Hydrophobic Nanoparticles as Antimicrobial Coatings

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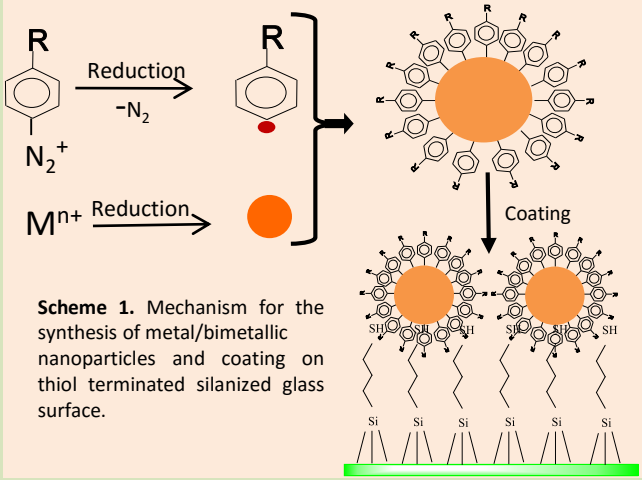
1. Introduction and Objectives

The modification of solids with various species permits to tune surface properties including adhesion of dirt and bacteria. For instance, hydrophobic coatings have been used to prevent the formation of biofilms by pathogenic bacteria.[1] Therefore, by providing bacterial resistance surfaces, the risk of cross contamination could be markedly reduced if not totally eliminated. The antibacterial effect of certain metal nanoparticles including silver has been well understood for centuries. However, the mechanism of these antibacterial effects are still under debates and not fully understood.

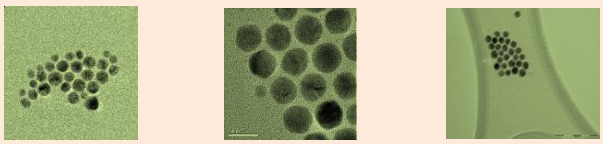
This study aims to investigate the antimicrobial properties of films of novel hydrophobic nanoparticles (NPs) onto solid surfaces such as glass, metals, metal oxides plastics and fabrics. We have previously introduced a new range of hydrophobic metal NPs stabilized by metal-carbon bonds.[2-4] These NPs containing various metal and bimetallic cores and functionalities were examined to study their antibacterial and cytotoxic properties via their effects on bacterial and cell growth when attached onto a surface.

2. Methods



Scheme 1. Mechanism for the synthesis of metal/bimetallic nanoparticles and coating on thiol terminated silanized glass surface.

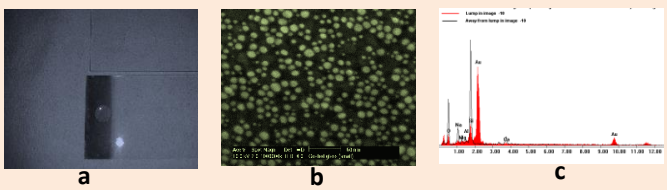
3.Results A: Synthesized bimetallic nanoparticles



Au Au/Cu Cu

Scheme 2. HRTEM of Au (8nm), Cu (12 nm) and bimetallic Au/Cu NPs (6 nm) stabilised with decylphenyl (DP) groups.

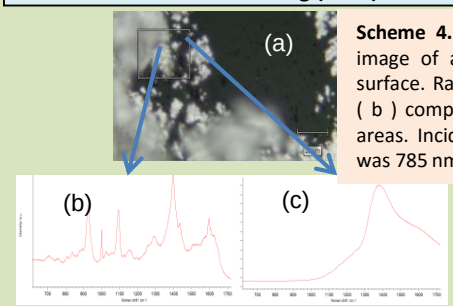
3.Results B: Coating of the M-DP nanoparticles on glass surface



a b c

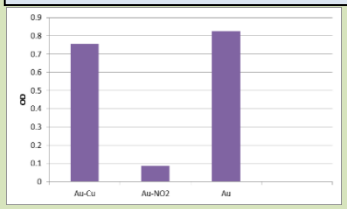
Scheme 3. a: picture of hydrophobicity of coated glass compared to uncoated; b: SEM image of the coated area; and c: EDX spectra of coated area (red) compared to the uncoated surface (black).

3.Results C: Raman Scattering (SERS) of Au NPs coated on glass



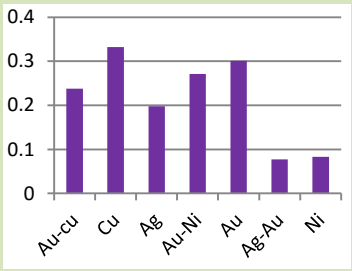
Scheme 4. (a) x50 magnification image of a section of the glass surface. Raman spectra of coated (b) compared to uncoated (c) areas. Incident Laser Wavelength was 785 nm.

3.Results D: Antibacterial properties of NPs coated on glass



Scheme 5. Growth of E-Coli on glass coated with NPs; left: (Au-Cu)DP, middle: AuDP functionalised with $-NO_2$ groups, right: AuDP.

3.Results E: Cytotoxicity properties of NPs coated on glass



Scheme 6. Growth of prostate cancer cell lines in contact with various metal core NPs capped with DP.

4. Conclusion

1. This procedure is proposed for the preparation of hydrophobic NPs of most transition metals and alloys.
2. The functionality of the capping ligand can be changed using diazonium chemistry.
3. Both functionality and metal core are effective to the antibacterial and cytotoxic properties of NPs.
4. These NPs can be used for tuning antimicrobial and cytotoxic properties of surfaces.
5. By selecting suitable functionality and metal core, antifouling hydrophobic surfaces can be obtained.
6. It is proposed that the effect of these NPs on bacteria and cell lines is due to the formation of reactive peroxide species after the reduction of oxygen under the hydrophobic local environment catalyzed by NPs.

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References

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