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Production of superhydrophobic surfaces on polyolefins by combining an imprinting process with atmospheric-pressure plasma surface coating

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Protein adsorption on surfaces is the first step for biofilm formation. One possible approach to prevent the protein adsorption on polymers is to avoid wetting of their surfaces by a cell culture medium as it is needed for special biochemical applications of plastic components with wettable and non-wettable surface regions. For this purpose, a superhydrophobic bilayer system was developed at Fraunhofer IST, to be deposited on polypropylene (PP) by atmospheric-pressure plasma-enhanced chemical vapor deposition (AP-PECVD). This system consists of a nanoparticulate base layer of SiO_2, providing surface roughening, combined with a dense top layer of plasma-polymerized tetramethylsilane (TMS) covering the SiO_2 particles and offering hydrophobic groups on the surface. Coatings with TMS itself provide a water contact angle of 120° on a smooth surface, while in the bilayer system > 150° are achieved. Unfortunately, the bilayer system lacks in mechanical stability and its transparency is poor due to the highly scattering SiO_2 particles.
To overcome the limitations related to SiO_2 particle layers, surface roughening of PP by an embossing process was subsequently employed. For this purpose, special Ballard skins were prepared using high-resolution rotogravure or laser engraving. Suitable parameters for the used structures were taken from the analysis of superhydrophobic surfaces by Yamamoto et al.. These authors found that pillars with distances between 5 and 15 µm and heights larger than 20 µm should be ideal. However, such geometries could be realized only approximatively, due to resolution limitations of the engraving techniques employed in this work. Consequently, the produced structures which look cone-like have distances in the range of 10 to 30 µm and a maximum height of 15 µm. Embossing of PP films was performed at 160°C and 250 kN. In the illustrated work, the relationship between surface topography and coating parameters is examined using laser scanning microscopy (LSM) and water contact angle measurements as well as wetting tests.

Keywords
superhydrophic