1.25, and 1.50.

B) Determination of the amoxicillin pharmaceutical dosageform-
Equation (1) and Equation (2) were used to calculate the amount and % of amoxicillin in the capsules:

$$Cs = As \times CRS/ARS \quad (1)$$

$$Cs\ \% = Cs \times 100/Ct \quad (2)$$

where Ct is the theoretical concentration of AMX in the sample (mg/pellet), As is the absorbance of the AMX sample pellet, CRS is the concentration of AMX RS solution (mg/pellet), ARS is the absorbance of the AMX RS pellet, Cs% is the percentage concentration of AMX in the sample, and As is the absorbance of the AMX sample pellet.

Validation of Methods- In accordance with Brazilian law and ICH principles, the following factors were examined in order to verify the method: linearity, precision, accuracy, robustness, and selectivity ((R1):, 2005).

1)Linearity- To confirm the linearity of the procedure, five distinct AMX RS concentrations (0.5 to 1.5 mg/pellet) were examined over three different days.
Linearity and linear regression of least squares were verified using ANOVA statistical analysis.

2)Precision-There were two methods used to evaluate precision: repeatability (within a day) and intermediate precision (between and within a day). Using the same experimental conditions, six AMX RS pellets were analyzed across three different days at a dose of 1.0 mg each to get inter-day precision. The level of similarity between the absorbances measured on various days was evaluated using analysis of variance (ANOVA). To evaluate the precision between the analysts, two separate analysts analyzed six AMX RS pellets (at 1.0 mg/pellet). To compare the absorbances, the t-test and Ftest were employed.

3)Accuracy- Accuracy was evaluated by examining AMX RS recovery in triplicate at three distinct levels (R1, R2, and R3), which ranged from 80 to 120% of the method's working concentration (1.0 mg/pellet). The instructions are followed for preparing the pellets for the recovery assay. The Association of Official Analytical Chemists (AOAC) formula was used to calculate the recovery percentage (GW).

4)Robustness- The capacity of a method to remain dependable even when slight adjustments are made to the analytical parameters is termed as robustness. The workroom's temperature was varied between 21 °C and 26 °C with the air conditioning on and off, the pellets' compression time was adjusted between two and three minutes, and the KBr brand (Shimadzu) was used. For this, each of the previously mentioned conditions was examined using six AMX RS pellets at a dose of 1.0 mg/pellet. Using the F-test and t-test to compare the results to normal working conditions, the similarity of the results was assessed.

5)Selectivity- Selectivity analysis was used to evaluate the method's capacity to measure the drug in the presence of the adjuvants present in the pharmaceutical dosage form of the capsule. Qualitative Analysis already explains the methodology used.

RESULTS

Table 1: Preparation of pellets for the recovery assay of the method of FT-IR spectrophotometry for amoxicillin

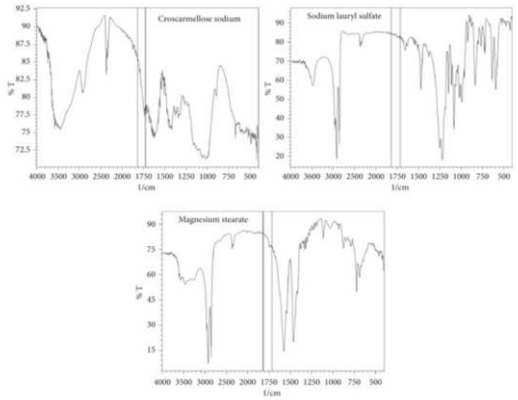


Figure 9 : Overlay of the absorption spectra of the AMX RS and sample.

TABLE: 1

| | AMX sample (mg) (diluted 1 : 10 w/w in KBr) | AMX RS (mg) (diluted 1 : 10 w/w in KBr) | Amount of KBr (mg)[1] | Final theoret concentra (mg/pel |
|---|---|---|---|---|
| Sample | 5.0 | – | 145.0 | 0.50 |
| R1 | 5.0 | 3.0 | 142.0 | 0.80 |
| R2 | 5.0 | 5.0 | 140.0 | 1.00 |
| R3 | 5.0 | 7.0 | 138.0 | 1.20 |
| Reference standard | – | 5.0 | 145.0 | 0.50 |

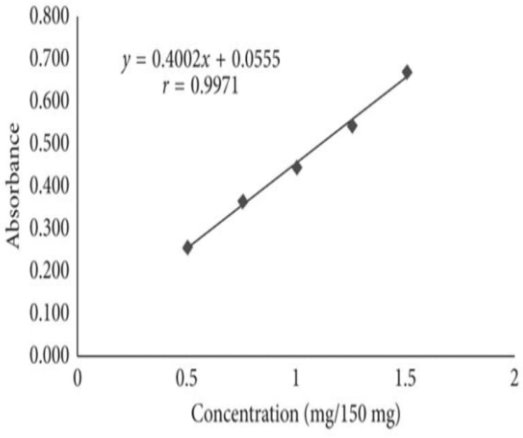


Figure 10: Absorption spectra of adjuvants

TABLE: 2

| Interday | | | Between analysts | |
|---|---|---|---|---|
| Day 1 | Day 2 | Day 3 | Analyst 1 | Analyst 2 |
| 0.466 | 0.447 | 0.424 | 0.466 | 0.447 |
| 0.472 | 0.417 | 0.456 | 0.472 | 0.417 |
| 0.458 | 0.413 | 0.445 | 0.458 | 0.413 |
| 0.437 | 0.445 | 0.436 | 0.437 | 0.445 |
| 0.436 | 0.447 | 0.417 | 0.436 | 0.447 |
| 0.432 | 0.417 | 0.457 | 0.432 | 0.417 |

