Durability of lubricant-impregnated surfaces: the effects of laser textured surfaces on lubricant retention under vibrations

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Adhesion of liquid substances on packaging surfaces could lead to wastage, an increase of recycling costs, and even customers' dissatisfaction in applications related to food, cosmetics and agrochemical industries. Surface functionalization approaches such as coatings and surface texturing/patterning have shown to enhance anti-adhesive properties of surfaces. However, inherent shortcomings of these approaches are durability and chemical leaching of such treated surfaces that hamper their broader use in practice. To overcome these limitations, lubricant-impregnated surfaces (LIS) have attracted recently the attention of industry and research. The research that will be presented reports an investigation into the durability of LIS, especially minimising any liquid food residues on surfaces of thermoplastic packaging solutions. Femtosecond laser processing and hot embossing were employed to produce two types of topographies for lubricant impregnation on stainless steel, polypropylene and polystyrene surfaces. In particular, the first type was surfaces with laser induced periodic surface structures (LIPSS), i.e. sub-micron ripples, while the second was surfaces with multiscale structures (MS), i.e. sub-micron on top of micro scale features. Then, LIS were attained by infusing silicon oil onto these two types of surface topographies. Droplet shedding characteristics of these LIPSS-LIS and MS-LIS substrates with water, milk and honey were examined before and after subjecting them to vibration. All the tested liquids have shown to be pinned onto the un-impregnated textured surfaces even at large tilt angles. At the same time, both LIPSS-LIS and MS-LIS samples exhibited excellent droplet shedding characteristics, even for tilt angles as low as 33°. In addition, the LIPSS-LIS substrates retained their functionality even after subjecting them to severe vibration cycles while this was not the case for the MS-LIS ones. The LIPSS topographies resisted to any lubricant migration due to high capillary forces. The research provides an insight into the design and manufacturing challenges associated with the cost-effective production of durable LIS for various potential application areas.