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Towards detergency in liquid CO_2 – A surfactant formulation for particle release in an apolar medium

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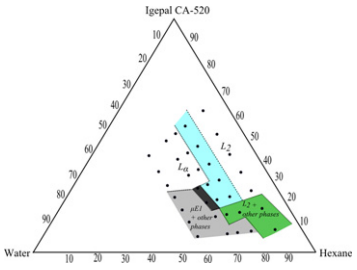
HIGHLIGHTS

- A new hydrocarbon surfactant and formulation for liquid CO_2 dry-cleaning introduced.
- In the formulation lamellar mesophases coexist with reverse micellar phase.
- Surfactant mesophases reduce adhesion force between a silica particle and cellulose.
- Formulation has five times better soil removal ability than control in liquid CO_2.

GRAPHICAL ABSTRACT



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ABSTRACT

In this paper we propose, characterize and test a surfactant formulation, consisting of a branched polyoxyethylene type commercial non-ionic surfactant (Igepal CA520), n-hexane and water, for use in CO_2 dry-cleaning to enhance the removal of particulate soil. In the formulation lamellar mesophases L_α coexist in an L_2 microemulsion (reverse micellar) phase. We hypothesize that enhanced soil removal would be possible due to the adsorption of lamellar liquid crystalline phases at the fabric–soil interface, the presence of water pools, the improvement of the solvent quality of liquid CO_2 by the presence of n-hexane, and the enhanced viscosity due to the presence of the lamellar mesophases. We have characterized the formulation by optical microscopy with crossed polarizers, confocal microscopy, dynamic light scattering and shear viscometry to determine the phase behaviour, the size of the reverse micelles and the flow behaviour. AFM force measurements in n-hexane show that large adhesion forces between a model soil particle (silica) and fabric surface (cellulose) in water-saturated hexane can be reduced by the action of the surfactant mesophases. In the presence of the surfactant formulation the interaction forces were found to be decreased from ~15 nN to 0.5 nN. The formulation, applied as a pre-treatment on standard soil test monitors and followed by washing in liquid CO_2, showed a five times better soil removal ability than the control.

1. Introduction

Traditional dry cleaning is carried out with perchloroethylene (PERC) which is toxic, harmful, carcinogenic and a depletant of the ozone layer. Therefore a more sustainable alternative is needed. Liquid CO_2 has been identified as a promising replacement for PERC in dry cleaning, as it is environmentally benign, non-toxic and cheap [1]. Tests with liquid CO_2 as a medium for textile cleaning have shown that it indeed is capable of removing fatty and greasy substances, which are sufficiently soluble. Moreover, polar compounds are also fairly well removed, in particular when a little water (1–2%) is added [1]. However, particulate dirt (soil) is poorly removed by liquid CO_2. This is to some extent expected, as the physical properties of liquid CO_2 make it a rather unfavourable

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