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Full Length Article

Influence of laser texturing on the wettability of PTFE

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ABSTRACT

Polytetrafluoroethylene (PTFE) is a synthetic fluoropolymer showing excellent thermal and electrical insulation properties and a low coefficient of friction. Due to its large stability, and hydrophobic nature, the wettability of PTFE surfaces can be reduced to transform them into superhydrophobic. In this regard, laser texturing is a fast, simple and versatile method to produce superhydrophobic PTFE surfaces in one-step, and over large areas. In this work, we used a CO_2 laser to modify the surface of PTFE samples. We studied the effect of the processing parameters (laser power or irradiance, scanning speed, and spacing -overlapping- between scan lines) on the wettability of textured surfaces using water, mineral oil and ethanol/water solutions as test fluids. Laser-treated surfaces showed a hierarchical micro- and nanotopography with a cotton-like appearance. The higher roughness and large quantity of air pockets make these laser-treated surfaces superhydrophobic, and highly oleophobic. Furthermore, they remain unaltered after being in contact with strong alkali and acid solutions or after slight friction. The self-cleaning performance of these surfaces was also demonstrated. The present findings suggest that CO_2 laser texturing of PTFE is suitable for the large-scale preparation of surfaces with low-wettability to different liquids.

1. Introduction

Polytetrafluoroethylene (PTFE) is a synthetic fluoropolymer only composed by carbon and fluorine, and with multiple applications due to its excellent properties. The strong C—F bonds of fluoropolymers confer them with a large thermal stability, chemical inertness, low surface energy, electrical insulation, low friction coefficient, low dielectric constant, or an excellent charge storage stability [1–3]. These properties make it an excellent candidate to be applied in fields such as electrical, mechanical, textile, biomedical, pharmaceutical or food, among others [4]. The wettability of PTFE surfaces has been researched in the past to expand their current applications. In this sense, the low wettability of PTFE hinders its application in the biomedical field; then, different surface treatments (e.g. laser or plasma treatments) have been tested to improve its wettability and to promote the cell adhesion, and proliferation of PTFE-based implants [5,6]. On the contrary, the low wettability of PTFE surfaces can be even more reduced to obtain superhydrophobic surfaces [7,8]. These low-wetting surfaces are extremely interesting for many applications, such as in drag reduction, self-cleaning or anti-icing surfaces [9–12]. Different techniques or physical/chemical procedures have been applied to obtain this kind of surfaces, such as plasma treatment, abrasion with sandpapers, laser treatments or deposition of colloidal coatings [12–15]. Among these techniques, laser texturing is one of the most versatile and efficient processes to tailor the surface properties of metals, ceramics and polymers, in particular, to modify the wettability of PTFE surfaces [16–19].

Laser texturing involves the utilization of a focused laser beam, which heats, melts, and/or vaporizes the surface of the polymer to produce regular or irregular patterns of bumps, dimples, or grooves [20,21]. These patterns modify the roughness of the surface, and then, its apparent wettability due to the formation of air pockets in the surface. On the other hand, the utilization of UV lasers (e.g. excimer lasers) can also produce the breaking of chemical bonds in the surface; this can induce the formation of functional groups, and then the modification of the surface chemistry of the polymers [18]. These modifications will also impact on the apparent wettability of the surface.

In the literature, many different works have explored the utilization of laser texturing to modify the surface roughness or the surface chemistry of the PTFE surfaces. The utilization of femtosecond lasers to modify the surface topography of PTFE has been largely explored in different research works. In this way, Huang et al. used a femtosecond

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