



Pyroelectricity as a possible mechanism for cell membrane permeabilization

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Abstract

The effects of pyroelectricity on cell membrane permeability had never been explored. Pyroelectricity consists in the generation of an electric field in the surface of some materials when a change in temperature is produced. In the present study, tourmaline microparticles, which are known to display pyroelectrical properties, were subjected to different changes in temperature upon exposure to cells in order to induce an electric field at their surface. Then, the changes in the permeability of the cell membrane to a cytotoxic agent (bleomycin) were assessed by a cloning efficacy test. An increase in the permeability of the cell membrane was only detected when tourmaline was subjected to a change in temperature. This suggests that the apparition of an induced pyroelectrical electric field on the material could actually be involved in the observed enhancement of the cell membrane permeability as a result of cell electropermeabilization.

1. Pyroelectricity, a natural source of voltage gradients

Pyroelectricity is the physical property of certain crystalline materials to produce a spontaneous electric polarization when submitted to a change in temperature [1]. The mentioned change in polarization is translated in a variation on the dipole moment leading to a redistribution of surface charges in those materials [2]. Tourmaline is a complex borosilicate found in nature under different forms all of them displaying pyroelectrical properties (Martin-Olmos et al. 2012). Specially, granulated tourmaline in particles of several microns displays a spontaneous and permanent dipole.

2. The possible biological effects analyzed

The interaction of biological membranes with electric fields has been widely studied and applied to different fields of Biology and Medicine. The goal of the present study was to show the possible effects of tourmaline on cells due to its pyroelectrical properties. Specifically, this study sought to demonstrate how pyroelectrical materials can be a source of electric field generation for electropermeabilization. The changes in the cell membrane permeability when tourmaline is submitted to different changes in temperature were studied.

3. Results and conclusions [3]

As deeply studied by many authors, the exposure of biological membranes to electric fields can modify their permeability to molecular species in a phenomenon known as “electroporation” or “electropermeabilization”. Electropermeabilization of the cell membrane leads to a transient increase in the permeability of the cells due to the presence of an external electric field that provokes reversible changes in the lipid bilayer organization. Using a classical test to reveal cell electropermeabilization, we could demonstrate that the presence of Tourmaline nanocrystals resulted in cells transient permeabilization, only if Tourmaline nanocrystals had been subjected to a previous change in temperature responsible for the generation of pyroelectricity in these crystals.

We conclude that in the present study the pyroelectric-mediated cell permeabilization could be the result of this type of cell permeabilization. The microparticles could create microdomains where the transmembrane potential could reach the threshold for permeabilization. However, at this stage, we cannot exclude that other related phenomena differing from the classical electropermeabilization description could play a significant role in the observed results.

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7. References

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