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Roughness and Wetting, a Multiscale Approach

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1. Introduction

Two major equations are used to described the effect of surface roughness on wetting: The Wenzel one and the Cassie Baxter one. However, these two equations are still under discussion and some questions arise.

What are 3D roughness parameters that can be used to verify these 2 laws? At which scale must be the roughness taken? How to treat these equations if surface is anisotropic? How introduce the stochastic aspect of the roughness and the variability of the wettability measurement? Does it exist phenomenological relation that will better describe the wettability relation with the roughness? Is it possible to mixt the two relations by taking account two roughness 3D parameters?
The aim of this paper is to proposed a methodology to answer to these questions.

2. Surface preparation

Polypropylene surface were textured by femtosecond laser Ti: Saphire, 800 nm, 130fs. Three parameters were modified in order to create different surfaces morphologies, the power, the vertical and horizontal delay of laser beam.

3. The multi-scale aspects of roughness parameters introduced in the wetting laws.

Firstly, it will be shown that the 3D normalized roughness S_{DR} can be used to model wenzel equations and the 3D ones S_{DA} and S_{HA} to model Cassie one.

Then using a multiscale decomposition, it will shown that theses roughness parameters depends on the scale. This clearly means that the wettability depends on the scale and this multiscale aspect must be taking account.

4. Multiscale selection models

To analyze the effect of roughness on wettability, different models are proposed. Then a statistical methods is specially built to take account the effect of the scale, uncertainty and stochastic aspect of the roughness. All 3D roughness parameters are tested with different stochastic models including the Wenzel and the Cassie Baxter ones (an original mixed model is also proposed by the authors). A measure based on the coefficient correlation is the proposed to classify models. Double bootstraps are employed to introduce the variability (i.e confidence intervals on the correlation coefficient) and classify models of same influence (Fig.1).

Our model find that the Sdr roughness parameter is the best parameter to explain wettability data (fig.2.a) but with a different law described by the Wenzel model (fig.2.b).

Then Multiscale analyses is performed with 2D (anisotropy quantification) and 3D measurements to improve the proposed wettability model.

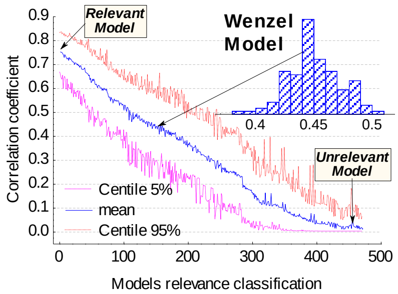

Fig. 1. Selection model graph.

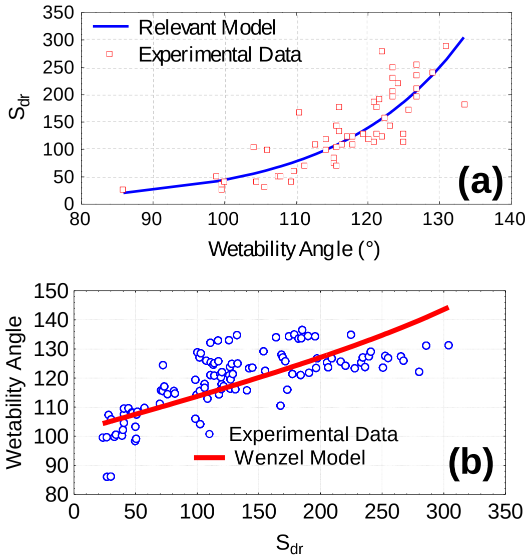

Fig. 2. Wettability curves with both models.