Solvents affect the gating kinetics of sodium and potassium channels.

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Summary

Sodium channels and potassium channels are typical voltage-gated ionic channels for a generation of action potentials in nerve and brain. Kinetics of these ionic channels has been extensively studied, but has not been mentioned so much in relation with solvents. So, a molecular mechanism of effects of solvent and water on the gating process of these ionic channels is not clear. It is helpful to imagine a voltage-dependent conformational change in these ion channels, if these effects are qualitatively analysed at a viewpoint of dynamics in protein conformational change.

Solvent effects on a gating process of sodium channels were analysed, using an intracelluarly perfused squid giant axon. The same amount of nonelectrolyte was added on both sides of axolemma in order to change a solution osmolariy and/or viscosity, keeping an osmotic balance across the axolemma.

The time course of gating current was slowed as a nonelectrolyte concentration increased. The change of a time constant t_g is expressed as a function of osmolarity or viscosity of solutions. Comparing with solvent effects on sodium currents , effects on gating current are smaller but are simply explained by a viscosity effect. The main reason that solvent affects the kinetics is attributed to a flexible structure of the sodium channel proteins. Sodium channels have a lot of hydrophilic structure interacting with solvents and determining the rate-limiting step of overall conformational change of ionic channels, because a basic structure of sodium channels is maintained in the lipid bilayer and the interface of water and lipids.

A difference between effects on the gating current and those on sodium current was clear and might show a characteristic of a final transition to an open state. As expected from a lower temperature dependence of this transition, this transition may be attributed with a rearrangement of protein segments and side chains, ions and solvents among states separated with a smaller activation enthalpy than those in a previous process accompanying a gating current.