Developing nanomaterial based drug delivery system to compact drug resistant bacteria

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Introduction

Nanomaterials have similar size range to that of proteins found inside living cells and thus, nanomaterials takes advantage of existing cellular machinery to facilitate the delivery of drugs.

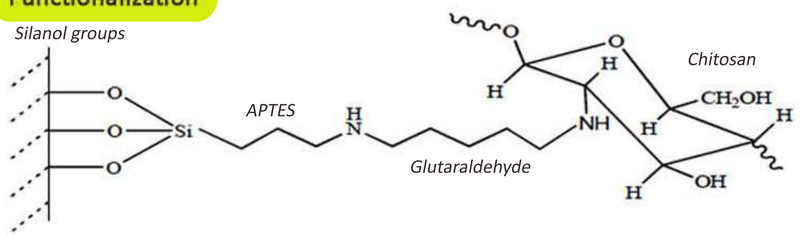
Nanomaterials such as hollow mesoporous silicates have high surface covered with silanol groups, allowing the functionalization of pore surface adjustable. Functionalization of the surface allows the adhering of nanomaterials to the cell surface of living cells.

In the present study, the main objective is to develop different nanomaterials for drug delivery with sustainable release to compact drug resistant bacteria such as Methicillin-resistant *Staphylococcus aureus* (MRSA).

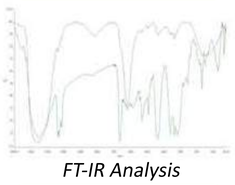
Methods

Functionalization

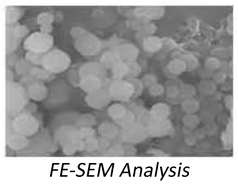
Silanol groups



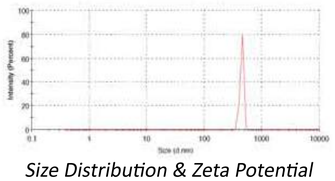
Characterization



FT-IR Analysis

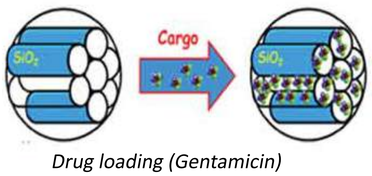


FE-SEM Analysis



Size Distribution & Zeta Potential

Bioassay

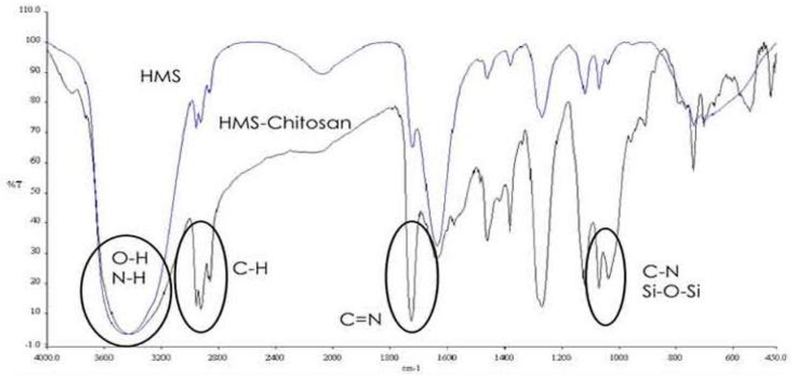


Drug loading (Gentamicin)

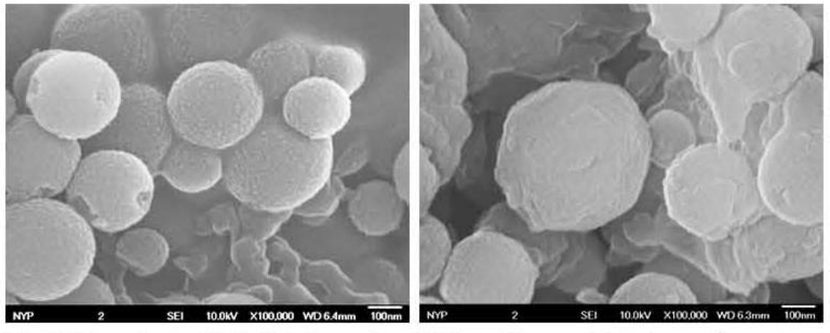
MRSA bacteria

Resazurin Assay

Results



FT-IR analysis. The FT-IR spectra shows the difference between HMS and HMS-chitosan. Bonds such as C=N, Si-O-Si, C-N, C-H can be seen more significantly on HMS-chitosan. This shows the result of the functionalization of HMS using 3-APTES, glutaraldehyde and chitosan.

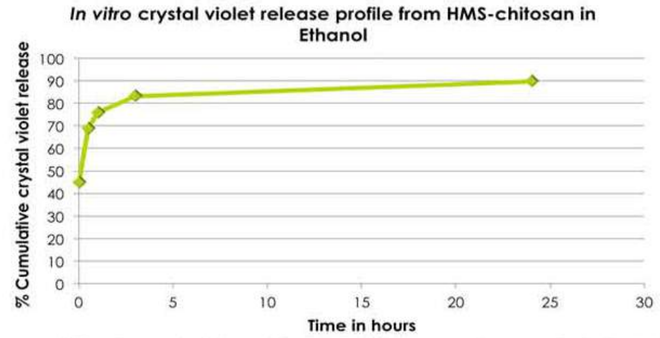


FE-SEM analysis. HMS (left image) and HMS-chitosan (right image) topology at x100,000 magnification. The topology of HMS shows that the unmodified nanomaterial have pores on the surface whereas the topology of HMS-chitosan shows a layer of modification to the surface of the nanomaterial upon the addition of 3-APTES, glutaraldehyde and chitosan.

	HMS	HMS-APTES	HMS-Gluta.	HMS-Chi.
Size Distribution (d.nm)	546.3 (±183.7)	405.2 (±22.11)	517.7 (±181.6)	565.3 (±71.85)
Zeta Potential (mV)	-9.83 (±5.25)	22.5 (±4.25)	-5.00 (±5.62)	34.1 (±5.10)

Size Distribution & Zeta Potential analysis. There isn't much difference in the size distribution between the samples, probably due to agglomeration. However, there is a significant difference in the zeta potential of each sample. Eventually, HMS-chitosan is positive charged, which allows the modified nanomaterial to adhere to the negative charged cell membrane of living cells.

Results Continued



Release profile. Crystal violet release profile was taken at 0, 1/2, 1, 3 and 24 hour intervals. The results showed that at 24-hour interval, the cumulative release of crystal violet is 89.7%. This may suggests that the release of crystal violet from HMS-chitosan is a sustainable one.

Cell viability. The loading of gentamicin and chlorpromazine (inhibitor of efflux system in MRSA) to HMS-chitosan seems to decrease MRSA viability from 3.125 ug/ml as compared to gentamicin only. However, the experiment need to be repeated to get a better explanation of the above observation.

Conclusion

The characterization analysis (FT-IR, FE-SEM, Zeta potential) shows a significant difference between HMS and HMS-chitosan in terms of the FT-IR spectra, the topology and the overall charged of the nanomaterial.

The preliminary results of the Resazurin assay (cell viability) seems to suggest that the delivery of gentamicin, coupled with chlorpromazine in HMS-chitosan, to MRSA reduces the cell viability as compared to gentamicin only.

However, more experiments on release profiles and Resazurin assay need to be done to further validate the above observation.

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