Chemical perturbations on oscillatory electrochemical interfaces: From multistability and relaxation oscillations to synchronized bursters

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Abstract

The electrode-solution interface in electrochemical systems is an interfacial phase boundary serving as a membrane which is permeable to some of the chemical species comprising the phases and impervious to others. In the lower level of description, the neural cell membrane and the electrochemical interface have a phenomenological resemblance due to several kinetic analogies. Electrochemical interfaces that are spontaneously active can also behave as beaters or bursters, similarly to neural oscillators. A typical example is the electrodissolution / passivation of the iron electrode in sulfuric acid solutions. This system behaves as a beater and the temporal response consist of relaxation spikes of high periodicity. Chemical perturbation on the interface induces transition among coexisting stable states, excitability or recurrent groups of spikes interrupted by periods of quiescence *i.e.* bursting.

By considering the applied potential V as a bifurcation parameter of the system, it is shown experimentally that for low values of V the electrochemical burster is of elliptic (subHopf/fold cycle) type whereas for high values of V is of square-wave (fold/big homoclinic) type. The response of coupled electrochemical busters is determined by the type of bursting. Thus, in-phase burst synchronization takes place for elliptic bursters, no matter if the connection is excitatory or inhibitory. Spike synchronization is also observed for the case of elliptic bursters which is in-phase for excitatory coupling and out-of-phase for inhibitory coupling. For square-wave bursters neither burst or spike synchrony is observed for any connection type. It is claimed that the response of assemblies of electrochemical bursters is determined mainly by the non-linear dynamic characteristics of the electrochemical interface.

References

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