The impact of surface hydrophobicity and roughness on bacterial adhesion.

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The ability of bacteria to adhere to various different surfaces is a result of aeons of evolutionary growth. After adhesion, bacteria can colonize the surface by growing into large habitats, called biofilms. This affects a wide range of industries, e.g. medical, food and marine.

Currently two factors are thought to affect a surface's ability to adhere bacteria; –surface roughness
–surface chemistry

An investigation was performed elucidating the ability of bacteria to adhere to differing surfaces, with range of surface chemistries and root mean squared (RMS) roughnesses.

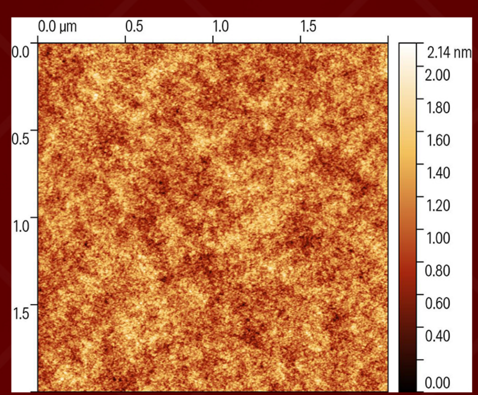
Initially a glass capillary was treated with 7 different surface treatments. The borosilicate glass was treated with a standard protocol across all of the treatments. These were chosen in order to investigate a range of surface hydrophobicities as well as their ability to facilitate said protocol.

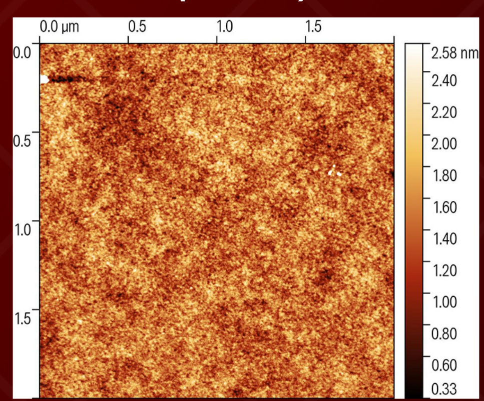
The treatments performed are as follows;
3-(Trimethoxysilyl)propyl methacrylate (3(TMOS)),
trimethoxy propyl silane (TMOPS),
(3-Aminopropyl)triethoxysilane (APTES),
Dichlorodimethylsilane (DCDMS),
n-butyltriethoxysilane (NBTS),
Trimethoxy(octadecyl)silane (TMODS),
1H,1H,2H,2H-perfluorooctyltriethoxysilane (PFOTES).

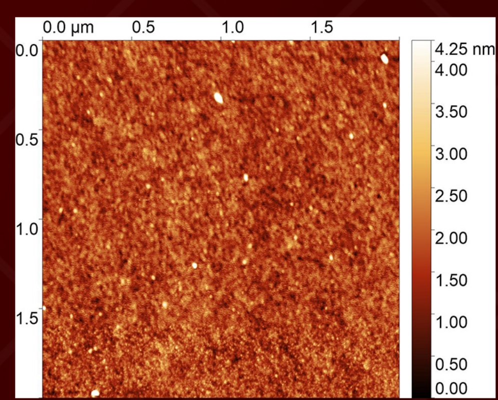
The water contact angle of the surfaces were then examined.

