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作品名稱 **Fabrication of Hydrophobic Coatings Using the Sol-Gel Method**

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Abstract

The aim of our research is to produce superhydrophobic coatings on both glass and cloth substrates in order to achieve high contact angles and low sliding angles for self-cleaning. In addition, we aim to modify these coatings to be as transparent as possible so as not to interfere with the aesthetics of the objects which will be coated. To achieve this goal, we synthesised a solution using 1H, 1H, 2H, 2H-perfluorooctyltriethoxysilane (a type of FAS), silica nanoparticles (SiO_2), tetraethyl orthosilicate (TEOS), (3-glycidyloxypropyl) trimethoxysilane (Glymo) and deionised water. Using the convenient sol-gel method, coatings of 20% and 30% by weight of FAS-SiO_2 nanoparticles were prepared on glass and cotton substrates.

It was found that coatings containing 30% by weight of FAS-modified SiO_2 nanoparticles on glass slide produced coatings with water contact angle as high as 162.8° and sliding angle as low as 4°. It can also be seen that for glass substrates, the hydrophobicity increased with an increase in percentage of FAS-modified SiO_2 nanoparticles. Although the highest percentage transmittance was about 30%, texts and pictures beneath the coated glass slides were clearly readable.

The cotton substrates also exhibited excellent hydrophobicity, with a water contact angle of 150° and sliding angle of 22°. Furthermore, the substrates showed good retention of colour and durability after simulated washing and 72 hours of ultraviolet (UV) weathering chamber test. These results show that the effects of washing and UV on the important properties of the cloth were insignificant.

Summary

Superhydrophobic surfaces have numerous applications, such as resisting water and fog condensation, preventing adherence of snow, and slowing down oxidation and corrosion. Within these possible applications, we narrowed our research focus to the use of superhydrophobic surfaces to improve commonly used objects made of glass and cloth. In particular, we hope that with a superhydrophobic coating, windows and car windscreens made of glass can achieve self-cleaning properties. In addition, clothes and shoes made of cloth with such coatings may become water and stain resistant, thus making them more long-lasting.

By definition, a surface with a water contact angle higher than 90° is hydrophobic, and that with water contact angle higher than 150° is superhydrophobic. A surface with a good sliding angle has a sliding angle of less than 40°.

In this project, we aim to develop a convenient and viable approach to produce superhydrophobic coatings on glass and cloth substrates in order to achieve high contact angles and low sliding angles. In addition, we aim to modify these coatings to be as transparent as possible so as not to interfere with the aesthetics of the objects to be coated.

Using the sol-gel method, we synthesized a solution using 1H, 1H, 2H, 2H-perfluorooctyltriethoxysilane (a type of fluoroalkylsilane, FAS), silica nanoparticles (SiO_2), tetraethyl orthosilicate (TEOS), (3-glycidyloxypropyl)trimethoxysilane (Glymo) and deionised water. Even though these chemicals have been used in previous research to synthesize superhydrophobic surfaces, they were not combined via the sol-gel method which is more convenient. Hence, in this project, we aim to investigate the

effectiveness of synthesizing superhydrophobic surfaces using these chemicals via the sol-gel method.

In our experiments, coatings of 20% and 30% by weight of FAS-modified SiO_2 nanoparticles were prepared. After preparing the 2 solutions, TEOS, Glymo and deionised water were added to them and left to stir. Following which, the solutions were coated onto glass and cotton substrates and cured in the oven. After curing, their water contact angles and sliding angles, as well as their percentage transmittance, were measured and recorded.

It was found that coatings containing 30% by weight of FAS-modified SiO_2 nanoparticles on glass slide produced coatings with water contact angle as high as 162.8° and sliding angle as low as 4°.

Also from the results, it can be seen that the higher the percentage of FAS-modified SiO_2 nanoparticles in a coating, the more hydrophobic the coating turns out. This can be attributed to the properties of the two main components, FAS and SiO_2, which lower the surface free energy and increase surface roughness respectively - the two widely-known ways to increase hydrophobicity.

In addition, the sliding angle of the coatings on glass decreases with an increase in FAS-modified SiO_2 nanoparticles. This might be because the larger number of FAS-modified SiO_2 nanoparticles allowed a more needle-like structure to be formed on the glass substrate. This needle-like structure serves to increase surface roughness, resulting in a lower sliding angle.

On the other hand, the transmittance of the coatings decreases with an increase in FAS-modified SiO_2, due to the presence of SiO_2 nanoparticles which are not transparent.

However, texts and pictures beneath glass slides were clearly readable although the highest transmittance value was around 30%.

Before the experiments, we also hypothesized that with an increase in the amount of FAS-modified SiO_2 solution sprayed on glass, the contact angle would be greater, as there are now more FAS-modified SiO_2 nanoparticles present in the coating. However, comparing the results for our glass substrates, this was not the case. We found out that when we sprayed more solution, the contact angle actually decreased.

For both pure cotton and cotton blend substrates, the percentage of FAS-modified SiO_2 nanoparticles for 20% and 30% did not have much significant difference in contact angles and sliding angles. The highest contact angle measured is around 150° and lowest sliding angle measured is 22°. We can also see that the percentage of cotton in a fabric did not have much effect on the contact angle and sliding angle. Hence, we concluded that the percentage of cotton does not play an important role in the determination of contact angles and sliding angles of the substrates.

Furthermore, important cloth properties such as colour and durability were tested using simulated washing and 72 hours of ultraviolet (UV) weathering chamber test. Results showed that the effects of washing and UV on the properties of the cloth were insignificant.

In conclusion, superhydrophobic silica-based films were fabricated using the sol-gel method. SiO_2 nanoparticles were introduced into the solution to increase the surface roughness, while surface modification was done through the introduction of a water repellent agent, FAS. Both the glass and cotton substrates displayed excellent superhydrophobicity. In particular, the glass substrate coated with 1.5 ml of 30% FAS-modified SiO_2 solution achieved the best result, displaying superhydrophobicity

with the highest water contact angle of 162.8° and the lowest sliding angle of 4°. This is better than the contact angle (160°) and sliding angle (12°) reported in previous research using similar chemicals but not via the sol-gel method. Durable superhydrophobic coatings were also prepared on different types of cloth.

評語

超疏水性鍍膜與材料開發為目前抗沾黏性研究發展重點，該研究結合 FAS 低表面能與奈米 SiO_2 高表面積之複合材料結構，應用低表面化學鍵結與高粗糙奈米結構學理，唯建議可增加耐磨耗測試。