CORRELATION OF MICROWAVE ASSISTED EXTRACTION (MAE) WITH GREEN CHEMISTRY

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ABSTRACT
The process of extraction basically deals with separation of desired or medicinally active constituents from matrix that will be either plant or animal cell culture. Numbers of conventional extraction procedures are available but they are suffering from such kind of drawbacks like the conventional procedures are very tedious as well as require large quantity of solvent and other chemicals. Assistance of microwaves in the conventional extraction procedures leads to not only make the process less tedious but also consumption of solvents and other chemicals also reduces. As the Microwave Assisted Extraction (MAE) consumes less chemicals, chances of waste generation as well as toxic substances are less as compare to conventional extraction procedure which will lead to generate toxic substances and waste in large quantity. These phenomena of MAE can be correlate with Green Chemistry. Ultimate goal of the green chemistry is to reduce impact of generated toxic substances on environment as well as human health. However, prevent the generation of toxic substances or hazardous materials from the chemical processes is quite manageable and preferable as compare to treatment of the same once generated. That is why Microwave Assisted Extraction process is correlated with Green Chemistry. This review covers the principle lying behind Green Chemistry and Microwave Assisted Extraction as well as correlation of both the phenomena is also included.

KEYWORDS: Green Chemistry, Microwave Assisted Extraction (MAE), Principle behind Green Chemistry, Chemical process.

INTRODUCTION
Principle of chemistry lying behind separation of substance from matrix is known as extraction. The basic mechanism on which extraction process works is movement of analyte from initial solvent towards solvent which is utilized in extraction (extracting solvent). In such a case where impurities are going to be extracted from the desired compound, “washing” word can also be used. Microwave Assisted Extraction (MAE) is advancement in the field of extraction and one of the widely used techniques for extraction, due to its number of advancement over conventional process of extraction.
Microwave Assisted Extraction is the process of transfer of components present in solid which are organic in nature towards organic liquid phase, stated process of extraction accelerated with
the help of microwave radiation, Application of microwave radiation in the conventional process of extraction was first time done by Ganzler et al. in the year of 1986. In the year of 1995, first patent was filed by Pare which describes utilization of microwave radiation for the extraction process of natural products. [1]

Development and designing of products and processes in such a way that they could diminish or eliminate the use as well as generation of hazardous substances from the process, is the area of chemical engineering and chemistry known as Green Chemistry. This branch is also known as sustainable chemistry.

Area of estimation of impact which is delivered to the environment due to chemistry is the main focus of Green Chemistry. The concept and implementation of green chemistry is also deals with different ways for reduction of resources which are non-renewable in the processes. Technological approaches are also applied in green chemistry in order to prevent pollution in environment.

**Principle behind Microwave Assisted Extraction:**

Microwaves are a type of electromagnetic waves which are non-ionizing and having frequency starting from 300 MHz to 300 GHz. In the electromagnetic spectrum, microwaves lying between X-ray and infrared rays. The basic principle of microwave theory is the active actions of waves which are imparted on such kind of materials which are capable for conversion of electromagnetic energy directly into the heat energy.

In the process of Microwave Assisted Extraction, the heating process is carried out in closed vessel leads to reduction or elimination of heat which is lost to the environment. This is possible because MAE works in a very selective as well as targeted manner, as compare to conventional procedures which is followed for extraction, MAE reduces the extraction time (usually the extraction time in MAE is less than 30 minutes) and even with short extraction time the yield of result is more as compare to conventional extraction procedures. [1,2]

Minute microscopic traces are generally present in dried plants which play an important role to act as a target for microwave heating. At the time of process of extraction, high temperature as well as pressure created in the vessel; this will lead to cellulose dehydration which is responsible for mechanical strength reduction of the same. Microwave Assisted Extraction can be briefly describes as mentioned below:

\[
\text{Microwave Radiation} \downarrow \rightarrow \text{Heating of Moisture}
\]
Evaporation of Moisture
Pressure generation on the wall of cell
Swelling of the cell
Rupture of the cell
Phyto constituents leaching

Principle behind Green Chemistry:
Green chemistry works on its basic twelve principles. They were introduced by Paul Anastas and John Warner in the year of 1998. [3,4]

1. Atom Economy:
Design of synthetic methods should be done in the way that all the material which were utilized in the process should be incorporated in final product at maximum level.

2. Prevention:
Prevention of waste generation is quite better as rather than cleaning and treatment of generated waste.

3. Less Hazardous Chemical Synthesis:
If possible, design of synthetic methodology should be done in such a way that the utilized as well as generated substances having less toxicity towards environment as well as human health.

