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Hybrid Lipids as Line Active Molecules

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The lipid raft hypothesis suggests that stable nanoscopic domains in cellular membranes play an important role in several biological processes. Model membranes composed of saturated lipids, unsaturated lipids, and cholesterol (SUC membranes) exhibit coexisting chain-ordered and -disordered domains. However, these domains are unstable and the positive line tension at the interfaces between these domains drives coarsening until their size reaches of the order of the system size. This motivates the search for physical mechanisms that may reduce the line tension to zero and thus stabilize nanoscopic domains in biological membranes. There is a theoretical suggestion that the positive line tension at the interfaces between domains in SUC membranes results from the chain packing incompatibility between the ordered chains of saturated lipids and the disordered chains of unsaturated lipids. Hybrid lipids that have one saturated and one unsaturated chains may reconcile this chain packing incompatibility. We have used a phenomenological model to predict that a small concentration of hybrid lipids added to SUC membranes can reduce the line tension between coexisting domains to zero. However, this tends to occur only at low temperatures that may not be experimentally accessible, because localizing the hybrid lipids to the interfaces costs mixing entropy and this strongly suppresses the reduction of the line tension. Indeed, hybrid lipids are major components of biological membranes; unsaturated lipids are rather minor and uncommon. We have used a liquid crystal model to analyze the phase separation and line tension between domains in model membranes composed of saturated lipids, hybrid lipids, and cholesterol (SHC membranes). This model predicts that the line tension is reduced to zero at relatively higher in SHC membranes because the hybrid lipids are already at the interface and the mixing entropy of localization is no longer relevant.