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ORIGIN OF MARANGONI CONVECTION ON A FREE SURFACE OF LIMITED AREA

Abstract

Marangoni convection is the key mechanism responsible for the motion of non-isothermal fluid with a free surface under microgravity conditions. It is generally assumed that the surface of a Newtonian fluid begins to move at any arbitrary small shear stress. However, the experiments show that under realistic conditions the capillary fluid flow can be initiated by a certain (threshold) stress. For subthreshold shear stresses generated by the surface forces or volumetric flows, the fluid surface remains immovable. Such a behavior of the surface is caused by the existence of an adsorption layer formed by uncontrolled surface-active impurities contained in the fluid. The composition and amount of impurities absorbed on the surface are dependent on the degree of purification of the fluid and the value of its surface tension. The condition of a threshold initiation of the capillary motion have been determined experimentally for the case of development of the solutal Marangoni convection after placing a droplet of the surfactant liquor on the interface of water, aqueous surfactant solutions of lower concentrations and some organic fluids. A group of monatomic alcohols and carboxylic acids were used as the surfactants. It has been found that the value of the threshold difference in surfactant concentration rapidly increases with a decrease of fluid initial concentration and the characteristic dimension of the free surface. Due to the latter fact the threshold effects are of crucial importance for a variety of problems in microfluidics. It has been found that a threshold origin of a capillary motion is also peculiar to the liquid-liquid interface. The relationships between the threshold Marangoni number and the surface activity of a surfactant have been determined.