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OWENS-WENDT CHARACTERIZATION OF WATER REPELLENT TEXTURES OBTAINED ON POLYMER FILMS

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Abstract *This research focuses on the characterization of liquid-repellent polymer films with micro- and nanostructured surfaces, using the Owens-Wendt method. The study investigates polydimethylsiloxane (PDMS) and low-density polyethylene (LDPE) films engineered to enhance water repellency. The Owens-Wendt approach was applied to estimate surface energy and evaluate the influence of surface texture on wetting behavior. Results demonstrated that while both materials exhibited superhydrophobic properties under specific conditions, PDMS surfaces showed lower stability against wetting transition compared to LDPE. The presence of the Cassie-Baxter state was confirmed through deviations from linearity in Owens-Wendt plots. These findings support the potential of structured polymer surfaces for developing efficient liquid-repellent materials in various applications.*

Key words *Liquid-repellent surfaces, Owens-Wendt method, PDMS, LDPE, superhydrophobicity, Cassie-Baxter state, surface energy, wetting behavior, micro/nanotexture.*

Textured liquid repellent materials rely on surface micro- and nanostructures combined with low surface energy coatings to repel liquids. Inspired by natural surfaces like lotus leaves, these materials create a rough topography that minimizes the contact area between the liquid and solid, causing water or other fluids to bead up and roll off easily. This phenomenon, known as the Cassie-Baxter state, allows droplets to remain suspended on the surface without wetting it fully.

These materials have broad applications across various industries. In textiles, they are used to produce water-repellent and stain-resistant clothing [1]. In electronics, they protect sensitive components from moisture. In transportation, they are applied to windshields and sensors to improve visibility and performance under wet conditions. Additionally, in healthcare and biotechnology, they help prevent biofouling and bacterial adhesion [2]. Their self-cleaning properties also make them ideal for building materials like glass and coatings exposed to the environment.

Thermal pressing is a promising technique for forming liquid-repellent textures on polymer film surfaces. It offers excellent scalability, making it suitable for the mass production of functional surfaces in industrial settings. The method allows for high accuracy in replicating micro- and nanoscale patterns, which are critical for achieving desired wetting behaviors. Moreover, thermal pressing supports a wide range of texture variations, enabling customization for specific liquid-repellent needs, such as hydrophobicity or oleophobicity. Its compatibility with various thermoplastic polymers and relatively low processing costs further enhance its appeal for applications in packaging, textiles, and flexible electronics.

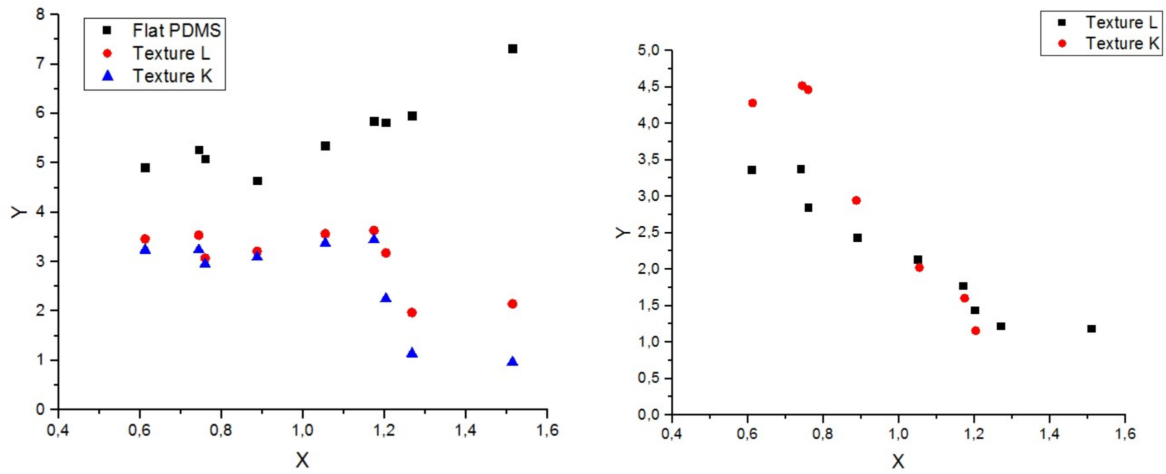
The Owens-Wendt theory is used to characterize surface energy by dividing it into polar and dispersive components. This method involves measuring contact angles of different probe liquids on a surface and applying the Owens-Wendt equation to estimate the surface energy. In studying liquid-repellent materials, the theory helps quantify how a surface interacts with various liquids. A lower surface energy, particularly in both polar and dispersive terms, typically indicates higher liquid repellency. This makes Owens-Wendt's theory valuable for optimizing coatings and surface treatments in hydrophobic and oleophobic applications.

