Electronic Supplementary Material for

High efficiency of biosurfactant in stabilizing oil micro-droplets with millisecond aging time: a microfluidic study

*Zhi-yuan Yang[a], Shi-zhong Yang[a,b], Gang-zheng Sun[c d], Wei-dong Wang[c], Fei dan[a], Bo-Zhong Mu[a,b], Hong-ze Gang[a,b],**

a State Key Laboratory of Bioreactor Engineering and School of Chemistry and Molecular Engineering, East China University of Science and Technology, Meilong 130, 200237 Shanghai, P.R. China

b Engineering Research Center of Microbial Enhanced Oil Recovery, MOE, East China University of Science and Technology, Meilong 130, Shanghai, 200237, P.R. China

c Shengli Oilfield Company, Sinopec, Dongying, 257000, P.R. China

d Research Institute of Petroleum Engineering and Technology, Shengli Oilfield Company, Sinopec, Dongying, 257000, P.R. China

This electronic supplementary material includes:

1. The images captured by the high-speed camera in the coalescence chamber of the microfluidic chip are edited into three movies (Movie S1-S3).

2. Results of ESI-MS for biosurfactant C_{15}-SFT and chemically synthetic surfactant 8-SCBS (Fig.S1)

3. Three kinds of microfluidic chip designs with different narrow channels to create three aging times used in this work (Fig. S2), volume shared by the micro-droplets in different radii (Fig. S3), micro-droplet radius distribution at different positions of the coalescence chamber (Fig. S4).

4. The calculation of the average coalescence time, $\bar{t}_v$.

Description of movies

Movie S1: Micro-droplets stabilized by 1×10^{-4} mol/L C_{15}-SFT at the outlet of the coalescence chamber with 600 ms aging time. Shooting speed: 30 fps; Playing speed: 10 fps.

Movie S2: Micro-droplets stabilized by 1×10^{-4} mol/L 8-SCBS at the outlet of the coalescence chamber with 600 ms aging time. Shooting speed: 30 fps; Playing speed: 10 fps.

Movie S3: Coalescence event of micro-droplets stabilized by 1×10^{-6} mol/L C_{15}-SFT at the inlet of the coalescence chamber with 600 ms aging time. Shooting speed: 13600 fps; Playing speed: 60 fps.

