# MAP YOUR MICROWAVE



## Materials Needed

mini marshmallows, one bag
waxed paper or parchment paper
microwave oven

## Safety

Safety glasses or goggles must be worn in the laboratory at all times.

If this experiment is performed in a chemistry laboratory, all work surfaces must be cleaned and free from laboratory chemicals.

Make sure that no materials extend beyond the cooking chamber of the microwave oven and become trapped in the door. If the door is not shut completely, microwave leakage will occur.

## Disposal

Generally, all waste materials in this experiment can be disposed in the trash. All disposal must conform to local regulations.

## Procedure

Open the microwave oven. Remove any turntable. If there is a glass tray in the microwave, it can be left in place or removed.

Cover the entire bottom of the oven (or the glass tray) with waxed paper or parchment paper.

Spread mini-marshmallows evenly over the bottom of the oven. The marshmallows do not have to be standing on end.

Close the door. Turn the microwave on using the HIGH setting. You may observe the process through the window in the microwave door or check every 30 seconds. Turn off the oven when the marshmallows are melted and browned. (Note: they will not be evenly browned.)

The degrees of melting and browning indicate the hot spots and cold spots in the microwave oven.

Allow the marshmallows to cool before removing them from the oven.

If the oven has a turntable, it can be covered with waxed paper and mini marshmallows and the effect of the rotating dish can be observed.

## Explanation

Microwave ovens operate by electromagnetic radiation. The magnetron tube, which is essentially a radio transmitter, sets up an electromagnetic field which reverses itself about 2 or 5 billion times a second (i.e., frequencies of either 915 Hz or 2450 Hz). All polar molecules in the food, particularly water molecules, will align themselves with the surrounding electromagnetic field. Since the field is reversing itself, the molecules are oscillating back and forth in order to realign themselves with the changing field orientation, resulting in kinetic energy and a build-up of heat.

The magnetron tube has only two settings, on and off. The percent power setting cycles the tube on and off during the cooking time so it is only on 25% of the cooking time if a setting of 25% power was used, or 50% of the cooking time if a setting of 50% power was used.

Usually the microwaves enter the oven chamber from one side. They are then reflected off the interior oven surfaces. This makes for uneven dispersion of the microwaves throughout the oven chamber. Thus, the melted marshmallows show areas of high and low reflection.

Since glass, ceramics, and plastics are non-polar, they are transparent to microwaves and do not heat up. The reason that some ceramic or plastic materials may heat up is that they may have absorbed some water into their pores when washed.

Metals reflect microwaves and tend to build up electric charges creating sparks. Metal utensils and metalized materials should not be placed in a microwave oven. Also avoid any dishes or cups with metal bands or decorations on them. The sparking will discolor and form breaks in the thin metal decorations.

Microwaves can penetrate deeper into food than infrared waves (normal heat waves), allowing the food to cook faster. Since most of the "cooking" is done by the oscillating water molecules, the temperature of the food does not rise much above the boiling point of water, 100ºC (212ºF).

To get around the temperature limitations, products such as Microcrisp® paper or Brown and Crisp® bags can be used. These contain a plastic layer coated with a thin layer of aluminum and backed with paper. Food is wrapped in the Microcrisp® paper with as much of the metalized surface in contact with the food as possible and taped together. If a Brown and Crisp® bag is used, the food is placed in the bag, the side flattened to make contact with the food, and the open end of the bag folded over and/or taped shut. The

interaction of the metal with the microwaves produces a higher temperature to allow the food in close contact with the metalized plastic layer to surface brown. In the process, the paper coating on the outside of the material may start to char.

To protect the microwave oven surface and the glass tray, on the bottom of the oven, from the heat produced by the metal coating during cooking, and to provide an even dispersion of the microwaves around the food, foods wrapped Microcrisp® paper or in Brown and Crisp® bags are placed on plastic platforms which may be included with the Microcrisp® paper or Brown and Crisp® or purchased separately.

## References

McGee, Harold, *On Food and Cooking,* Charles Scribner's Sons, New York, NY, 1984.