Printable Superhydrophobic Coating on Paper for Security Printing Applications

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Introduction

Security Printing

Security printing helps distinguish counterfeit products from authentic products. Common examples of security printing include security holograms and watermarks. Security marks can also be something more complex such as covert QR code, that contains information related to the document.

Purpose

In this research a superhydrophobic coating, producing a contact angle greater than 150^{o}, was explored for use as a security printing feature.

Procedure

Pretreatment & Coating

Silica (SiO_2) nano-particles received surface treatment after refluxing with dodecyltrichlorosilane ($CH_3(CH_2)_{11}SiCl_3$). The surface treated silica nano-particles were added to a solvent and deposited onto a paper substrate using an aerosol jet printer.

Preliminary Results

Ethanol (C_2H_5OH) was not an effective solvent due to the particles settling on the bottom of the ink solution too fast after sonication. See Figure 1. Toluene ($C_6H_5CH_3$) was found to suspend the particles much longer before settling was observed. A polymer (polystyrene $(C_8H_8)_n$) was also added to the ink to help the particles adhere to the substrate.

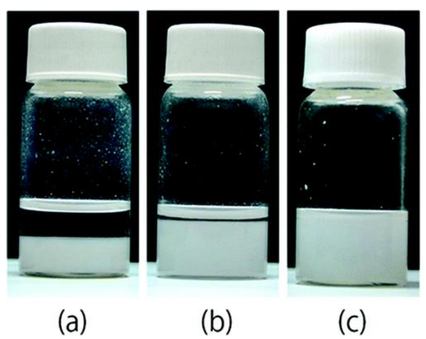

Figure 1: Settling of silica particles 10 minutes after sonication
A) Ethanol B)1-Propanol C)1-Butanol.

Results

Four different coatings were created using 100:0, 75:25 50:50 and 25:75 weight percent of polystyrene to treated silica nano-particles. The contact angle (^{o}) of each coating was then tested in four different locations. See Table 1.

Table 1: Average contact angle (^{o}) taken from four locations on each substrate.

100% Polystyrene			75% Polystyrene			50% Polystyrene			25% Polystyrene		
Left	Right	Mean	Left	Right	Mean	Left	Right	Mean	Left	Right	Mean
98	100	99	157	160	158	143 *	153 *	148 *	167	171	169
114	109	112	162	168	165	155 *	148 *	152 *	168	164	166
114	114	114	155	169	162	165	159	162	160	160	160
108	103	106	153	167	160	163	166	165	162	163	163

When the contact angles are compared to the weight% of polystyrene used, excluding runs one and two (*) from the 50% polystyrene due to apparent error in data recording, an inverse relationship is seen between the amount of polystyrene used and the observed contact angle. See Figure 2.

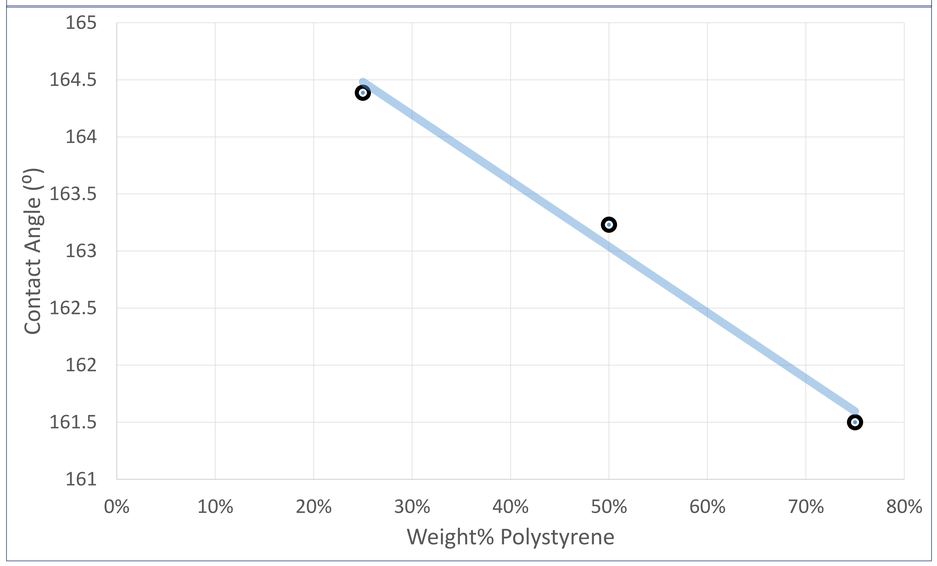

Figure 2: Linear relation comparing % weight of polystyrene to contact angle.

Scanning electron microscope (SEM) images showed the morphology of the coated paper substrates. See Figure 3. The coatings showed a rough coating containing both micro and nano sized roughness. This multiscaled roughness helps to improve the hydrophobic characteristic of the surface.[1]

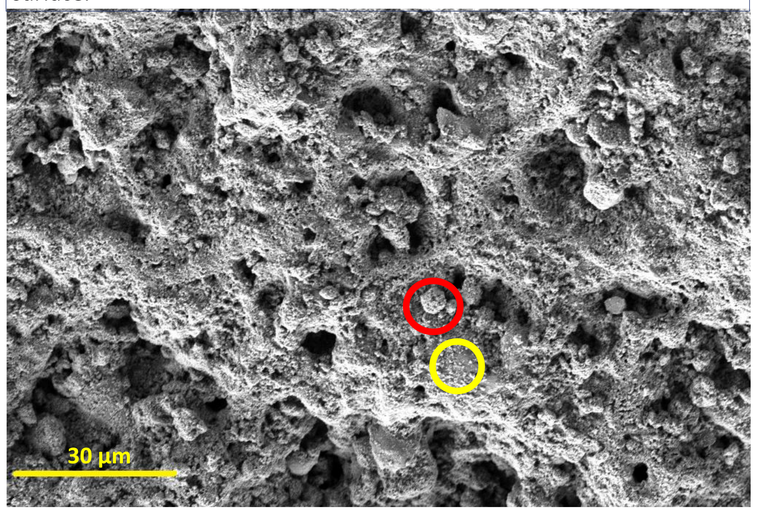

Figure 3: SEM image of coated paper substrate
Red circle large roughness, Yellow circle small roughness

Conclusions

Surface treated silica nano-particles will impose a superhydrophobic surface when deposited on a paper substrate. It is also possible to print an ink containing these treated nano-particles onto paper using an aerosol jet printer. These findings could lead to the possibility of superhydrophobic marks used for the purpose of security printing.

Further Research

Further research could lead to more effective solvents used to suspend the particles, leading to a stable ink. A more effective polymer may also be discovered leading to a more durable coating that cannot be rubbed off easily.

Acknowledgements

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References

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