RECENT ADVANCEMENTS IN MICROWAVE TECHNOLOGY IN PHARMACEUTICAL INDUSTRY

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ABSTRACT

Microwave is apparently heading for exhibiting good potential in the field of Pharmaceutical industry. The write up attempts to throw light on what is microwave, how is it generated and what importance may it have. Microwave radiation, an electromagnetic radiation, is widely use as a source of heating in organic synthesis Microwaves have enough momentum to activate reaction mixture to cross energy barrier and complete the reaction. The basic mechanisms observed in microwave assisted synthesis are polarization (mainly dipolar polarization) and conduction. The benefits of microwave synthesis including increasing speed, yield and clear chemistry with decreasing time, have provided the momentum for many chemists to switch from traditional heating method to microwave assisted chemistry. The present paper highlights the current scenario of microwave technology in pharmaceutical sector.

INTRODUCTION

Microwave heating refers the use of electromagnetic waves ranges from 0.01m to 1m wave length of certain frequency to generate heat in the material. These microwaves lie in the region of the electromagnetic spectrum between millimeter wave and radio wave i.e. between I.R and radio wave. Microwave, which has gained recent popularity, has a great potential in pharmaceutical industry. Waves are generally of two types Electromagnetic waves and Mechanical waves. The main point of differentiation is electromagnetic waves do not require a medium for transportation, as required by mechanical waves.[1, 2] Microwave is generated in special type of electron tubes. These contain cathode, anode and grid inside an evacuated envelope. For generation of microwaves these should operate at very high frequency range (300 – 3000 MHz). Ordinary electron tubes can operate at frequencies up to about 30 MHz. So the tubes must be designed in a different manner, because the frequency is comparable to the electron transit time (it is the time needed for electrons to travel between electrodes). [3.4.5] Microwave is a type of electromagnetic wave whose wavelength range falls in between Radio waves & Infrared waves as shown in Table

Table: -Range of frequencies of Electromagnetic waves

TYPE	**APPROXIMATE WAVELENGTH RANGE (METERS)**	**APPROXIMATE FREQUENCY RANGE (HERTZ)**
RADIO WAVES	10 - 1000	$3 X 10^5$ - $3 X 10^7$
TELEVISION WAVES	1 - 10	$3 X 10^7$ - $3 X 10^8$
MICRO WAVES	$1 X 10^{-3}$ - 1	$3 X 10^8$ - $3 X 10^{11}$
INFRARED	$8 X 10^{-7}$ - $1 X 10^{-3}$	$8 X 10^{-7}$ - $4 X 10^{14}$
VISIBLE LIGHT	$4 X 10^{-7}$ - $7 X 10^{-7}$	$4 X 10^{14}$ - $7 X 10^{14}$
ULTRA VIOLET	$1 X 10^{-8}$ - $4 X 10^{-7}$	$7 X 10^{14}$ - $3 X 10^{16}$
X-RAYS	$5 X 10^{-12}$ - $1 X 10^{-8}$	$3 X 10^{16}$ - $6 X 10^{19}$
GAMMA RAYS	$1 X 10^{-13}$ - $5 X 10^{-12}$	$6 X 10^{19}$ - $3 X 10^{21}$
COSMIC RAYS	Less than $1 X 10^{-13}$	Greater than $3 X 10^{21}$