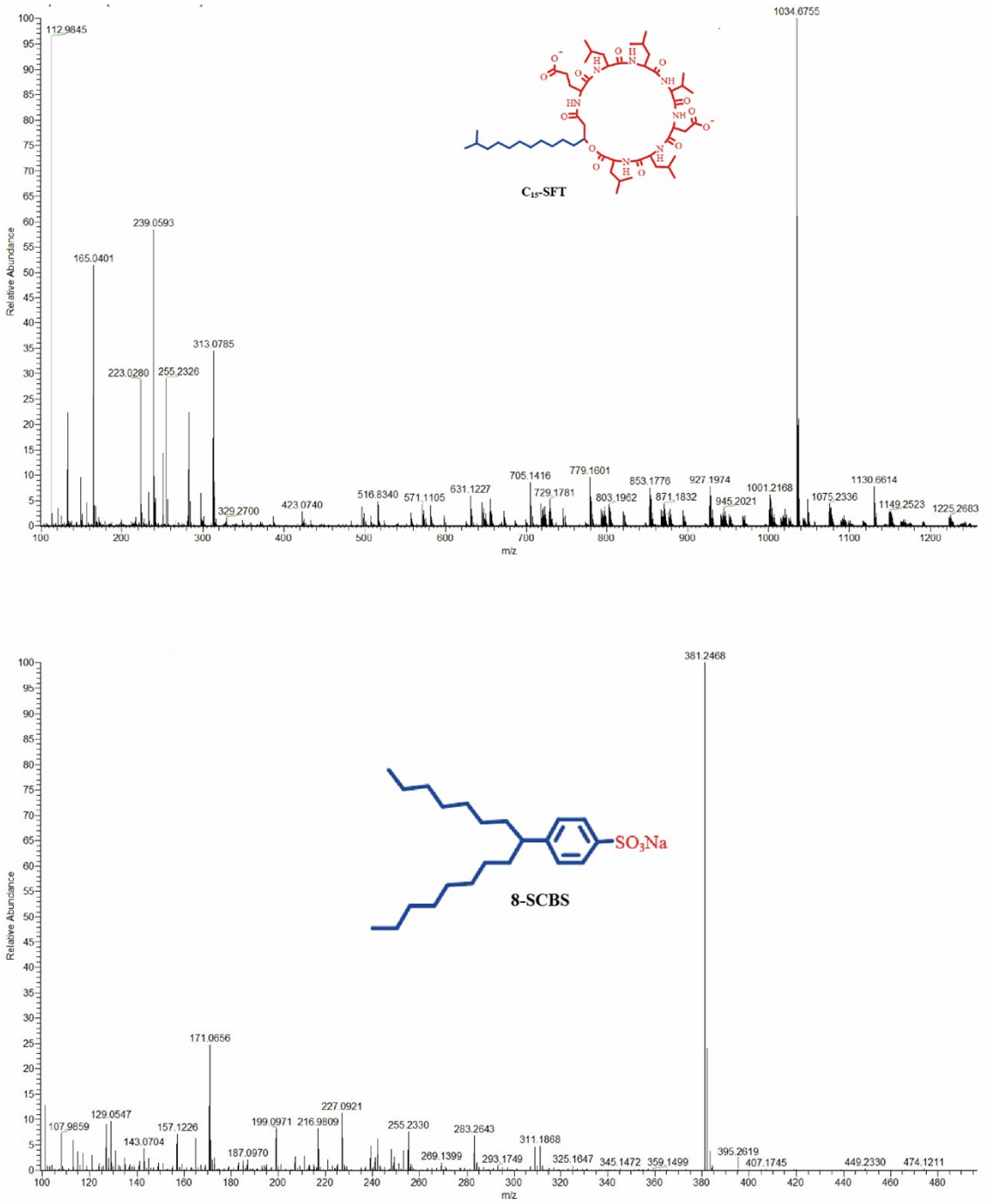

Fig. S1. ESI-MS for biosurfactant C_{15}-SFT and chemically synthetic surfactant 8-SCBS

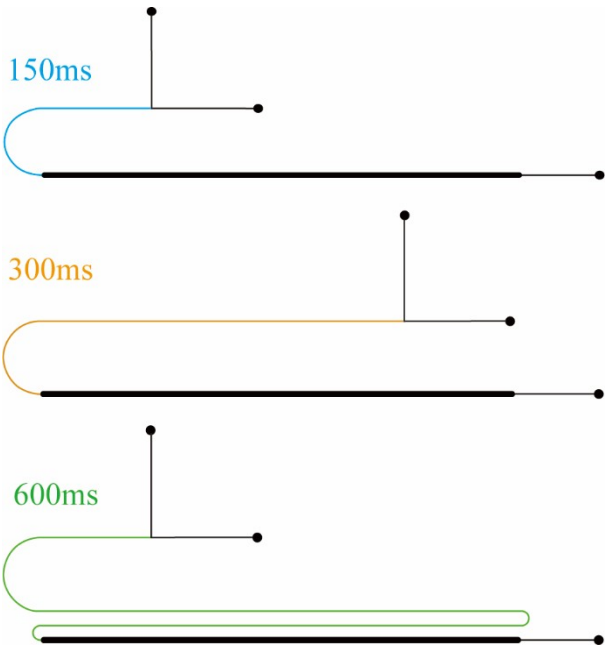

Fig. S2. Schematic diagrams of microfluidic chips that have three aging times. (The lengths of the narrow channels in blue, orange, and green are 23.3mm, 46.7mm, and 93.3mm, respectively)

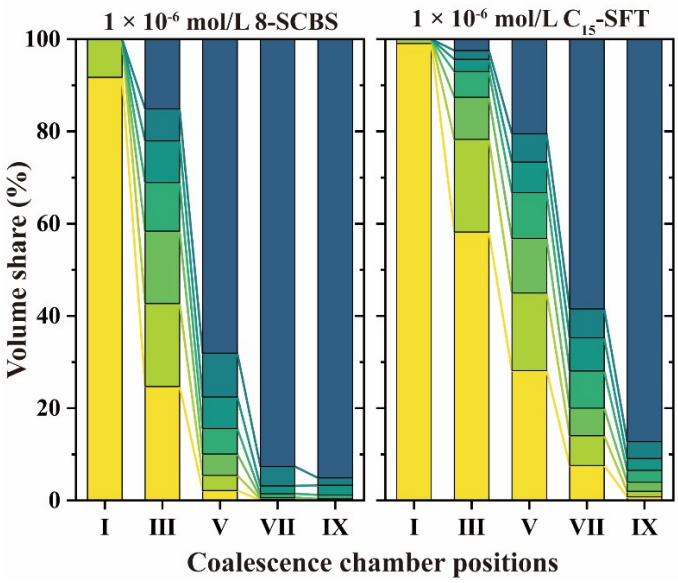

Fig. S3. Volumes shared by the micro-droplets in different radii (concentrations of C_{15}-SFT (right panel) and 8-SCBS (left panel) are 1×10^{-6} mol/L). Size1 represents the

micro-droplets in original size, size *n* represents the droplets formed by the coalescence of *n* original micro-droplets, and size7+ represents the droplets formed by the coalescence of seven or more original micro-droplets.