As it was shown in [3], the Owens-Wendt method is very sensitive to the appearance of the Cassie-Baxter state, where the surface becomes heterogeneous in the wetting process.

This work aims at the characterization of polymer film samples, which were textured by the thermal pressing process with the Owens-Wendt method.

Materials used in this work were 2-component platinum-cured PDMS, low-density polyethylene film. The templates for textures were fabricated as it is described in [3]. PDMS negatives were obtained via casting method and LDPE - via thermal pressing at 110 deg. C

An Owens-Wendt plot of flat cured polydimethylsiloxane may be linearly approximated, that accords with the classical approach (Fig.1). In that case, the surface energy of this material is near 24,7 mN/m and it's disperse and polar components - 21,7 and 3.0 mN/m respectively. It may be noticed, that experimental curves corresponding to a different textures cannot be approximated by linear dependance because they contain another significant pattern. Low (Y) plateau is responsible for the Cassie wetting anomaly. It's Y coordinates lets us to compare materials liquid repellency and X coordinates - the stability of this state in the range os surface tensions.



a b

Fig.1. Owens-Wendt plots: a - polydimethylsiloxane film; b - low density polyethylene film

It is noteworthy that structures on the siloxane surface are likely to be less stable to the wetting transition than the polyethylene ones. In their case the wetting happens faster at X values 1,20-1,25. And is the case of polyethylene is prolonged on the ranges of X 0,70-1,20. This may be an indicator of the sub micron structure of the surfaces tested: it is known that despite PDMS, that is amorphous material, the LDPE has it's own supramolecular texture, that may be formed under crystallization from the melt and produce the lower level of liquid repellent structure.

It is also evident that the negative of K sample texture provides higher initial water repellency than L does. It is approved by their water contact angle values: 151 and 136 for silicone and 155 and 146 for polyethylene substrate.

CONCLUSIONS

It was demonstrated that the polymer films' liquid repellent properties may be characterized by the use of the Owens-Wendt approach. It was shown that the liquid repellent structures, obtained on the surface of polydimethyl siloxane by curing casting, are less stable to wetting transition than the structures obtained by thermal pressing of low-density polyethylene films. However, both of the film types demonstrated superhydrophobicity for the K-type structure.

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ХАРАКТЕРИСТИКА ВОДОВІДШТОВХУВАЛЬНИХ ТЕКСТУР, ОТРИМАНИХ НА ПОЛІМЕРНИХ ПЛІВКАХ ЗА МЕТОДОМ ОУЕНСА-ВЕНДТА

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Анотація *Дане дослідження присвячене характеристиці водовідштовхувальних полімерних плівок з мікро- та наноструктурованою поверхнею з використанням методу Оуенса-Вендта. Досліджено плівки полідиметилсилоксану (ПДМС) та поліетилену низької густини (ПНГ), розроблені для покращення водовідштовхувальних властивостей. Підхід Оуенса-Вендта було застосовано для оцінки поверхневої енергії та впливу текстури поверхні на поведінку при змочуванні. Результати показали, що хоча обидва матеріали демонструють супергідрофобні властивості за певних умов, поверхні PDMS демонструють нижчу стійкість до переходу змочування порівняно з LDPE. Наявність стану Кассі-Бакстера була підтверджена відхиленнями від лінійності на графіках Оуенса-Вендта. Ці результати підтверджують потенціал структурованих полімерних поверхонь для розробки ефективних водовідштовхувальних матеріалів для різних застосувань.*

Ключові слова *Гідрофобні поверхні, метод Оуенса-Вендта, ПДМС, ПНГ, супергідрофобність, стан Кессі-Бакстера, поверхнева енергія, змочуваність, мікро/нанотекстура.*