Spreading driven by Marangoni stresses from a point source of surfactant

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Introducing surfactant on the interface of a fluid causes Marangoni stresses that drive a flow. The flow transports the surfactant and distrbutes the surfactant non-uniformly giving rise to the Marangoni stress. If the surfactant is introduced at a steady rate through a point source in an semi-infinite fluid pool, the resulting flow has a self-similar character with a singularity at the source, and can be calculated sei-analytically. We calculate this self-similar flow for the case of an insoluble surfactant, i.e. one which is transported in a phase adsorbed to the interface. The fluid velocity at a distance r from the source decays as $r^{-3/5}$. In contrast, the fluid velocity decays as r^{-1} for the case where the surfactant is predominanlty transported is a dissolved phase, as first presented by Bratukhin and Maurin, 1967, Prikladnaya Mathematica i Mechanica, 31, 577. We further show through transient numerical solutions of the governing fluid equations that the steady self-similar flow is approached as the transients die out. We propose that experimentally measuring the power law exponent of the velocity field decay can be used to determine whether the predominant transport of the surfactant occurs in an adsorbed or dissolved phase. Such a measurement does not require the explicit a priori knowledge of the material or transport properties of the surfactant or its interaction with the fluid. For example, we find that when camphoric acid is released at a steady rate on an air-water interface through a finite source, far from the source the fluid velocity decays as $r^{-3/5}$. Therefore, we conclude that, despite being soluble in water, camphoric acid spreads along the interface in an adsorbed phase.