

POSSIBLE MECHANISMS FOR THE BIOMOLECULAR ABSORPTION OF  
MICROWAVE RADIATION WITH FUNCTIONAL IMPLICATIONS

James R. Rabinowitz

Institute of Environmental Medicine  
New York University Medical Center  
550 First Avenue  
New York, New York 10016

Abstract

Theoretical analysis of the possible modes of molecular interaction with microwave radiation suggests that the absorption of a microwave photon may interfere with stereospecific biomolecular processes.

Introduction

A physical model, on the molecular level, of the absorption of microwave radiation, the structural changes that may result, and the relationship of these changes to biomolecular function, is important for both analyzing the existing experimental information and designing new experiments that are likely to be informative. As a first step towards constructing such a model, the modes of molecular excitation in the microwave region and their possible effects on biological processes are considered here, using the insights of theoretical molecular physics.

Text

At normal biological temperatures, the number of background photons in the microwave portion of the spectrum is very small, and in a non-irradiated system the only excitations in this energy range are induced by collision. The absorption of a microwave photon is then unlikely to have any direct functional effect on molecules or parts of large molecules that in normal biological circumstances undergo a large number of collisions. In the interior of large molecules, essentially free from collisions, microwave irradiation can cause excitations that will not occur in non-irradiated systems<sup>1</sup>.

The excitations that can result from the absorption of a microwave photon with an energy of  $10^{-3}$  to  $10^{-6}$  electron volts may be divided into three general categories: excitations of 1) magnetic and electric nuclei-electron coupling states; 2) molecular free rotational states; 3) constrained motional states of molecular segments (both rotational and vibrational, although at these energies rotational states are much more likely to be important).

1. Magnetic and electric nuclei-electron coupling states are due to the interaction of unpaired electrons with magnetic nuclei in the former case and the interaction of nuclear quadrupole moments with the molecular charge distribution in the latter case. Excitations of these modes do not cause changes in molecular structure, and if biomolecular functions are affected the mechanism is obscure.

2. Molecular free rotational states are a function of the mass distribution of the

molecule. These excitations leave molecular structure unchanged but increase the rotational kinetic energy of the absorber. A large amount of the microwave radiation incident on a biological system is absorbed in this way because water and other small biomolecules have rotational states in the microwave region of the spectrum. The biological importance of these excitations is that they allow for the absorption of large amounts of energy by biological systems. The energy is spread throughout the system by collision and may lead to microscopic state changes. The biological effects are a result of molecular collisions and are only indirectly related to the absorption of a microwave photon.

3. Constrained motional states are rotational or vibrational states of part of a molecule that leave covalent molecular structure unchanged. For vibrational motion the states are only in the microwave region when tunneling is important. The ammonia molecule provides the classic example of this type excitation<sup>2</sup>. The rotational states are much more important in the context of this paper because they are more generally in the microwave region.

Parts of molecules, from the size of OH groups up to a number of amino acids, are often free to rotate constrained by existing covalent bonds. The relative orientation of these molecular segments to the remainder of the molecule is determined by the weak electrostatic interaction potential between the segment and its environment (generally the remainder of the molecule). Although the relative depths of the minima, heights of the barriers and distances between minima are highly dependent on the segment we are considering and its chemical environment, the potentials are in general multiwell functions and Figure 1 is a characterization of such a potential. Depending on the number of constraints, the potential may be more than one dimensional. Similar potentials have been found for ions in solids and smaller chemical systems<sup>3,4</sup>.

The absorption of a microwave photon by the molecular segment would increase its rotational energy. This increase in energy may have two effects that are significant. The segment may now be in a state that is localized in more than one potential well like states C and D and re-emission of a photon may result in its rotation being

localized in a well different from the initial well. Or the segment may be excited to a state like B, still confined to the same single potential well but with enough energy to greatly increase the possibility of tunneling to another well. This type of rotational tunneling has been demonstrated in a number of different circumstances for ionic defects in crystals<sup>5</sup>. Both of these effects lead to the same type of structural changes: covalent molecular structure remains unchanged but the relative position of one segment of the molecule with respect to the remainder of the molecule is altered.

There are many biological processes that depend on steric structure. The molecular absorption with the resulting change in non-covalent chemical structure outlined above provides a model for the direct interference of microwave radiation with biomolecular function where the internal three dimensional structure of the absorbing molecule is critical to its biological function. The effect of microwave radiation on these processes will depend on the details of the process itself. From our previous discussion we would expect any effect to be frequency dependent, and if allowed a long enough time, to be reversible. Biological considerations, however, may not allow enough time for reversibility to become apparent.

#### Conclusion

In this paper a possible mechanism for the direct influence of microwave radiation on biomolecular processes has been elucidated. Intermolecular interactions that are dependent on steric conformation are the processes one would expect to be influenced.

#### References

1. K. H. Illinger, in "Biological Effects and Health Implications of Microwave Radiation," ed. S. F. Cleary, p. 112, U. S. Department of Health, Education and Welfare, Public Health Service, Environmental Health Service (1970).

2. (a) E. Merzbacher, "Quantum Mechanics," p. 74, John Wiley and Sons, Inc., New York (1961).
- (b) C. H. Townes and A. L. Schawlow, "Microwave Spectroscopy," Chap. 12, McGraw-Hill, New York (1955).
3. L. Pauling, Phys. Rev. 36: 430 (1930).
4. R. H. Silsbee, J. Phys. Chem. Solids 28: 2525 (1967).
5. V. Narayananamurti and R. O. Pohl, Rev. Mod. Phys. 42: 201 (1970).

#### Acknowledgment

I am indebted to Dr. Merrill Eisenbud for suggesting that I consider the topic of this paper and for his assistance in its preparation.

FIGURE 1

