Burst noise: Electrical breakdowns in myelinated nerve membrane

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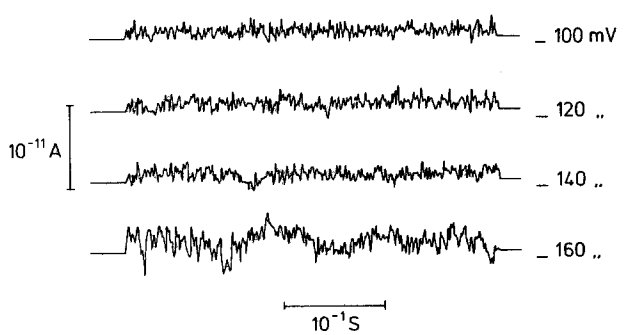
The spontaneous fluctuations of the ionic current of voltage clamped node of Ranvier contain mainly 1/f noise and channel noise (Lorentzian) in a broad range of membrane voltages (1). At certain levels of the membrane voltage for a certain time of application, the current fluctuations exhibit transients, called burst noise (figure).
This type of noise is investigated in motor fibres of Rana esculenta under voltage clamp conditions. The skewness of the amplitude probability density function (apdf) of the membrane noise is used to indicate the presence of burst noise. The voltage levels, where the gaussian apdf changes into a skewed one (transition voltage E_T), were measured for pulses of a duration of 700 ms and 3 min.
Burst noise currents are present at both negative and positive membrane voltages. Beyond the E_T level the amplitude and frequency of occurrence are increasing. The value of E_T is different for the different pulse durations (table):

pulse duration (s)	E_T (mV)		$\|E_c\|$ (mV)	$\Delta\Psi$ (mV)
0.7	-150	+70	110	-40
180	-100	+10	55	-45

Burst noise is identified as dielectric breakdown (2): a) occurrence at extreme levels of potential. b) increase of amplitude and frequency of occurrence beyond a critical level. c) relation between duration and transition voltage.
The membrane breakdown starts after reaching the critical level E_c, which is related to the voltage E_T by:

$$E_T = E_c + \psi_o - \psi_i$$

where ψ_o and ψ_i are the surface potentials at the outer and inner surface of the nodal membrane. From the estimates of E_T and the sole assumption that the breakdown is independent of the direction of the electric field both E_c and $\psi_o - \psi_i$ can be calculated (table).



Noise current records during the last half of 700 ms pulses to four different membrane voltages.

1. Van den Berg, R.J., Siebenga, E., De Bruin, G. (1977) Nature, 265, 177-179.
2. Callagher, T.J. (1975) Simple dielectric liquids. Oxford University Press.