The Properties of Ionic Channels Measured by Noise Analysis in Thin Lipid Membranes

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Summary. Noise analysis was performed on the membrane currents produced by the ion channel former gramicidin A in black lipid bilayer membranes. The average channel lifetime and the unit channel conductance can be determined from the autocorrelation function. The values agree with the independently obtained data from measurements of single channels. The dependence of this function on the channel density reveals information on the process of channel formation. The kinetic information is the same as that obtained by voltage clamp measurements.

Key words: Noise Analysis — Ionic Channel Properties — Gramicidin A — Black Lipid Membranes — Autocorrelation.

Noise measurements on the ion currents across nerve membranes have been introduced into neurophysiology recently (Verveen and Derksen, 1968). They led to an estimate for the magnitude of the conductance increments produced by the opening of individual ionic channels (Katz and Miledi, 1972; Anderson and Stevens, 1973; Siebenga et al., 1973) and provided information on the kinetics and voltage dependence of acetylcholine gates (Katz and Miledi, 1972; Anderson and Stevens, 1973). There is also the expectation that noise analysis will allow a decision between various classes of models for the voltage dependent conductance changes in nerve membranes (Stevens, 1972; Fishman, 1973).

Theories suggesting noise analysis as an analytical tool were established many years ago (Groot and Mazur, 1962). Measurements on well characterized physico-chemical systems, proving the applicability of the concept, have been scarce. In fact, successful applications of noise analysis in physiology still outnumber applications to problems of chemical reaction kinetics. Therefore it seemed worthwhile to take an effort in testing the method on a simple system.

Discrete conductance steps representing the opening and closing of individual ionic channels are produced in black lipid membranes by a number of polypeptides, the antibiotic gramicidin A being the best characterized ion channel former (Haydon and Hladky, 1972). The random superposition of many single events leads to higher membrane
Fig. 1. (a) Autocorrelation function obtained at the unit channel conductance level. Single ion channels were produced by small amounts of gramicidin A in black lipid membranes formed from solutions of dioleoyl-α-lecithin in n-decane at 1 M KCl. Insert: Direct recording of a few current fluctuations. The autocorrelation function