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Motion of a foam lamella in a circular channel under a relaxing small pressure jump

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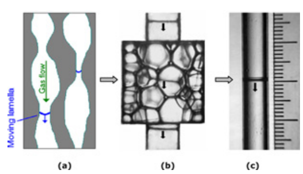
HIGHLIGHTS

- ► Foam lamella dynamics in a channel studied experimentally.
- ► Effect of viscous resistance in lamella dynamics is negligible.
- ► Marangoni stress controls the lamella motion.

GRAPHICAL ABSTRACT

Modeling of a foam flow in porous media (a) by two configurations: lamella motion through series of the cubic elements (b) and along the circular tube (c).



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ABSTRACT

The drag force of a foam lamella moving along a circular tube under low pressure drop was measured experimentally. We applied a small pressure jump on one side of the lamella and followed its trajectory until this pressure jump is relaxed. The experimental trajectories were found to be significantly different from those resulted from theoretical model based on a viscous resistance of the Plateau border. An alternative model is suggested. The model is based on the assumption that strong deformation of surface around the Plateau border causes considerable variation of the surface tension and the variation controls the lamella motion.

1. Introduction

A foam flow is a key element of many processes ranging from medical problems in such diseases as a pulmonary edema to methods of gas phase mobility control in oil and gas recovery, underground gas storage, and waste disposal sites sealing [1,2]. While technologically apparent, these processes are far still from complete understanding. The main difficulty is that choosing of proper micromechanical model of the foam flow. Among the available models, two classes based on different mechanisms of gas mobility reduction may be selected. According to the first approach, usually referred to as "break-and-reform", blocking of gas paths is by way of lamellas, i.e., thin, surfactant stabilized liquid films temporarily located at prescribed sites and spanning throats of pore channels [3].

The second approach treats the gas mobility reduction because of gas encapsulation into a system of bubbles, so that the gas is transported in the form of "bubble trains", and therefore an apparent viscosity of such a system is essentially greater than that of alone gas [4]. In [5] the details of this mechanism are discussed. The visualization of the foam motion through a channel of varied cross-section (as a simple model of porous media [5]) demonstrates that foam consecutively fills sections of the channel, forming bubble media with an apparent film duct (Fig. 1a). The duct cross-section is of the order of thin part of the channel. When each next lamella moves through the film duct, it slightly deforms but not breaks, with the lamella being stable itself (Fig. 1b). As soon as the apparent duct formed, the motion of the lamellas in the duct provides foam transport [5,6].

In this work we study the motion of a single lamella of foam through a smooth channel (tube): this process can be considered

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