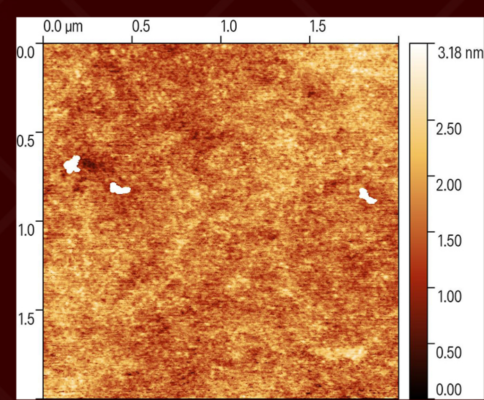
Glass

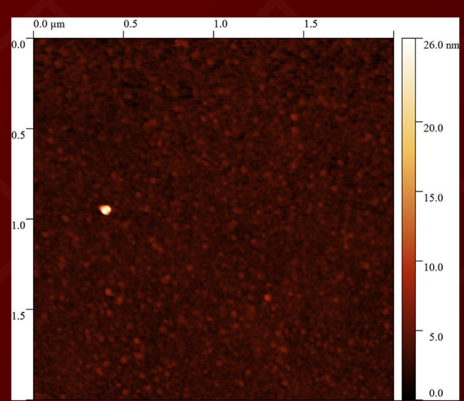
The surfaces were then imaged under AFM in tapping mode. Each of the surfaces were broken open using a diamond tipped pen and the inside scanned. The RMS roughness was then calculated using the 99th percentile of the data in order to give an indication of the average of the surface.

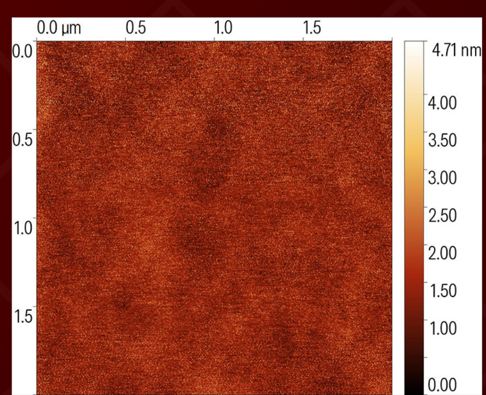
Glass

RMS: 1.65nm

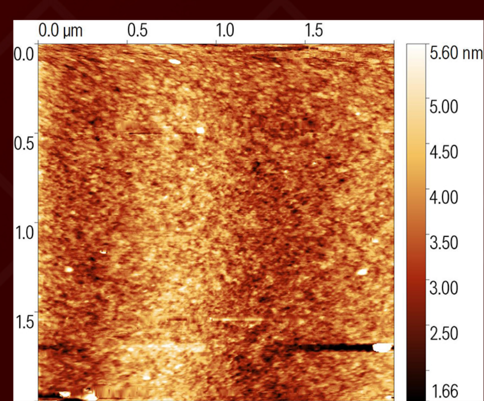
3(TMOS)

RMS: 2.12nm

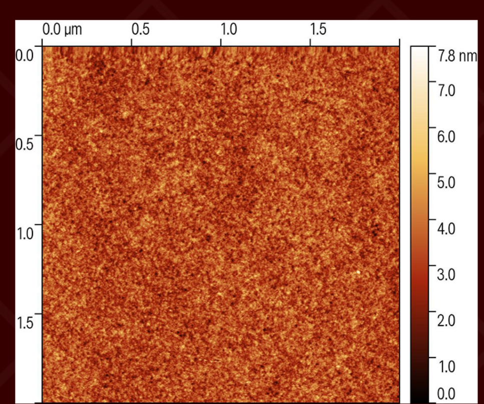
TMOPS

RMS: 2.69nm

APTES

RMS: 2.56nm

DCDMS

RMS: 5.00nm

NBTS

RMS: 2.76nm

TMODS

RMS: 4.98nm

PFOTES

RMS: 4.80nm

A suspension of bacteria in Berg's motility buffer was injected inside the capillary at an optical density of 0.03. The bacteria were then left to adhere to the surface, then the number of fully adhered bacteria were counted within frame. The percentage of bacteria adhered to mobile bacteria was observed.

