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Superspreading: A possible mechanism

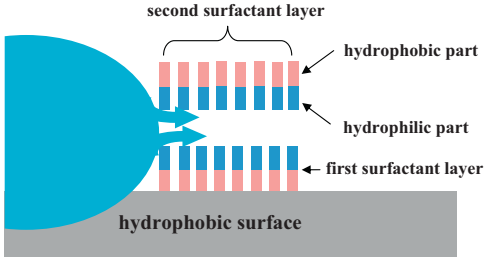
Eli Ruckenstein*

Department of Chemical and Biological Engineering, State University of New York at Buffalo, Buffalo, NY 14260, USA

HIGHLIGHTS

- A qualitative explanation of superspreading is suggested.
- It involves bilayer surfactant spreading, suction of water, and the Marangoni effect.
- The maximum rate of spreading observed experimentally is explained.

GRAPHICAL ABSTRACT



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ABSTRACT

It is suggested that superspreading of droplets of dilute aqueous solutions of siloxane surfactants over a hydrophobic surface is driven by: (i) the spreading at their leading edges of the surfactant as bilayers, (ii) the suction of water in the hydrophilic atmosphere between the two layers and (iii) the displacement of the surfactant and water by a Marangoni effect intensified by the formation of bilayers. An explanation is provided for the observation that the rate of spreading passes through a maximum at an optimum degree of surface wettability (surface hydrophobicity).

1. Introduction

Ananthapadmanabhan et al. [1] have observed that some siloxane surfactants, consisting of a trisiloxane hydrophobic moiety and an oligo(oxyethylene) hydrophilic one containing 7–8 EO units, generate a rapid spreading (superspreading) of droplets of dilute aqueous solutions of those surfactants over a hydrophobic surface. A number of partially successful attempts have been made to explain this observation. They have been presented in a few reviews [2–5]. The most recent of them [5] summarizes both the experimental and theoretical results obtained and emphasizes that the main mechanism suggested involving the Marangoni effect provides only a partial explanation of the observations, but cannot explain why the rate of spreading against the degree of surface wettability has a maximum. In 1996, the author suggested a possible mechanism based on the idea that superspreading occurs because the surfactant employed spreads from the drop over the substrate as bilayers, generating channels through which water is rapidly flowing, and that the Marangoni effect is also involved [6]. The goal of the present note is to provide additional details regarding that mechanism and to explain the maximum observed experimentally when the rate of spreading is plotted against a characteristic of the substrate reflecting its hydrophobicity, such as the wetting angle of a droplet of water on the surface of the substrate.

2. Mechanism of superspreading

The attractive interactions between the trisiloxane hydrophobic moiety and the hydrophobic surface triggers the spreading of the surfactant at the leading edge of the droplet over that surface. Because the hydrophilic moiety can become in this manner exposed to air, the free energy of the system can be decreased

* Tel.: +1 716 645 1179; fax: +1 716 645 3822.
E-mail address: feaeliru@buffalo.edu

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