EFFECTS OF MAGNETIC FIELDS ON BIOCHEMICAL REACTIONS

Examination of the effects of low static magnetic fields and rf- exposure on biochemical reactions by the radical pair mechanism, the only known potentially active mechanism

J. Boiden Pedersen, M. J. Hansen, N.N. Lukzen, A.B. Doktorov; Department of Physics and Chemistry, University of Southern Denmark, Campusvej 55, DK-5230 Odense M, Denmark

Background and research objectives

The aim of the present work is to determine to what degree magnetic fields and especially rf-fields can influence biochemical and biological reactions and whether such effects conceivable could be hazardous to human health.

Methodology

Our investigation is based on numerical and analytic solutions of the relevant model equations for the radical pair mechanism (RPM). The RPM is a well established mechanism for magnetic field effects on chemical reactions and it has been used to obtain detailed information on the intermediate radical pair steps in such reactions. It is well known that model calculations can be used to provide reliable estimates of the effects. In most cases numerical calculations are more accurate than experimental measurements that are extremely difficult to carry out. This procedure allows us to consider a large range of systems as well as different types of reactions.

Results

Our results for the influence of rf-fields, radiated from mobile phones, on biochemical reactions are divided into four different types of reactions.

1. Reactions in liquids, where the radicals are free to diffuse apart. Such reactions show no measurable effect of the weak rf-field radiated by mobile phones.
2. Reactions on membranes are characterized by a very slow diffusion and a reencounter probability equal to one in the absence of scavengers. These characteristics can potentially give rize to a very large effect of magnetic fields. However, there are several conditions that must be met in order to have an effect of an rf-field. The frequency of the field, 900 MHz or 1800 MHz, must be in resonance with an electron spin transition. This requires that the radicals must have very large hyperfine constant, much larger than the most common values. Another condition is that the lifetime of the radical pair must be long, i.e. scavenging must be slow. Such reactions are rare; In fact no one is known.
3. Reactions of types 1 or 2 may show an enlarged effect if the reaction scheme includes chain reactions. One extremely important example is the lipid peroxidation which is described by a complex set of reaction steps that include chain reactions. This leads to bifurcations and under some conditions the reaction explodes. We have determined the trigger point and are investigating its dependence on magnetic fields. However, the reaction contains no nuclei with a large hyperfine constant and thus there is no effect in the frequency range used by mobile phones.
4. Enzyme reactions and electron transfer reactions often involve metal radical ions with large hyperfine constants. Such reactions have the potential to be affected by magnetic fields. Our calculations[1] predict that the phosphorylation by ATP synthase should have very strong magnetic field dependence and this has recently been confirmed[2]. There is a spin resonance at 1800 MHz, one of the frequencies used by mobile phones, but the effect of the weak rf-fields from mobile phones is expected to be insignificant.

[1] A.L. Buchachenko, N.N. Lukzen, J. Boiden Pedersen, Chem. Phys. Lett., 434 (2007) 139-143.
[2] A. L. Buchachenko et al, J. Phys. Chem. B, 112 (2008) 2548-2556.