Microwave drying

Introduction

Microwaves are electromagnetic waves having wavelength varying from 1 mm to 1m. Frequency of these microwaves lies between 0.3 GHz and 3 GHz. Microwaves have greater frequency than radio waves so they can be more tightly concentrated. Application of microwave energy to dry food materials is a good approach for coping with certain drawbacks of conventional drying. Microwaves penetrate to interior of the food causing water to get heated within food. This results in a greatly increased vapor pressure differential between the center and surface of the product, allowing fast transfer of moisture out of the food. Hence microwave drying is rapid, more uniform and energy efficient compared to conventional hot air drying. The problems in microwave drying, however, include product damage caused by excessive heating due to poorly controlled heat and mass transfer.

Mechanism of Heating

In microwave heating or drying, microwave-emitted radiation is confined within the cavity and there is hardly heat loss by conduction or convection so that energy is mainly absorbed by a wet material placed in the cavity. Furthermore, this energy is principally absorbed by water in the material, causing temperature to raise, some water to be evaporated and moisture level to be reduced.

A domestic microwave oven works by passing microwave radiation, usually at a frequency of 2450 MHz (a wavelength of 12.24 cm), through the food. Water, fat, and sugar molecules in the food absorb energy from the microwave beam in a process called dielectric heating. Many molecules (such as water) are electric dipoles, meaning that they have a positive charge at one end and a negative charge at the other, and therefore rotate as they try to align themselves with the alternating electric field induced by the microwave beam.

This molecular movement creates heat by friction as the rotating molecules hit other molecules and put them into motion. Microwave heating is most efficient on liquid water, and much less so on fats and sugars (which have less molecular dipole moment) and frozen water (where the molecules are not free to rotate). Large industrial/commercial microwave ovens operating in the 900 MHz range also heat water and food perfectly well. The microwave heating rates and potential non uniformity are functions of oven factors and load characteristics (size, shape, dielectric properties, etc.).

In conventional heating, heat is transferred to the surface of the material to be heated by conduction, convection, and/or radiation, and into the interior by thermal conduction. Depth of penetration of microwaves is dependent on food composition and the frequency, with lower microwave frequencies being more penetrating. The heat generated per unit volume of material (Q) is the conversion of electromagnetic energy in to heat energy. Its relationship with the average electric field intensity (Erms) at that location can be derived from Maxwell's equations of electromagnetic waves.

$$Q = 2\pi f \epsilon_0 \varepsilon'' E^2 \text{ rms}$$

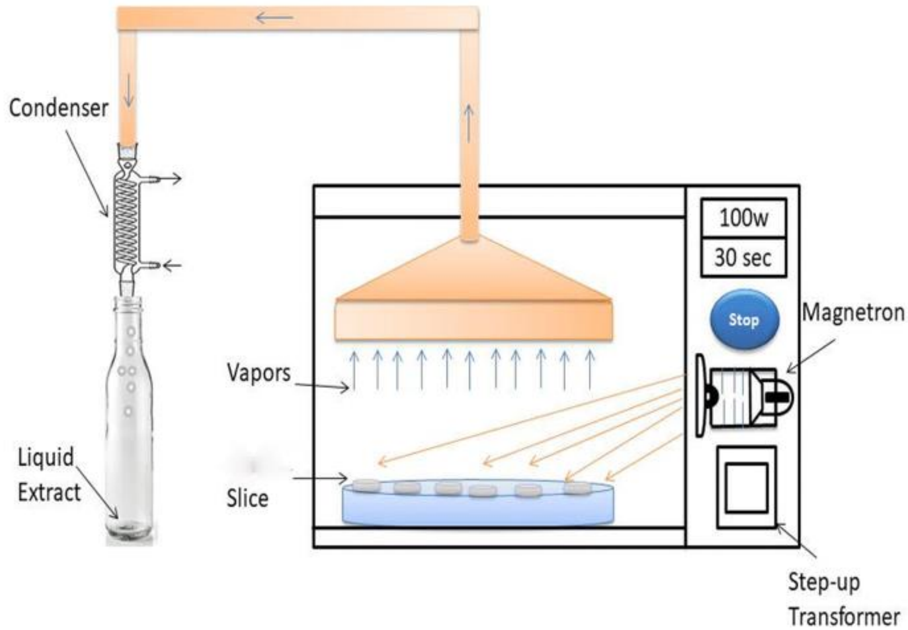
Where, f is the frequency of microwaves
ϵ_0 is the dielectric constant of the free space (8.854×10^{-12} A^2 s^4/kg m^3)
ε " is the loss factor of the food being heated.
At a given frequency, the dielectric loss factor is a function of the composition of the food materials and its temperature. Penetration depth (Dp) is another important factor in microwave heating. It is defined as the depth below the surface of the material where the power density of a plane electromagnetic wave decays by 1/e (37%) from the original value at the surface. The Dp is calculated as follows:

$$D_p = \frac{c}{2\pi f \sqrt{2\varepsilon'}\left[\sqrt{1} + (\varepsilon''/\varepsilon')^2 - 1\right]}$$

Where
c is speed of light in free space (3×10^8 m/s)
f is the frequency (Hz)
ε " is the loss factor of the food
ε ' is dielectric constant

Microwave assisted drying

Several researchers in the developed and developing countries have done studies on microwave assisted drying of various fruits and vegetable and reported that the drying by microwave assisted convective and microwave vacuum methods is more efficient than conventional drying techniques. Microwave assisted hot air drying of foodstuffs and found considerable improvements in the drying process and quality of dehydrated products. The simple laboratory microwave convective dryer for foodstuffs is shown.



Microwave assisted dryer

Basic parts of microwave system

- Microwave source – the microwave source
- Waveguide
- applicator

0**Advantages of microwave drying**

- Adjustment of energy absorption level by the wet product automatically.
- Possibly selective heating of the interior portion (microwave focusing effect).
- Rapid energy dissipation throughout the material.
- Relatively minor migration of water soluble constituents.
- Lower product temperature with combination of vacuum.
- More efficient drying in falling rate period.