

Research Abstract

Yingxian (Estella) Yu

I. INTRODUCING REMARKS

My research is centered around low Reynolds number flows, motivated by industrial and medical applications. I have two research projects to which I am applying the knowledge from various fluid mechanics courses, including MAE 551 (Fluid mechanics), MAE 552 (Viscous flows and boundary layers), and MAE 559 (Fall 2015: Self-similarity at the fluid-fluid interface; Fall 2016: Low Reynolds number flows). In one project, I have studied the movement of a gravity current in a porous medium accounting for drainage from a permeable substrate and an edge (submitted). The second project is about coating a bubble in the flow of colloidal suspensions (submitted), which is the basis for my general exam as described below.

II. RESEARCH PROJECT INTRODUCTION

Armoring confined bubbles in the flow of colloidal suspensions. Particle coated bubbles have great potential in medical applications, such as drug encapsulation, due to their enhanced stability, but the hydrodynamics for bubbles in a suspension hasn't been widely studied. In this project, we investigate a translating bubble in a horizontal capillary tube filled with a colloidal suspension, and study the mechanisms that initiate the particle coating and govern the armoring procedure, see Fig. 1. By analyzing the

theoretical flow field around a clean bubble, we hypothesize that the particle accumulation is initiated at the stagnation points on the rear cap of the bubble, which is confirmed with experimental streamline visualization. Particle accumulation then progresses from the back

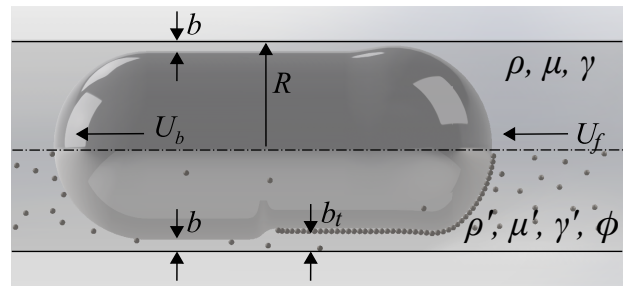


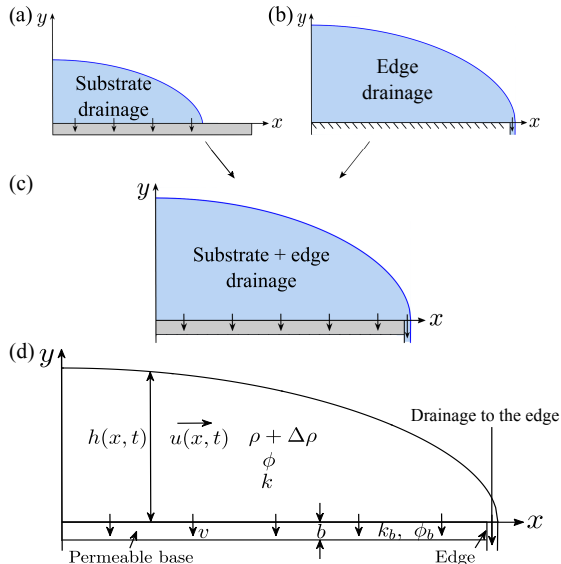
FIG. 1. Particle accumulation project schematics.

of the bubble to the front, with the fluid film thickened at the interface where particles are attached, while the film thickness at the clean interface is unchanged. Thus, two solutions co-exist on the interface of the same bubble before the bubble is completely coated. The coating process will cease when particle monolayer reaches the nose of the bubble, and the fluid film thickness will adjust again to a final value. These different solutions of film thickness are obtained analytically as functions of the capillary number $Ca \equiv \mu U/\gamma$, using the lubrication approximation and dimensional analysis. This project has been submitted for publication.

III. RESEARCH PLANS

Having great interest in investigating multiphase flow problems, I aspire to apply my research results in more industrial and medical applications. As one of the future research directions, I am planning to investigate the bubble-particle interaction in a vertically-oriented capillary tube, and design a system that can be used for fine particle separation.

Appendix A: Gravity current project



Motivated by the CO₂ underground storage projects, we studied the coupled drainage mechanisms of a propagating viscous gravity current that leaks from both a permeable substrate and a fixed edge, see Fig. 2. Theoretical analyses are employed to obtain self-similar solutions that describe the time evolution and steady-state shape profiles, which are further confirmed by numerical simulations. The results enable a more realistic prediction of the gravity current profile and the amount of fluid loss through each of the drainage mechanisms. This work has been submitted for publication.

FIG. 2. Coupled drainage schematics.