In-situ observation of drying-induced deformation and coalescence of emulsions

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Emulsion is a solution in which small immiscible liquid droplets are dispersed. Interfacial energy between two immiscible liquids is generally high and surfactant is necessary to form emulsions. We frequently use emulsions in a variety of fields, such as cosmetics, paintings and adhesives. Drying of emulsion occurs in these fields and several studies have been done on the drying of emulsions.[1],[2] However, as far as we understand, we are still lacking in understanding of fundamental drying dynamics of emulsions.

We observed drying of oil-in-water emulsions using a confocal microscope. We used nonvolatile oil as dispersion phase and only water evaporated in this system. Due to drying of water, suspended oil droplets were gradually compressed by receding air-water interface, followed by deformation of oil droplets as shown in Fig. 1. These compressed oil droplets coalesced in the final stage of drying. In addition, we also observed a decrease in drying rate in a late stage of drying. We consider that mass transfer of water from the center to the drying edge of the emulsion was severely retarded by the deformation of oil droplets. Due to the compression of oil droplets, paths for water transport between droplets became narrower, which resulted in the decrease in drying rate. Drying kinetics of emulsions, such as drying rate and the onset of coalescence, are discussed.

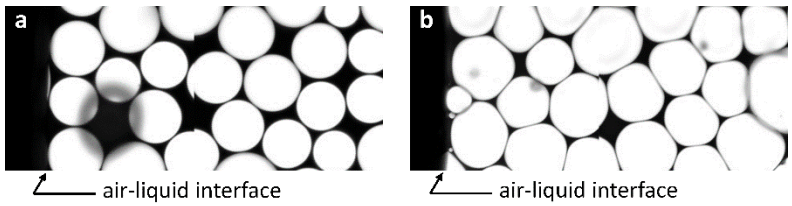

Fig. 1 Drying emulsions observed by a confocal microscope, (a) in the initial stage of drying and (b) in a late stage of drying. Oil phase was dyed and shown as white in images. Voids between oil droplets were filled with water. Diameter of droplets was about 60 μm.

References

[1] A. Q. She, D. Wang, and P. T. Spicer, *Langmuir*, **2007**, *23*, 12821.
[2] H. Feng, J. Sprakel, D. Ershov, T. Krebs, M. A. Cohen Stuart and J. v. d. Gucht, *Soft Matter*, **2013**, *9*, 2810.