Qualitative Analysis: Figure 9 shows an overlay of the absorption spectra of the AMX RS and sample. Figure 10 displays the absorption spectra of each adjuvant present in the capsules. the spectral range chosen for quantitative analysis (from 1815 to 1736 cm−1 ) is also identified in both figures.

IV. Applications in pharmaceutical and cosmetics analysis -

Titrimetric methods :

Numerous pharmaceutical companies continue to employ titration as a conventional analytical approach. To make the titration method more environmentally friendly, trials were conducted. To assay the chloride ion, for instance, Rojanarata et al. created a miniature microscale chemistry-based design of Volhard's titration. Safer reagents were substituted for the toxic ones, and the titration was reduced to a few milli litres(Rojanarata T, 2011).

A method that is environmentally friendly was developed by Lima et al.(] L.S. Lima, 1999-2004).to detect ranitidine in human urine or pharmaceuticals. Pollo et al. employed a green approach to ascertain bumetanide in pharmaceutical preparations by the use of diffuse reflectance spectroscopy.

Spectro fluorimetry -

Pharmaceutical analysis uses spectrum fluorescence measurement techniques extensively. By observing the mebeverine’s quenching effect on eos’s native fluorescence, Derayea used a spectroflourimetric approach to determine the amount of Mebeverine hydrochloride inside A green spectroflourimetric approach employing water as the solvent was successfully used by Y. Sarr et al. (S.O. Sarr, 2013).to estimate ciprofloxacin in bulk powder and pharmaceutical-dosage forms.

Near-infrared (NIR) spectroscopy-

Rapid and nondestructive, NIR spectroscopy is an excellent instrument for quantitative analysis and a fantastic substitute for other time-consuming and environmentally harmful analytical methods(E.W. Ciurczak, 2002). This is especially true when used in conjunction with chemometrics. The homogeneity of powder mixes was tracked online by studies conducted by Sekulic et al. and Maesschalk et al . To determine the water content, Beyerand and Steffens employed NIR spectroscopy. The quantitative analysis of ketoprofen in pharmaceutical gel was conducted using transmission FT-IR spectroscopy.

Raman spectroscopy -

Raman spectroscopy is a potent analytical method since it is extremely quick, entirely non-destructive, non-contact, and requires no sample preparation. The pharmaceutical and cosmetics industries can utilize it for online process monitoring and analysis as well as in-vitro and in-vivo analyses (e.g., examination of cosmetics on skin). A pharmaceutical suspension's medroxyprogesterone acetate content was measured using FT-Raman spectroscopy. De Beer et al.'s (De Beer TR, 2007) results from determining medroxyprogesterone acetate using Raman spectroscopy were compared to those using HPLC.

Electroanalysis:

Screen-printed, disposable electrodes were used to measure dextromethorphan. Using two distinct modified CPEs, dopamine was selectively examined in its combination with uric acid and ascorbic acid. PVC and dextromethorphan CPE electrodes were created and contrasted(Zare HR, 2005). Owing to PVC electrode constraints, Khaled et al. created a CPE based on β-cyclodextrin and multi-walled carbon nanotube (MWCNT) for piroxicam detection using FI potentiometry. Using a modified electrode called “Printed-Circuit-Board Waste,” FIA was used to determine the ascorbyl glucoside content of cosmetics. A carbon electrode was used to measure the amount of ellagic acid present in skin whitening treatment.

Chromatography:

Due to these characteristics, SFC is a more environmentally friendly choice, particularly when used for chiral separations. Chisvert et al.’s . green HPLC approach was used in trials for green cosmetics analysis to identify UV filters that are approved globally for use in sunscreen formulations without the use of extremely harmful solvents. Chisvert et al. later proposed a more ecologically friendly LC method to identify the 15 fat soluble UV filters present in cosmetic products.

## VI. CONCLUSION

An impressive rise in the environmental friendliness of analytical techniques can be ensured by following the GAC principles. The analysis of pharmaceuticals and cosmetics should be greened at every stage. The analytical features and overall greenness of the methodology can be significantly improved by new trends and advancements in areas such as instrumentation, sample preparation, data handling, and waste management. In addition to the financial gain, using automated, streamlined, accelerated, and compressed systems has other significant advantages, including significant solvent, reagent, and energy preservation, lower dangers for analysts and researchers, and less waste production. In terms of energy usage, operator safety, and ecological effect, environmentally friendly HPLC processes outperform traditional ones. Pharma companies, the micro community, and analysts all gain from the application of green principles in drug analysis.

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