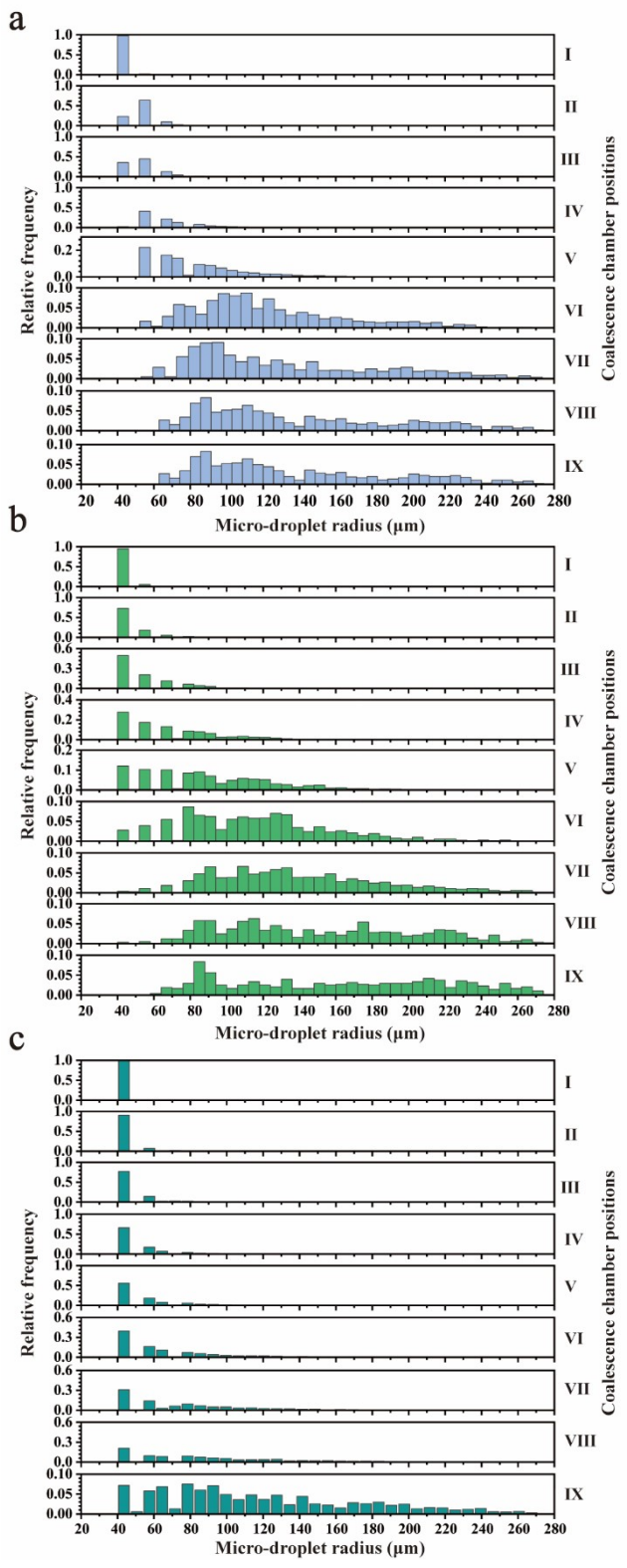

Fig. S4. Radius distributions of micro-droplets stabilized by (a) 1×10^{-6} mol/L 8-SCBS, (b) 1×10^{-4} mol/L 8-SCBS, and (c) 1×10^{-6} mol/L C_{15}-SFT at different positions in coalescence chamber after 600 ms aging time.

Averaged coalescence time, $\bar{t}_v$

In a coalescence event, one approach velocity corresponds to one coalescence time. All the coalescence events were sorted by approaching velocity, and the averaged coalescence time, $\bar{t}_v$, were calculated by the number-average coalescence time of the coalescence events in which the approaching velocities were below v.

$$\bar{t}_v = \frac{\sum_0^v t_{coal}}{\sum_0^v N}$$