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The use of organofunctional silicon compounds in the process of obtaining materials with specific surface properties

Summary

Materials with specific surface properties interest scientists working in various fields. One such property is wettability, which describes how a liquid interacts with a solid surface. Both the high affinity of water for a surface, called hydrophilicity, and its repulsion from a material, known as hydrophobicity, are widely used in many branches of industry and everyday life.

Organosilicon compounds can be used to modify the surface of materials. They are known for their many advantages, including low toxicity, high thermal stability, and the ability to be applied to the substrate by various techniques. Silicon compounds can be modified with different functional groups, which, on the one hand, will be designed to bond to the surface of the material, and on the other hand, give the surface specific properties.

The aim of this dissertation was to use organofunctional silicon compounds to develop a method for obtaining materials with specific surface properties. The research focused on modifying the surface's wettability, aiming to obtain coatings with hydrophilic or hydrophobic properties. To achieve this, the glass surface was functionalized with organosilicon compounds solutions or modified silica, obtained by the sol-gel process. The wetting properties of all received coatings were characterized by measuring the values of water contact angles.

Solutions of organofunctional silanes were used to prepare coatings on glass microscope plates. The compounds used differed in the length of the polyether chain, its termination, and the presence of the ester group. The obtained coatings were characterized by excellent wetting properties, in many cases reaching a water contact angle below 10°, which meant that they had superhydrophilic properties. On the other hand, anti-fog tests carried out by exposing the surface to steam showed, that the coatings also exhibited very good anti-fogging properties. Their great optical clarity was confirmed by UV-VIS spectroscopic analysis. Moreover, both the coatings produced on glass and the modifying solutions used for their preparation, stored under laboratory conditions, successfully maintained their very good wetting and anti-fogging properties.

Silicon compounds functionalized with long alkyl chains, fluorinated groups, and polyether groups were applied to modify silica obtained in the sol-gel process. Subsequently, the synthesized silicas were used to prepare glass coatings, which showed strong hydrophobic or hydrophilic properties depending on the nature of the compound used. The obtained silicas were also analyzed for particle size and specific surface area, as well as for pore distribution and volume.

Commercially available silicas AEROSIL 130 V and AEROSIL 300 were also functionalized with long-chain alkyl silanes. The use of silicas with different particle sizes made it possible to study the effect of this parameter on the wetting properties of the coatings.

Synthesized and commercially available modified silicas, were used to investigate the effect of surface morphology on its wetting properties. Additionally, coatings were also prepared using a two-step method – first covering the glass surface with unmodified silica and then functionalizing it with appropriate silane solutions. The results of water contact angles obtained on coatings with silicas were compared with the values of this parameter obtained on the glass surface without them. It was found that the formation of a rough surface with silicas significantly affected the wetting properties of the surface. These observations were confirmed by performing surface studies with a confocal microscope, which allowed for obtaining 3D images and determining the roughness parameters of the received surfaces.

In this thesis, a simple method for obtaining coatings with hydrophilic and anti-fogging properties on glass, which were characterized by excellent transparency and stability, was successfully developed. The possibility of storing the formulations for up to eight months under laboratory conditions without affecting their properties, combined with the simple method of preparing and applying them to surfaces, may constitute the possibility of using this type of coatings in practice.

In turn, obtaining silicas modified with long alkyl chains, the use of which in the preparation of coatings on glass allows obtaining contact angles of over 146° means, that the application of compounds containing fluorine is not necessary for the production of coatings with highly hydrophobic properties. Studies of the morphology of surfaces modified with silicas made it possible to determine the effect of surface roughness on its wetting properties.