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Light-induced Non-pulsatile Bursting of Lipid Vesicles VINIT KUMAR, University of Illinois at Urbana-Champaign, SANGWOO SHIN, University of Hawaii at Manoa, JIE FENG, University of Illinois at Urbana-Champaign —
Lipid vesicles are topologically closed compartments bounded by semi-permeable lipid shells. Upon exposure to a hypertonic bath, vesicles respond with remarkable swell-burst events, showing oscillations in vesicle size and pore formation. Such lysis has been extensively harnessed to study dynamics of biological membranes, as well as releasing encapsulated actives for targeted drug delivery. Recently, some studies show osmotic shock by light-induced reactions achieves fast release of vesicle contents via an explosion process, e.g., irreversible bursting, yet the rationale for this is missing. Here we present a fundamental and quantitative understanding of bursting dynamics through a comprehensive theoretical model. Our model accounts for the kinetics of light-triggered reactions inside vesicles while considering the stochastic nature of pore nucleation by incorporating activation energy based on the vesicle expansion rate. The model quantitatively captures features of irreversible bursting dynamics, with good agreement between experimental observations and model predictions. Our work furthers a fundamental framework for nonequilibrium vesicle dynamics under osmotic stress induced by chemical reactions, offering design guidelines for vesicle-encapsulated substance release.

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