4. Energy Efficiency Designing:
Recognition of requirement of energy on the stated chemical process should be carried out. After recognition, chemical process should be carried out in a way that economic as well as environmental impacts of the utilized energy should be minimized. If possible, such procedures should be performed at atmospheric temperature and pressure.

5. Safer Chemical Designing:
Designing of chemicals should be done with consideration of reduction of toxicity as well as preservation of function efficacy.

6. Renewable Feedstock Uses:
Whenever economically as well as practically possible, renewable feedstock and raw material should be used.

7. **Safer Solvents and Auxiliaries:**
   Auxiliary substances like separation agents and solvents utilization should be made unnecessary whenever possible and when used innocuous.

8. **Catalysis:**
   Uses of catalytic reagents whenever possible are preferable as well as superior to stoichiometric reagents.

9. **Reduce Derivatives:**
   If possible, do not go for unnecessary derivatization, or use it at lower extent. Such kind of steps in procedure like, protection/deprotection, blocking groups, temporary modification of chemical or physical processes requires additional amount of reagents and will lead to waste generation.

10. **Pollution Prevention through Real-Time Analysis:**
    Further development of analytical methodologies need to be to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

11. **Design for Degradation:**
    Designing of chemical processes should be done in such a way that when the chemical procedure completes, it should result no or minimal generation of waste or if generated it should be innocuous degradation products as well as it should not also persist in the atmosphere.

12. **Inherently Safer Chemistry for Accident Prevention:**
    Selection of substances as well as different forms of the same which are utilized in chemical process should be done on the basis of that they have minimal potential for chemical accidents including explosion and fires.

**Accomplishment of Green Chemistry by Industries:**
As a first example, a greener synthetic pathway which was attributed to Eastman for its enzymatic esterifications. This biocatalytic process runs under mild conditions, minimizes the formation of byproducts and saves energy, resulting in increased efficiency. Overall hundreds of litres of organic solvents were eliminated from the previous process. [5]

In 2008, researchers at Dow Agro Sciences were rewarded for the design of green pesticides. While trying to understand the structure–activity relationships of natural biopesticides in an effort to predict analogues that would be more active, they designed Spinetoram. The company
expects that the production of this new pesticide will eliminate “about 1.8 million pounds of organophosphate insecticides during its first five years of use.”

**Microwaves in Green Synthesis:**

Microwaves were not introduced to organic synthesis until the mid-1980s. The first academic reports on the use of microwave heating to mediate organic reactions were published by the groups of Gedye et al. and Giguere et al. These early experiments of microwave-assisted organic synthesis (MWAOS) were typically carried out in sealed Teflon or glass vessels in a domestic household microwave oven without any temperature or pressure measurements.

Although there were several violent explosions due to the rapid uncontrolled heating of organic solvents in those early days, an increasing number of scientists started to investigate this new technology. In the 1990s, the first attempts at solvent-free microwave chemistry (dry-media reactions), which eliminated the danger of explosions, were made.

The solvent-free approach was very popular, since it allowed the safe use of domestic microwave ovens and standard open-vessel technology. Such reactions not only reduce the amount of waste solvent generated, but, also, the products often need very little or no purification.

Additionally, MWAOS in dedicated sealed vessels using standard solvents—a technique pioneered by Christopher R. Strauss in the mid-1990s has renewed its attractiveness to chemists in recent years.

Due to the beneficial combination of rapid heating by microwaves with sealed-vessel (autoclave) technology, this approach will most likely be the method of choice for performing MWAOS on a laboratory scale in the future. Nowadays, “microwave chemistry” has risen as a boon in disguise for the eco-friendly-conscious chemists.

The microwave-mediated organic reactions take place more rapidly, safely, and in an environmentally friendly manner, with high yield. Very little solvent, dry media on solid support or using water as a solvent is a big advantage of microwave chemistry.

In the early days of microwave synthesis, experiments were typically carried out in sealed Teflon or glass vessels in a domestic household microwave oven without any temperature or pressure measurements. Kitchen microwave ovens are not designed for the rigors of laboratory usage: acids and solvents corrode the interiors quickly and there are no safety controls.

The results were often violent explosions due to the rapid uncontrolled heating of organic solvents under closed vessel conditions. In the 1990s several groups started to experiment with solvent-free microwave chemistry (so-called dry-media reactions), which eliminated the danger of explosions. Here, the reagents were pre-adsorbed onto either a more or less microwave
transparent inorganic support (i.e., silica, alumina or clay) or a strongly absorbing one (i.e., graphite), that additionally may have been doped with a catalyst or reagent.

REFERENCES