Effect Of Microwave Heating On The Migration Of Additives Into Food Simulants

Microwaves heat food rapidly and foods are prepared in less time. However, dueto non-uniform heating nature of microwave cooking, there exists a serious concern overcomplete elimination of pathogens in the food. There has been an increase in interest toaccurately understand the behavior of different food materials in a microwave field andmicrobial inactivation during microwave cooking. The main objective of this thesis is to test three different microwaving packaging materials that are the most common material in the market, which are polystyrene (PS), polypropylene (PP), and polyethylene terephthalate (PET), migrated into four food simulant solutions. Four different simulant solutions were used based on the food type and FDA recommendations and regulations. These food simulants includevegetable pure oil, 3% (v/v) aqueous acetic acid, 15% (v/v) ethanol, and olive oil in the temperature of 100°C. Headspace gas chromatography with mass spectrometric detection (GC/MS) was used to determine the relative migration values from packaging materials into food by putting the materials into contact with simulants for 10 days in temperature of 5°C. The analyzed results show that the migrations of food package are dependent on microwaving time, packagematerial types and simulant types. The polystyrene (PS) caused the fastest relative migration in oliveoil while the polyethylene terephthalate (PET) has the most relative migration in food simulant containing 15% ethanol. In addition, acetaldehyde, which may be hazardous to consumers, was found in both 3% aqueous acetic acid. A factor that is highly important during microwave processing is dielectricproperties of the material. The interaction of microwave with the food is mainly based onits dielectric properties, which can change with temperature. Therefore, determination of dielectric properties of food with respect to temperature becomes critical. IntroductionMicrowaves are high frequency radio waves (radiofrequency fields) and, like visible radiation (light), are part of the electromagnetic spectrum.

Microwaves are reflected, transmitted or absorbed by materials in their path, in a similar manner to light. Metallic materials totally reflect microwaves while non-metallic materials such as glass and some plastics are mostly transparent to microwaves. Materials containing water, for example foods, fluids or tissues, readily absorb microwave energy, which is then converted into heat. Microwave heating is a multiphysics phenomenon that involves electromagnetic waves and heat transfer. any material that is exposed to electromagnetic radiation will be heated up. The rapidly varying electric and magnetic fields lead to four sources of heating. Any electric field applied to a conductive material will cause current to flow. In addition, a time-varying electric field will cause dipolar molecules, such as water, to oscillate back and forth.

A time varying magnetic field applied to a conductive material will also induce current flow. There can also be hysteresis losses in certain types of magnetic materials. One obvious example of microwave heating is in a microwave oven. When used according to manufacturers' instructions, microwave ovens are safe and convenient for heating and cooking a variety of foods. However, several precautions need to be taken, specifically with regards to potential exposure to microwaves, thermal burns and food handling. The design of microwave ovens ensures that the microwaves are contained within the oven and can only be present when the oven is switched on and the door is shut. Leakage around and through the glass door is limited by design to a level well below that recommended by international standards. However, microwave leakage could still occur around damaged, dirty or modified microwave ovens. It is therefore important that the oven is maintained in good condition. Users should check that the door closes properly and that the safety interlock devices, fitted to the door to prevent microwaves from being generated while it is open, work correctly. The door seals should be kept clean and there should be no visible signs of damage to the seals or the outer casing of the oven. Microwave energy can be absorbed by the body and produce heat in exposed tissues. Organs with a poor blood supply and temperature control, such as the eye, or temperature-sensitive tissue like the testes, have a higher risk of heat damage. However, thermal damage would only occur from long exposures to very high power levels, well in excess of those measured around microwave ovens.

