Comparison of Poly-L-lactic Acid (PLA) & Acrylonitrile butadiene styrene (ABS) biodegradable materials for 3D printed Lab-on-chip Applications

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Motivation

•Magnetic nanoparticle drug delivery, being one of the important active drug targeting systems, is commonly used to increase the concentration of the drug at a defined target site and away from a reticular endothelial system, with the aid of a magnetic field.

•However, the analysis and optimization of drug delivery to a targeted site through in-vivo experimental analysis are quite complex, time consuming, and expensive.

•Hence, in-vitro studies provide an efficient way of understanding the mechanisms of nanoparticle movement and its transport through the physiological system. To make a realistic comparison, such a system should be able to mimic the tissue environment with attaching cells/proteins etc.

•This paper investigates the effect of surface modification of commonly used 3-D printed materials such as PLA & ABS on the attachment of proteins and provides a critical analysis of the experimental results.

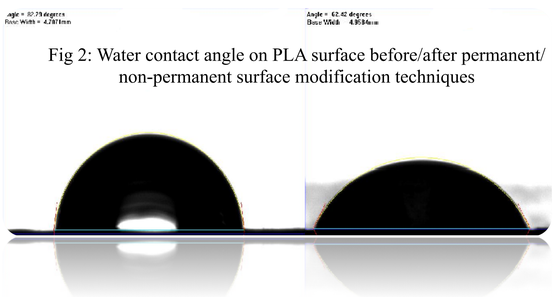


Fig 2: Water contact angle on PLA surface before/after permanent/ non-permanent surface modification techniques

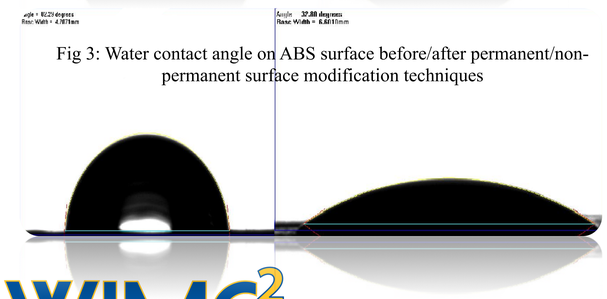


Fig 3: Water contact angle on ABS surface before/after permanent/non-permanent surface modification techniques

Experimental

•Surface modification & functionalization (introduction/ activation of carboxyl side chain group) is necessary in order to improve hydrophilicity of the surface of 3D printed bio-degradable plastics such as ABS and PLA for Cell Culture and Lab-on-chip applications. Surface modification & functionalization were performed by wet chemical etching as well as plasma/UVO irradiation techniques.

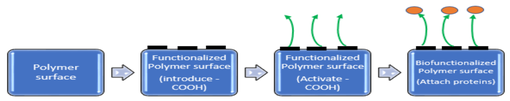
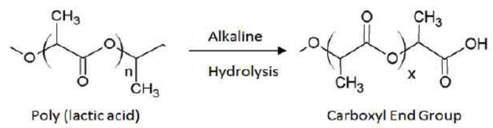


Fig 1: Typical steps in Surface modification of materials

Hydrolysis

- Hydrolysis is one of the wet chemical etching techniques which was used to etch the PLA/ABS surface and to introduce & activate carboxyl side chain groups (-COOH)
- The PLA/ABS printed samples were immersed in 1 M NaOH/ Ethanol buffer solution and kept for one day.



Ultra-violet Ozone (UVO) treatment

- Ultra-violet ozone (UVO) plasma irradiation technique was used for 20 min on the 3D printed PLA/ABS samples to dissociate the hydrocarbon contamination on the surface by absorption of short UV radiation.
- The dissociated molecules react with the high energy oxygen to form volatile molecules which desorb from the surface. Radicals like *OH, COO* and CO* are formed on the surface of the substrate.

•Protein attachment was performed by dropping labelled poly-l-lysine on the modified and functionalized PLA samples.

Results

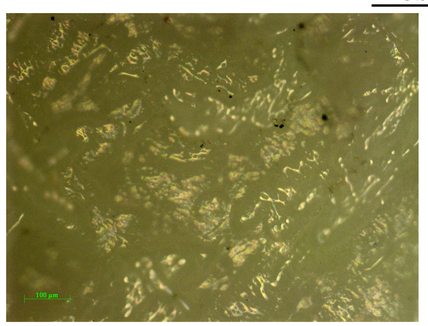


Fig 4: Microscopic image of surface modified PLA sample

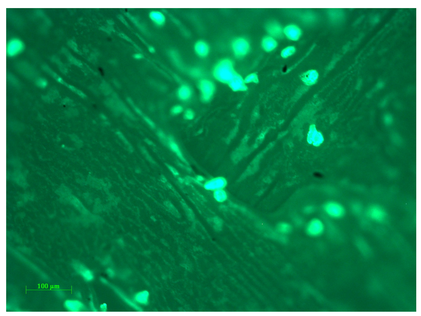


Fig 5: Fluorescence image of surface modified PLA sample after labeled protein attachment

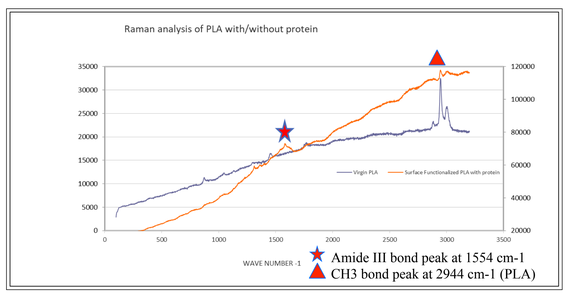


Fig 6: Raman Spectra of PLA with/without protein attachment

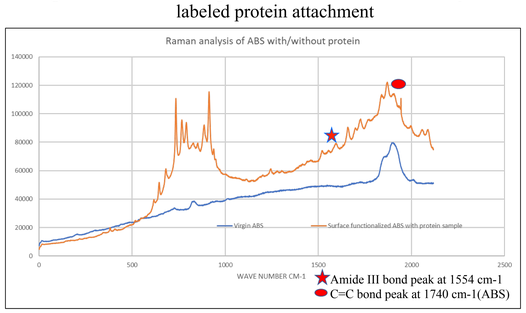


Fig 7: Raman Spectra of ABS with/without protein attachment

Summary

- Hydrolysis resulted in reduced contact angles (for water) from 82º to 62º & 32º respectively which demonstrates improved hydrophilic properties of the surface.
- Microscopic images before and after labelled protein attachment in Fluorescence mode portrays successful coupling of proteins on the modified/ functionalized PLA surface
- Raman spectra of PLA/ABS clearly indicates the coupling of the protein samples on the surface of the hydrolyzed 3D printed samples.

References

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