30–12 Athermic and Thermic Absorption Processes with Microwaves from 1 mm to 30 cm

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#259

Biological effects of microwaves have been useful in diathermy and related applications. In addition a vastly broadened use of this energy in communications has demanded knowledge of biological hazards. For example, the maximum exposure is set at 0.01 watts per square centimeter of body surface. Masers add to the variety of illuminators available and have their own distinctive capabilities. However, the spot size that can be illuminated is subject to a limit of concentration which is about one-half wavelength.

Most of the investigations reported deal with the thermic mechanism of absorption of microwave energy, for example, diathermy. Appropriate models for this mechanism have been presented for the general case and for sublimation of water in freeze-drying.[1] Usually concurrent engineering problems involve generation, transmission and distribution of microwaves as well as impedance matching. A particular one is the vacuum transition at high-power levels and inadvertent discharge of residual gases in the vacuum which is called glow discharge.

This type of response is readily recognized as an athermic one involving an electrical excitation at the molecular level. While such effects have been known, their analysis has only recently been studied. The problem has been to separate effects which may be due to heat from those due to other molecular, mechanical and chemical effects. The masking effect of heat on these other responses may be counteracted by indirect methods of study. If this is done, some clearly athermic effects appear. Similarly if rotational energy barriers for dipoles are examined, the information from spectroscopy is shown to be relevant. The usual application involves mixtures and special cases, for example, of hydration, especially of macromolecules.

The interpretation of these models requires an understanding of the microwave biophysics involved which obviously touches several disciplines. The macromolecule is shown to be influenced by its groups[2] in the microwave field even when the frequency is removed from the relaxation frequency of the macromolecule.

In a related effect temporary cross-linking may occur followed by degradation of large molecules. These effects suggest the need for a quantum-microwave explanation, but the energy of the quanta are in the neighborhood of one thousandth eV. This is far too small for the usual behavior of ionizing radiations on the biological materials.

Energy requirements for reactions of special interest are discussed and comparisons are made with other spectral radiation interactions with material.

1. Copson, D.A., Microwave Heating, in Freeze-Drying and Other Applications, Avi Publishing Co., Westport, Conn., 1962.

2. Haggis, G.H., Buchanan, T.J., and Hasted, J.B., Nature 167, 607, 1951.

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