Towards a macroscopic integro-differential equation accounting for triboelectrochemical phenomena.

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The triboelectrochemical phenomena is a dynamical process where the electrode kinetics and the mechanical interaction must be included in a general equation for the interpretation of experimental observations. The objective of the present work is the mathematical description of the time evolution of the indentation and the electrical current in a pin-on-disk tribometer.

In our model we consider that the metal mass (M_m) loss rate in a triboelectrochemical system can be expressed as the contribution of a wear term with an exclusive mechanical origin (Φ_{mech}) and the contribution of the electrochemical term caused by the tribocorrosion phenomenon (Φ_{chem}):

$$\frac{dM_m}{dt} = \Phi_{mech} + \Phi_{chem} \tag{1}$$

No synergy term has been included in this expression because it could be demonstrated that it is not necessary to describe the mechanical-electrochemical non-linear interaction. The model has been developed assuming the following hypothesis:

a) the pure mechanical wear is described by Archard's Law
b) the Faraday's Law describes the metal mass loss by repasivation of the bared metal surface
c) the dynamics of repasivation is described by the impulse response of Randles-like equivalent circuit
d) the wear track profile matches the radius of the ball indenter

Under these considerations, the wear track depth (x), an experimental observable magnitude, can be evaluated solving the equation:

$$\frac{dx}{dt} = \left[2\,\rho_m\,L\,R\big(x(2-x)\big)^{1/2}\right]^{-1} \left\{ \rho_m\,k\,\frac{F_N}{H} v_s + \frac{Mr}{n_e F}\frac{\rho_m}{\rho_{ox}} \int_0^L j(t,\tau)\cdot\lambda(x)\cdot\left|v_s(\tau)\right| d\tau \right\} \tag{2}$$

Where the integral is a convolution integral where considers the pin movement (v_s) and the wear track profile (λ(x)). The equation has been tested with a numerical 1D model for a tribometer. Indentation and current dynamics are provided.