Food safety is an important health issue. In a microwave oven, the rate of heating depends on the power rating of the oven and on the water content, density and amount of food being heated. When you place food in a microwave oven and press the "start" button, electromagnetic waves oscillate within the oven at a frequency of 2. 45 GHz. These fields interact with the food, leading to heat generation and a rise in temperature. Microwaves are produced by an electronic tube called a magnetron. Once the oven is switched on, the microwaves are dispersed in the oven cavity and reflected by a stirrer fan so the microwaves are propagated in all directions. They are reflected by the metal sides of the oven cavity and absorbed by the food. Only dishes and containers specifically designed for microwave cooking should be used. Certain materials, such as plastics not suitable for microwave oven, may melt or burst into flames if overheated. Microwaves do not directly heat food containers which are designed for microwave cooking. These materials usually get warm only from being in contact with the hot food. Microwave oven users should carefully read and comply with the manufacturer’s instructions because new ovens vary widely in design and performance. While most modern ovens can tolerate some food packaging made of metal, oven manufacturers generally recommend not placing metal in the oven, particularly not close to the walls, as this could cause electrical arcing and damage the oven walls. Also, because metal reflects microwaves, food wrapped in metal foil will not be cooked, while food not in metal wrap may receive more energy than intended, causing uneven cooking. Drawbacks of microwave heating are its inability to brown food, non-uniformcooking, and excessive drying of foods such as breads. Another major problem inmicrowave cooking or reheating of the food is the chance for pathogen survival. Population groups such as pregnant women, immunocompromised, elderly, and youngchildren are highly susceptible for food borne infections. As the cooking or reheating ofthe food is one of the last steps in food preparation, it should assure food safety. Therefore, food safety becomes important and cooking should ensure food safety. Migration has become a major factor in regulations regarding the safety and quality of packaged food.

The degree of migration is determined by various factors including the properties of real food, cooking temperature andpower, chemical nature of substances in polymer and food simulants. There are three differentmicrowave container applications, which are microwave susceptor packaging, dual-oven trays and microwavable containers. In the USA, the Food and Drug Administration (FDA) regulate packaging materials for foodcontact. Both the FDA regulations and the European Community (EC) have complex regulations tocontrol potentially harmful migrating substances from food packaging materials. However, thereare no specific requirements for microwave food contact containers. Therefore, there is guidance onplastic containers used in the microwave cooking, in the form of recommendations on chemistryinformation. Companies need to check compliance of this guidance with considerable amount ofmigration testing for their products. Based on these regulations above, the aim of this paper is to review critically the existingprocedures about migration modeling first, and then analyze the effect of plastic type in combinationwith four different types of food simulants to gain more knowledge on unpredictable migrationbehaviors during high temperature conditions for consumer. Two methods from the Food and DrugAdministration (FDA) and European Union (EU) regulations are used to evaluate the possible newcompounds may be found due to degradation of the additives or polymers during the microwave heating. The objectives of this paper is as followings:

1. To comprehensively and quantitatively investigate the percentage of migration frompolymer food packaging during microwave heating at different time span and temperature.

2. To evaluate the possible new compounds may be found due to degradation of the additives or polymers during the microwave heating. In general, food-packaging interactions can be divided into three groups: migration, which is the transfer of packaging components into food;sorption, which is the transfer of food components to the packaging; and permeation, which is thetransfer of components through the packaging in either direction(Ahvenainen, 2003).

The process of migration of additives from microwave packaging material to food may be separated into three states: diffusion within the polymer, solutionat the polymer-food interface, and dispersion into bulk food. To get better result of migration, the test should use three aqueous-based food simulants andhigher cooking temperature than normal direction on the package since real food is too difficult to analyze (Risch, 2009). Migration is a diffusion process subject to both kinetic and thermodynamic controls. Diffusionis the mas transfer due to random movement of molecules from regions of higher concentration toregions of lower concentration. However, diffusion rate is a function of only temperature, and is notaffected by concentration. In that case, when we put frozen food in to microwave oven, the activityof the macroscopic molecular structures inside of plastic start so become higher and higher, thehigher of heating temperature, the higher the flexibility of the polymer molecules and thus thehigher the migration rates.

The transparent non-metal packaging materials is one of the most common materials used inmicrowave packaging (Lentz & Crossett, 1988). In these types of packages, the microwavespenetrate the transparent material and are absorbed by the food. Plastics have been a huge part of everyday life since the fifties. In fact, most people could not imagine life without plastic. Today the industry offers hundreds of different types of plastics and millions of different products. The plastics industry has now grown to a multibillion-dollar business that shows no signs of slowing. One concern with using so much plastic is the safety of such an unnatural material. Many organic materials have been found to be carcinogenic if used excessively. Even the polyethylene used in plastics can cause health problems if ingested in large enough quantities. The heavy use of recycled materials in plastic processing is also a major health concern. Since plastics are organic substances, they can pick up other organic materials during recycling. Many of these organic substances, such as tolulene, diazinon, and chloroform are potentially hazardous to humans. These chemicals can leach into food from the containers if they are not properly sterilized. Many studies have been done to alleviate these concerns.

