Soap films for gas separation

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1. Introduction

Gas and nanoparticle filtration is generally performed via complex and expensive porous membranes facing clogging issues; breaking these current technological limitations relies on decreasing the costs and simplifying the existing protocols. A good alternative lies in specific liquid materials such as soap/foam films, which are thin liquid films stabilized by two amphiphilic surfactant monolayers located at the air/liquid interfaces [1]. The permeability of such films to gas depends on their thickness, the gas solubility in the liquid, and the surfactant monolayers' structure and mutual interactions. Understanding the properties of such systems remains challenging due to their inherent complexity.

2. Our work

The main objective of our study is to understand the phenomenon of gas permeation through a soap film as described in [1]–[3], and how the film properties (thickness, surfactant nature and concentration) affect its performances as a gas filter. We studied the evolution of a system of two gas compartments (air + non soluble C_6F_{14} | air) in a cylindrical syringe, separated by a soap film made of a solution of commercial dish-washing liquid (Fairy©). Only the soluble gas (here, air) will permeate through the membrane to balance both air concentrations (like osmosis phenomena in liquids). We developed a physical model to describe the evolution of the air + C_6F_{14} compartment volume, then compared it to our experimental measurements:

$$V(t) = V_0\,[(2\alpha t + 1)^{1/2} - 1] \qquad (1)$$

where a (s^{-1}) depends on the unknown film permeability; monitoring the film displacement enables us to compute $V(t)$.

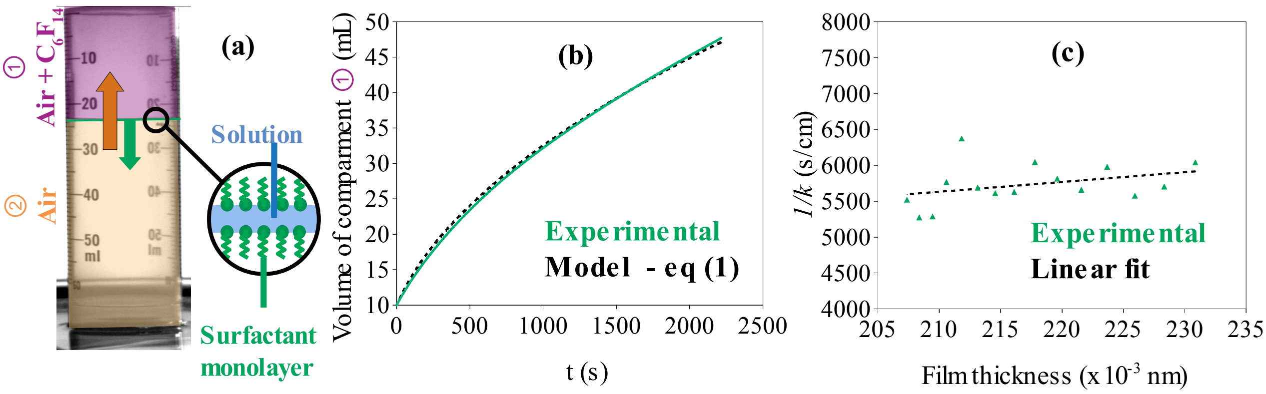

Figure 1: (a) Experimental setup – (b) Evolution of the volume of the upper compartment (air + C_6F_{14}) – (c) Estimated correlation between the film thickness and permeability k.

The permeability values are coherent with similar ones found in other papers [3]–[6]. We were able to estimate the correlation between the film permeability and thickness; this novel result paves the way for a better understanding of foam films. We are currently designing microfluidic equivalents to these systems in order to develop a functioning prototype amenable for repeatable separation of smaller volumes of various gases.

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