Cationic vesicle transport and deposition on anionic porous substrates

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Cationic vesicles are important ingredients in personal care, homecare [1], and drug delivery formulations [2] where they are used as vehicles to transport active ingredients to target surfaces. Most of the target surfaces such as textile, hair, and skin have a porous structure, and depending upon the purpose of the formulation an effective performance requires either low (example: fabric softening) or high permeation (example: drug delivery to skin) of vesicles into the porous structure. Therefore, it is important that the mechanism of vesicle transport and deposition on porous substrates is well understood.

In this work, the deposition of cationic vesicles, composed of lipids commonly used in fabric softeners, on porous anionic cotton yarns has been investigated. Cotton yarns were treated with vesicle dispersions under fully immersed conditions, and the interaction involved simultaneous diffusive transport of vesicles into the porous structure, and deposition on the constituent cotton fibers. Two different types of cationic vesicles, composed of chemically similar lipids, but with contrasting lipid bilayer phase behavior were used. Deposition was quantified based on spectrophotometric measurements of depletion of lipid concentrations in bulk dispersions [3]. Additionally, a novel streaming potential method was implemented to study the variation of the zeta potential of external yarn surfaces with deposition to get an insight into the distribution of deposition across the yarn cross-section.

It is identified that the post-treatment distribution of vesicle deposition across yarn cross-sections is dependent on two main factors, namely, (i) lipid bilayer phase behavior, and (ii) presence of electrolyte in the bulk liquid. It is found that the deposition of vesicles with solid-gel phase bilayers is concentrated near the yarn periphery, whereas the deposition of vesicles with liquid-crystalline phase bilayers is more homogeneously distributed across the yarn cross-section. Additionally, the presence of electrolyte in the bulk liquid is found to have a two-stage effect on the deposition of both the vesicle types with, (i) more deposition occurring near the yarn periphery in presence of electrolyte in the initial deposition stages, and (ii) attainment of higher equilibrium deposition levels in presence of electrolyte. The reasons underlying these observations were investigated, and established to be an outcome of the effects that the above factors have on DLVO interactions and vesicle deposition kinetics. The findings provide new insights which might be useful in preparation of more effective vesicle-based formulations.

Acknowledgements We acknowledge financial support from the Marie Curie Initial Training Network ‘‘Complex Wetting Phenomena” (CoWet), Grant Agreement no. 607861.

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