Abstract

The fusion and fission of fluid amphiphilic bilayers is a key process in biology, occurring both on the cellular and subcellular level. In a model system of excess water (D_2O), oil (*n*-decane) and nonionic surfactant ($C_{12}E_5$) the kinetics and mechanisms of transitions between two phase types of extended amphiphilic bilayers, i.e. the lamellar and sponge phase, are investigated. An abrupt change in temperature is used to initiate these phase transitions. The isotropic sponge or L_3-phase consist of a continuous membrane of multiply connected passages extending in three dimensions, while the anisotropic lamellar or L_α-phase is composed of stacks of bilayer sheets. Thus the L_3-to-L_α transition involves passage annihilation/bilayer fission, while passage formation/bilayer fusion marks the reverse case. By employing time resolved ^{2}H-NMR spectroscopy and SANS, it is found that these transitions occur through essentially different mechanisms: nucleation and growth in the case of the L_3-to-L_α transition and the formation of locally uncorrelated passages in the reverse case. The kinetics of the L_3-to-L_α transition (successfully described by the *Avrami* model) are strongly dependent on the change in temperature, the bilayer volume fraction, and viscosity, and slow (ca. 300-4000s) when compared to the opposite course (ca. 600s). Although initial (<200s) passage formation occurs very quickly in the fast L_α-to-L_3 transition, it appears that this slows considerably once a critical passage density is attained. Evidence suggests that disruption of long range lamellar order might also be a rate limiting process in this case. In the L_3-to-L_α transition, it is found that lamellar nuclei form at considerably higher bilayer volume fraction, than the equilibrium value. This can inhibit progressive nucleation at an advanced point in time. The work presented here represents the first systematic study on nucleation and growth phenomena in a microemulsion-type system. The results form the basis for improving the theoretical description of bilayer fusion and fission.