

Microstructured Hydrophobic Sol-Gel Coatings

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Abstract: Here we discuss the principles of the lotus effect and the approaches of constructing rough surface, especially the sol-gel method. With the advantages and disadvantages of several methods proposed, we suggest that coating is carried out after the modification in the sol state. Thus we find the best nano-micron structure mixed with fluorocarbon resin in the sol state to improve the technology condition.

Keywords: lotus effect; sol-gel; modified

1 Introduction

Unlike before, we prepare nano materials by the use of sol-gel method, the modification is performed by the direct use of silane coupling agent but not through the gel phase state, then with the other fluorocarbon resin, and add-micron hydrophobic particles are coated. From the development of domestic and international situation, the nano-silica becomes more popular and interests many scholars. As a fiber surface coating or a voltage dip adding material usually, it also makes great progress in construction as an adding component in membrane material. Many scholars have conducted in-depth researches to improve the dispersion of nano-silica or the performance of water repellent surface modified nano-silica. However, most scholars use the materials which are firstly changed into nano-silica powder, and improve its performance, then add to other materials or alone to achieve desired results. This research is not enough deep. This method can obtain the right size, stability, good performance of the modified silica sol, and then are added to the coating of other materials. The coating process can improve the original problem of poor dispersion of nano-silica particles and can resolve the problem that whether the nano-silica particles of adding to other materials are also nano level.

The required temperature of chemical vapor deposition is high, and the PVC is not resistant to such high temperatures. The strict temperature in the present experimental conditions is difficult to be realized; another method is the template method which requires the fine hair structure. These two methods are directly film and cannot be mixed with fluorocarbon resin. soft lithography causes too much damage to the PVC and the hydrophobic is not good and cannot meet the necessary conditions for the lotus effect; particle filling, the hydrophobic nano-particles are dispersed in the monomer solution or the bulk resin. However, due to very small nano-particles, surface energy in a large surface area is very difficult to disperse. To improve the dispersion of surface, active agent is added and will reduce the surface hydrophobic properties. Nano-silica particles are prepared by sol-gel

method. The modification of the way reduces the number of nano-silica surface hydroxyl groups; make the particles to have super-hydrophobic and have good dispersion stability in solvent. Then the nano-silica particles coated with coating finishing agent, such as Fluorocarbon resin. Finally, in the system micron hydrophobic particles are added. The morphology of these hydrophobic surfaces has been controlled by varying the content of silica particles, regarding size, degree of aggregation, and concentration. The structure of nano - micro roughness is made by improving the contact angle and reducing the roll angle to gain the hydrophobic effect and prepare for the anti-fouling materials. This can resolve the above issues better.

2 Theory

2.1 The mechanism of lotus effect

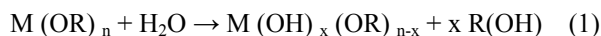
There is a very complex multi-nano and micron ultra-structure in the lotus leaf surface^[1], which is covered with some hills side by side. The entire surface is covered by tiny wax crystals. Therefore in the depression filled with air close to the leaf surface, a thin layer is formed. This makes the structure much larger than the size of dust, rain etc. After landing on the leaf surface, separated by a layer of thin air, only contacted with the several raised points, this makes the water droplets cannot infiltrate but to scrolling at will. Drops, because of their own surface tension, form into spheres, and they absorb dust while scrolling, and finally get out of the leaves. Researches based on the structure of the lotus leaf, the lotus' water repellent must have the following conditions (1) Surface material must be water repellent, and water on the surface contact angle must be larger than 90°. (2) The surface must be rough, and the roughness must be the nano-level or close to the nano level.

2.2 Method

(a) Sol-gel method is a specific approach that the precursors such as silicone or metal salt, and organic monomers or polymers is dissolved in water or organic sol-

vents for forming homogeneous solution. The reaction of hydrolysis and condensation occurs to form nano-particles. By aging sol change to the gel, after drying and heat treatment, the nano-particles are prepared. The most basic response is:

Hydrolysis reaction:



Polymerization:

Dehydration condensation:



Loss of alcohol condensation



(b) Chemical vapor deposition [2], the principle is that support one or several compounds, which are containing needed chemical elements, and both elementary gas to the carriers. Under the effect of the gas, they have a chemical reaction on the surface of the carriers and finally form the anticipant membrane. High temperature is the characteristic of this method. (c) Template method is to make the membrane, fixed on the substrate with the capillary structure, melting mainly through heating, then After cooling, remove the template substrate.(d) soft lithography. (e) Phases separation, phase separation of polymer theory, by controlling the phase separation of the different conditions of access to different pore size membrane. (f) Particle filled.

2.3 The silane coupling agent

Silane coupling agent is the largest species, the largest amount of coupling agent [3]. Its molecule contains two completely different types of groups, and generally has polar groups and non-polar groups. The general formula of silane coupling agent is $YR-SiX_3-$, where R is the aliphatic carbon chain, Y is organic groups such as vinyl, epoxy, amino etc. it can react with resin to form chemical combination. Scholars have put forward many theories about the mechanism of silane coupling agent, such as the chemical bond theory, surface infiltration theory, the deformation layer theory and the reversible hydrolysis bond theory.

3 Results and discussion

The experiment chooses self-made silica sol according to preliminary jobs. 60g N, N-dimethylformamide (DMF) are added in 150ml conical flask, and then added TEOS 30g. Water bath temperature of the magnetic stirrer is 40 °C, the speed is 40/s, ten minutes later, 1 ml ammonia is dissolved in 15g water, and then added to conical flask. After stirring to form emulsion, go on stirring until the sol is clear and transparent and continue stirring for 5 hours. Then add the modifier silane coupling agent KH-570, amount of 5g, modified time of 90min. F-100,

F-700 solvent-based fluorocarbon resin and PL-2 adhesive Silica are added to the obtained sol by the mass ratio of 10:1:3. The hydrophobic particles of 700 nanometer powder are added to the self-modified silica, stir to disperse evenly. Radio as follows (the amount of nano-silica sol in accordance with the yield, the yield was 40%).

Table 3-1 the proportion of nano-silica and micron hydrophobic particles is impart on contact angle and roll angle

The mass ratio of micron hydrophobic particles and nano silica	Contact angle (°)	Roll angle (°)
Smooth PVC surface	85	
Only nano-silica	130	>14
Only the hydrophobic particles	109	>20
0.1	133	>14
0.2	133	>14
0.3	136	>14
0.4	142	>10
0.5	141	>10
0.6	146	>10
0.7	151	>10
0.8	151	8
0.9	153	4
1	152	4

The table showing the contact angle increases, especially the roll angle is reduced to 4 degrees. These show perfect water repellency. Comparing with the single nano-systems, add-micron hydrophobic particles offer water repellency to the rough surface. It is considered that when the surface roughness increases, surface uplift can support droplet's own gravity. Due to the surface tension, water droplets shrink to turn into the ball, which are not contacted with the concave point of rough surface but only contacted with the hydrophobic nano-micron fulcrum of the coating surface, while the air layer remained between the water droplets and depression, this makes the contact area reach a minimum and increase the contact angle. After adding micron hydrophobic particles, the "packets" of surface uplift become uneven which make the water droplets very unstable in the above, so the roll angle of the test works well. But there is a certain limit to the roughness, beyond the limitation, the water droplets are not only contacted with the "packets" but also contacted with depression because of their gravity increasing the contact area.

References

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