PRINCIPLE

The basic principle behind the heating in microwave oven is due to the interaction of charged particle of the reaction material with electro magnetic wavelength of particular frequency. The phenomena of producing heat by electromagnetic irradiation are ether by collision or by conduction, some time by both. Microwave processings involve dielectric materials. A dielectric is an electrical insulator that gets polarized by the action of an applied electrical field. In the influence of electric fields, electrons move freely through a conductor but in case of a dielectric these electric fields displace electrons only slightly from their normal positions. The electric field causes a separation of negative charges (electrons) from positive charges (proton in the atomic nuclei). Thus an electric dipole is created in the molecule and the material is said to be polarized. [6] The dielectric materials can be divided into 2 groups, polar & nonpolar. A polar dielectric is one in which the molecules have an intrinsic dipole moment, where as in a nonpolar it is not so. In polar substance, where each molecule posses a dipole, the material becomes polarized due to the potential rotation of each molecule so that it is aligned in the direction of the applied electric field. [7] Because this involves rotation of the complete molecule there is strong coupling to the lattice. In general, this coupling causes the material to exhibit a high dielectric constant Î' and a high loss factor Î'', and makes its dielectric properties depend upon frequency and temperature. The variations of dielectric constant Î with frequency can often be expressed in the terms of a single relaxation time according to formula.

Î = Î' - jÎ'' = Îp + (Î$_s$-Îp)/(1+jwt)

where,

Îp = Î for w = ∞ ,

Î$_s$ = Î for w = 0,

w is frequency in radians per seconds, t is the relaxation time in seconds,and j is the square root of minus one.

ADVANTAGES

Microwave include following advantages, over the conventional heating. [8,9,10]

- Uniform heating occurs throughout the material as opposed to surface and conventional heating process.
- Process speed is increased.
- Desirable chemical and physical effects are produced.
- The energy source is not hot.
- Floor space requirements are decreased.

- Better and more rapid process control is achieved
- In certain cases selective heating occurs which may significantly increase efficiency and decrease operating cost.
- High efficiency of heating,
- Reduction in unwanted side reaction (reaction Quenching),
- Purity in final product,
- Improve reproducibility
- Environmental heat loss is save
- Reduce wastage of heating reaction vessel
- Selective heating i.e. heating selectively one reaction component.
- Super heating: conventional heating is done from out side, therefore the core of solvent may be as much as 5C cooler than the edge, while in microwave, the core is 5C hotter than the outside, because of surface cooling, therefore in microwave, we can raise the boiling point of solvent by as much as 5C, an effect is known as super heating.

Table Difference between conventional and microwave assisted heating

S.No.	CONVENTIONAL	MICROWAVE
1	Reaction mixture heating proceeds from a surface usually inside surface of reaction vessels	Reaction mixture heating proceeds directly inside mixture
2	The vessel should be in physical contact with surface source that is at a higher temperature source (e.g. mental, oil bath, steam bath etc.)	No need of physical contact of reaction with the higher temperature source. While vessel is kept in microwave cavities.
3	By thermal or electric source heating take place.	By electromagnetic wave heating take place.
4	Heating mechanism involve- conduction	Heating mechanism involve- dielectric polarization and conduction
5	Transfer of energy occur from the wall, surface of vessel, to the mixture and eventually to reacting species	The core mixture is heated directly while surface (vessel wall) is source of loss of heat
6	In conventional heating, the highest temperature (for a open vessels) that can be	In microwave, the temperature of mixture can be raised more than its boiling point i.e. superheating

	achieved is limited by boiling point of particular mixture.	take place
7	In the conventional heating all the compound in mixture are heated equally	In microwave, specific component can be heated specifically.
8	Heating rate is less	Heating rate is several fold high

APLLICATIONS

These waves have wide application in pharmaceutical industry. [11-15]

- Drying
- Sterilization
- Controlled Release Formulations
- Thawing
- Preparation of tissues for studies
- Ointment production
- In Organic Reaction
- Heterocyclic Nucleus Synthesis
- Miscellaneous – Microwave assisted Extraction, Microwave Ashing, Microwave drying.

CONCLUSION

Though few references hint towards lack of support for microwave, there are many reports favoring its use. Having several advantages microwave is emerging as need of the day. It has shown definite benefits over conventional ways of heating in thawing, drying, sterilization, and production of sustained release dosage units etc. Knowledge available for safe & efficacious use of this energy is growing day by day. It can be concluded that microwave energy will have an enhanced and prominent role to play in pharmacy.

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