Flow of wormlike micellar solutions around confined micro-fluidic cylinders.

Application Note

Simon J Haward *et al.*

Micro/Bio/Nanofluidics Unit, Okinawa Institute of Science and Technology.

Figure 1. Flow patterns for 60 mM CTAB/SHNC solution: orientation angle (top); retardation (middle); streak image (bottom).

Introduction

The Micro/Bio/Nanofluidics Unit at the Okinawa Institute of Science and Technology was established in July 2014. The two core research areas in the unit are: the fundamental aspects of micro- and nano-fluidic flows (including fluid mechanics, soft matter physics and rheology) and related biotechnology, nanotechnology and healthcare applications (e.g. bioassays, biosensing, bio- and nano-materials synthesis). The unit members have unique and complementary expertise in fluid mechanics, soft matter physics, biomedical and chemical engineering, materials science and polymer/physical chemistry.

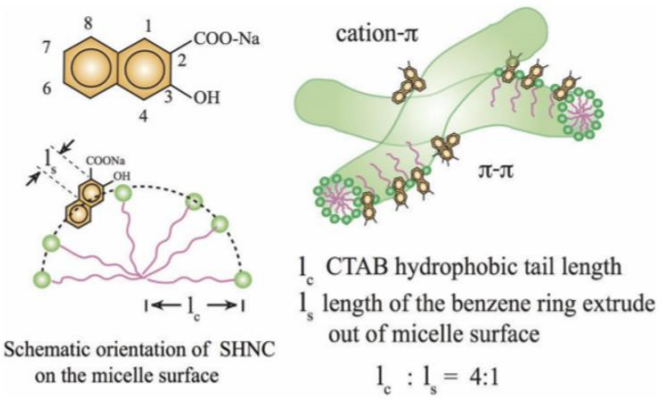

Figure 2. The chemical structures and schematic representation of the orientation of SHNC and SHNC/CTAB micelles.

Wormlike micellar (WLM) solutions are frequently used in enhanced oil and gas recovery applications in porous rock beds where complex microscopic geometries result in mixed flow kinematics with strong shear and extensional components. In this study, the flow behaviour of an aqueous WLM solution consisting of cationic surfactant and a stable hydrotropic salt were studied in micro-fluidic devices with three different cylinder blockage ratios.

Experimental

Flow pattern visualisations were performed by capturing streak images with an inverted epi-fluorescence spinning disc confocal microscope (Aurox/Andor DSD2), equipped with an Andor iXon camera and a Nikon 4x 0.13 NA objective lens. The fluids were seeded with fluorescent polystyrene particles with excitation and emission wavelengths of 530 nm and 607 nm respectively. Streak images were recorded with frame rates ranging from 0.3 to 10 frames per second and streak imaging videos were recorded over time periods of several seconds in order to observe the time dependent nature of the generated flow fields (Figure 3, overleaf).

Results

The Aurox/Andor confocal imaging system allowed high contrast and in-focus visualisation of the flow in a 100 µm thick optical section at the centre of the flow chamber.

1. *Simon J Haward et al, Soft Matter 12: 8666 (2016).*

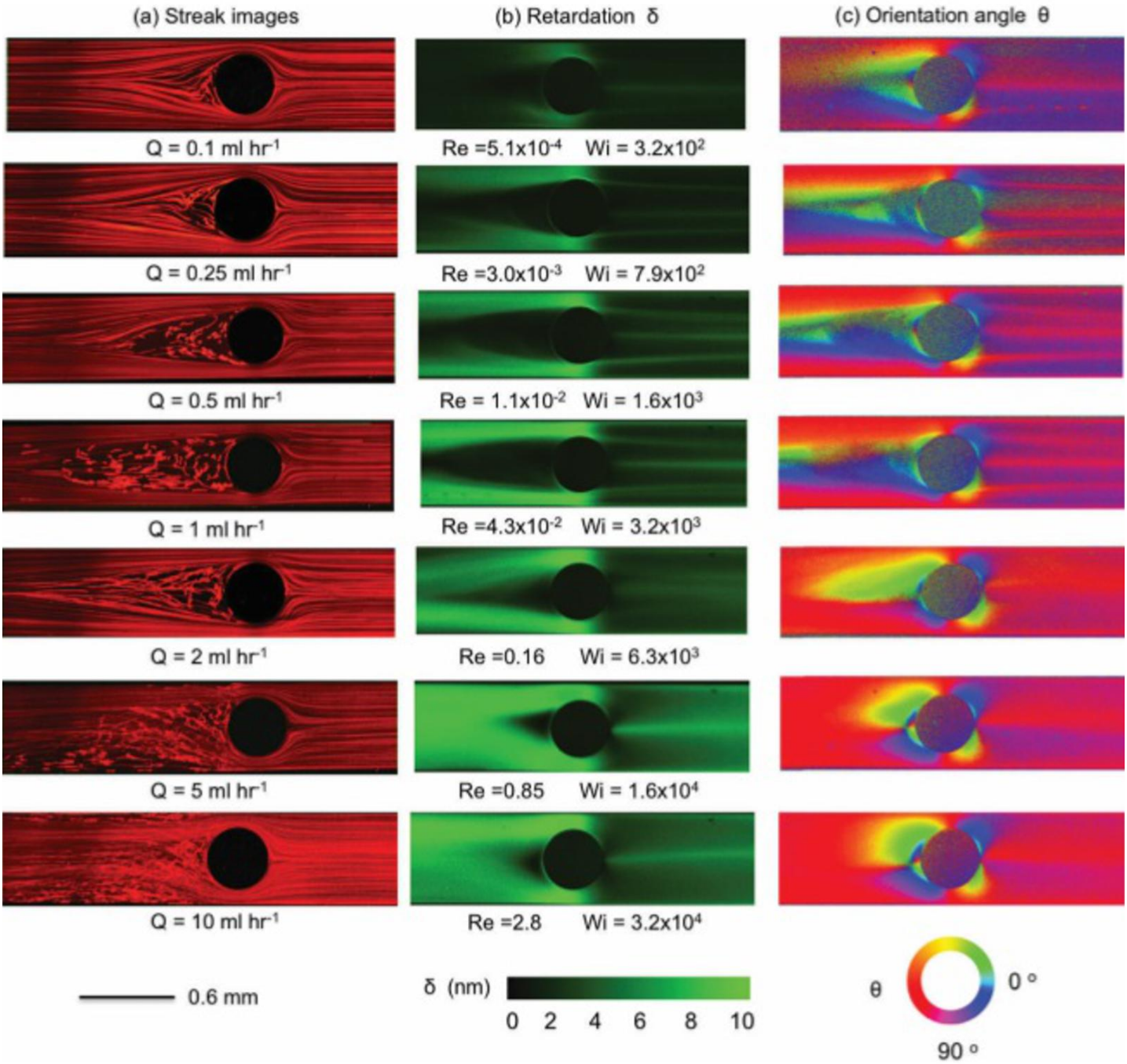

Figure 3 (Above). *The development of flow patterns for the flow of 60 mM CTAB/SHNC solution. (a) streak images; (b) retardation; and (c) orientation angles at flow rates 0.1 < Q < 10 mL per hour, corresponding to 5.1 x 10^{-4} < Re < 2.8, and 3.2 x 10^{2} < Wi < 3.2 x 10^{4}.*

Figure 4 (Left). *The Haward research group.*