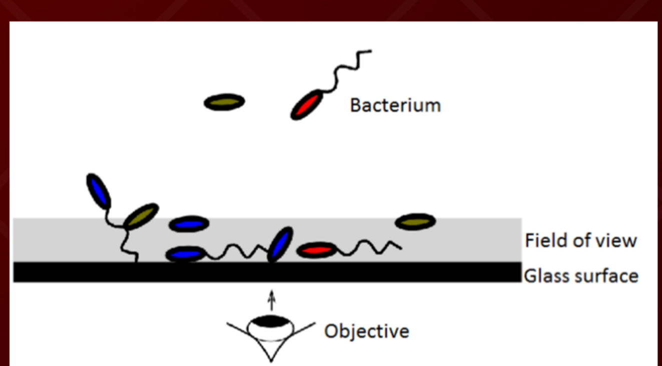


Fig 9. [1] (A) Schematic setup of bacterial adhesion on a phase contrast microscope. The grey area indicates the depth of field. Blue bacteria indicate adhered bacteria, yellow indicate bacteria moving under Brownian motion and red indicate flagella propelled bacteria.

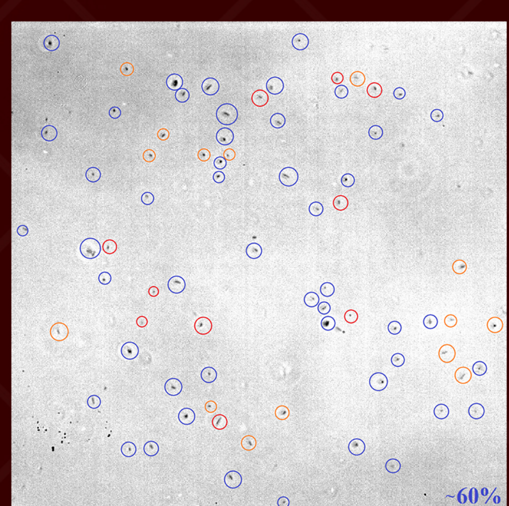
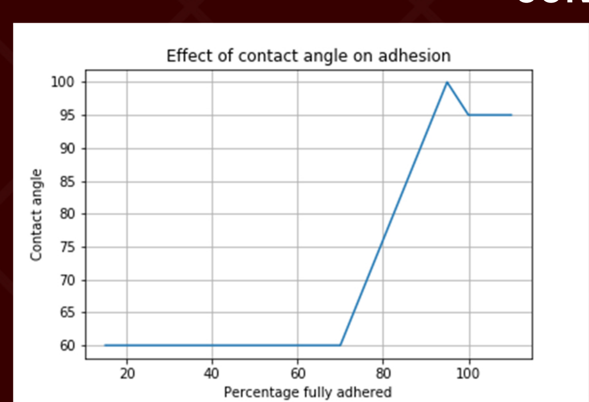


Fig 10. Phase contrast microscopy image of E.Coli cells at the surface. Of the bacteria within field of view approximately 60% fully adhere, with the flagellum motile bacteria highlighted in red and brownian motion bacterium in yellow.

CONCLUSION



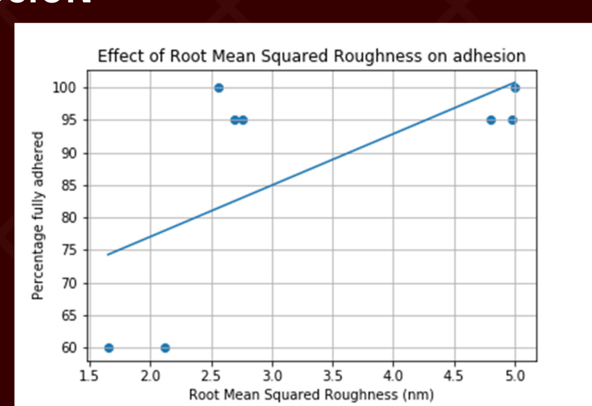


Figure A demonstrates that increasing the contact angle of the surface increases the amount of fully adhered bacteria, however Figure B does not separate the effect of surface roughness on adhesion.

[1] Vissers, T., [..], French, J. et al., in preparation
[2]Surface Roughness Mediated Adhesion Forces between Borosilicate Glass and Gram-Positive Bacteria, Emily Preedy et al, Langmuir 2014 30 (31), 9466–9476