The FDA has forced companies to spend millions of dollars to make sure the plastic we eat from is safe. All plastics currently used in food packaging are transparent to microwaves. The most common plastics used in in microwave packaging are polystyrene (PS),polypropylene (PP) or polyethylene terephthalate (PET) due to their high melting point (Belcher, 2006). Ahmed et al. indicated that during polymerization processing, there are thousands of possible additives added into polypropylene that could produce some unknown toxic chemicals which can be health risks (Ahmed, 1982). It is necessary to establish a link between the maximum temperature the container in contact with different food stimulants during heating or microwaving and migration of polypropylene additives since some additives are even carcinogens and have concernon endocrine disorder. Therefore, it is important that polypropylene products in the market shouldbe designed to minimize overall migration limitation of additives during food manufacturingoperations such as microwave heating. Polystyrene(PS)Polystyrene, a hard, stiff, brilliantly transparent synthetic resin produced by the polymerization of styrene. It is widely employed in the food-service industry as rigid trays and containers, disposable eating utensils, and foamed cups, plates, and bowls. Polystyrene is also copolymerized, or blended with other polymers, lending hardness and rigidity to a number of important plastic and rubberproducts. Polystyrene (PS) has the ability to replace many conventional materials like metals, paper etc, in which their mechanical, optical and thermal properties are acceptable. Heat resistance higher than 150 Deg. C and tensile strength above 700 kg/cm sq is not required for many applications. Allow redesigning of the articles and ease of production process.

Properties of polystyrene:

- Light weight
- Odorless, Tasteless and Non-Toxic
- Superior dimensional stability and low mould shrinkage
- Clear polystyrene has a high degree of Transparency
- Unlimited range of colors
- Easy to cement parts by solvent or special adhesives
- Give metallic sound
- Offer good low temperature impact strength
- Easily process able by injection moulding, extrusion and thermoforming.

Polypropylene(PP)Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene. Polypropylene belongs to the group of polyolefins and is partially crystalline and non-polar. One of the major benefits of Polypropylene is that it can be manufactured (either through CNC or injection molding, thermoforming, or crimping) into a living hinge. Living hinges are extremely thin pieces of plastic that bend without breaking (even over extreme ranges of motion nearing 360 degrees). They are not particularly useful for structural applications like holding up a heavy door but are exceptionally useful for non load-bearing applications such as the lid on a bottle of ketchup or shampoo. Polypropylene is uniquely adept for living hinges because it does not break when repeatedly bent.

Properties of polypropylene:

- Very low density (0. 9 gm/cc)
- High stiffness / Rigidity and High tensile strength
- Highest resistance to chemicals among polyolefins
- Good environmental stress-crack resistance in contact with highly polar chemicals
- High heat resistance among commodity thermoplastics and PP (90 Deg. C and intermittent of 120 Deg. C)polyethylene terephthalate

(PET)Polyethylene terephthalate commonly PET is the most common thermoplastic polymer resin of the polyester family and is used in fibres for clothing, containers for liquids and foods, thermoforming for manufacturing, and in combination with glass fibre for engineering resins. Even without additives to increase its strength, PET is still very strong for its light weight. This means that less material is required for uses such as plastic film for packaging. This means less fuel is required for shipping when using PET packaging. It is a naturally colorless, semi-crystalline material. Some of its most important characteristics include its resistance to water, its high strength to weight ratio, the fact that it is virtually shatterproof (it won’t break like glass packaging), and its wide availability as an economic and recyclable plastic. Properties of polyethylene terephthalate:

- Extreme low water absorption, in particular comparison to Nylon (Polyamides)
- Exceptional dimensional stability, due to the low water absorption.
- Excellent electrical properties.
- Excellent resistance to chemical attack and high environmental stress crack resistance, in particular in comparison to polycarbonates, due to the semi-crystalline nature of polyesters.
- Very good heat and heat ageing resistance.
- Very low creep, even at elevated temperatures.
- Very good colour stability.
- Excellent wear properties.