



HAL
open science

On precipitation during the coalescence of reactive droplets

M. Jehannin, S. Karpitschka, H. Mohwald, H. Riegler, T. Zemb, S. Charton

► **To cite this version:**

M. Jehannin, S. Karpitschka, H. Mohwald, H. Riegler, T. Zemb, et al.. On precipitation during the coalescence of reactive droplets. American Institute of Chemical Engineers (AIChE) Annual Meeting - 2016, Nov 2016, San Francisco, United States. hal-02441957

HAL Id: hal-02441957

<https://hal-cea.archives-ouvertes.fr/hal-02441957>

Submitted on 16 Jan 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

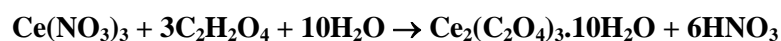
L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

On precipitation during the coalescence of reactive droplets

M. Jehannin, S. Karpitschka, H. Möhwald, H. Riegler, T. Zemb and S. Charton

The coalescence of sessile drops of completely miscible liquids can be affected by a Marangoni flow, resulting from the surface tension difference of the two liquids [1,2]. Although the surface tension is strongly related to solute's concentration, and particularly hydrotropes [3], the coalescence of drops containing reactive liquids was not investigated so far. However, the coalescence behavior of reactive droplets is encountered in a wide range of applications such as liquid-liquid extraction, ink jet printing, nanoparticles synthesis, etc. Moreover, controlling the reagents mixing and transport phenomena during the droplets coalescence is of major importance in the new precipitation in emulsion process we are currently developing [4,5].

We consider the coalescence behavior of sessile drops containing aqueous solutions of cerium nitrate and oxalic acid. Upon contact, these compounds form insoluble, color-less cerium oxalate.



We observed that in a given and limited range of component concentrations and surface tension differences between both liquids (the latter can be controlled using diols/water structured binary solvents), the precipitating cerium oxalate surprisingly forms periodic patterns of fringes with different light-scattering properties that allow easy detection by strongly contrasted images (Figure 1).

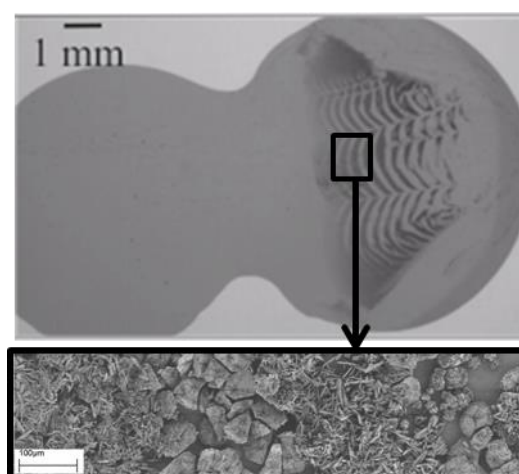


Figure 1: Periodic patterns appearing during drop coalescence (optical imaging via top view camera) and (after drying) by scanning electron microscopy. Black domains in the top picture correspond to needlelike crystals, while microflowers of micron-size aggregated needles are observed in the light domains. The fringes formation is observed regardless of the Marangoni flow direction.

SEM observation, performed after complete drying of the sample, reveals individual needle-like particles of typical length 25 μm in the dark, strongly light-scattering zone; whereas the latter appear aggregated in large “microflowers” (*i.e.* 65 μm) in the light areas. Additional experiments using confocal microscopy indicate that the two types of particle result from different precipitation mechanisms. However, XRD shows that particles exhibit a monoclinic structure typical of cerium oxalate decahydrate, regardless of their shape.

The relation between the various control parameters (initial contact angles, reactant concentrations, viscosity, surface tension difference), the stripe property (spacing of the fringes), and the Marangoni flow was further analyzed by optical microscopy and image processing. The results highlight a strong coupling between the transport processes and the fast chemical reaction [6]. On the other hand, for

given “hydrodynamic” parameters (*e.g.* initial contact angle and surface tension difference), the occurrence of the reaction appeared to modify the coalescence behavior, compared to the non-reactive cases investigated by Karpitschka and Riegler [1,2]. Coalescence of reacting droplets has therefore proved to be a valuable tool to further study crystal nucleation and growth mechanisms.

In this aim, the solvent influence on the precipitates is currently examined. Water, binary water/diols and ternary water/oil/hydrotrope mixtures are considered as solvent [7]. Still triggering the reaction by the coalescence of sessile droplets, first results have highlighted that mesoscale solubilization in structured solvents changes the particle morphology to a more compact mesocrystal shape described by [8].

- [1] S. Karpitschka and H. Riegler, *Langmuir*, 26, **2010**, 11823-11829.
- [2] S. Karpitschka and H. Riegler, *J. Fluid Mech*, 743, **2014**, R1.
- [3] W. Kunz *et al.*, *Current Opinion in Colloids and Interface Science*, **2016**, *in press*.
- [4] S. Charton *et al.*, *Chem. Eng. Res. Des.*, 91, **2013**, 660-669.
- [5] M. Ollivier *et al.*, *Proceedings of ATALANTE2016*, Montpellier.
- [6] M. Jehannin *et al.*, *Langmuir*, 31, **2015**, 11484-11490.
- [7] M. Jehannin *et al.*, *submitted to Physical Chemistry Letters*.
- [8] H. Cölfen and M. Antonietti, *Mesocrystals and Nonclassical Crystallization*, **2008**, John Wiley & Sons, Ltd

Keywords: Coalescence; Marangoni flow; Precipitation Mechanisms
