Magnetic nanoparticles as vectors to deliver therapeutic agents through mucus layers

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Introduction

Transport of nanoparticles (NPs) through mucus in a non-invasive way is made possible due to the magnetic push force created when 2 magnets are aligned adjacent to each other, at a certain angle. This could lead to a novel strategy of pumping antimicrobial agents to the middle ear of people affected by illnesses like otitis media, by providing the push force to drive these nanocarriers to their target site.

Aims

The aim of the project is to transport magnetic nanoparticles through different concentrations of mucus gels and to measure the speed of the nanoparticles moving through these different solutions. The two factors that could affect the rate of diffusion of the nanoparticles are the nanoparticle size and the viscosity of the various concentrations of mucin used.

Diagram 1: 20µl Magnetic nanoparticles seen crossing the 1ml cuvette

Methods

- Various solutions of different mucin concentration were prepared and the viscosity of each was measured.
- 20 µl of 100,300 & 500nm NPs were added to 1ml of each solution, and the time taken for the NPs to cross 1cm distance was measured (by observation via stereo microscope).
- This process was repeated 20 times for each different concentration and size of NP.

Results

- In 1%mucin, all NPs had an average velocity of 1mm per second, and could thus cross 1cm in 10 seconds.
- In 2%mucin, NPs had an average velocity of 0.5 mm/s and could potentially cross 1cm in 20 seconds.
- The 4% mucin solution was more viscous and thus the overall velocity of the NPs was lower (0.2 mm/s).
- 5 % mucin solutions were too viscous and NPs remained stationary after 60 seconds.

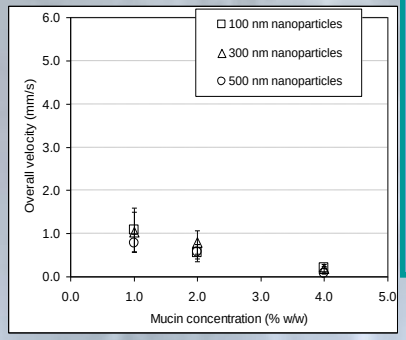

Figure 1: Velocities of nanoparticles of various sizes in different mucin concentrations.

Discussion

- In solutions that don't exceed 30 cP of viscosity, NPs are able to cross 1cm of distance in less than 30 seconds.
- Velocity of nanoparticles decreases with increasing mucin concentration.
- The size of the NPs does not seem to be important for movement through mucin, as all sizes of NPs showed very similar velocities for each mucin concentration.
- At 4% mucin, NPs would take much longer to cross the set distance, and that is because at that concentration, the solution becomes a gel (at 1 and 2%mucin it is still a viscous liquid), and thus the gel retards NP diffusion.

Conclusion

- Magnetic push of NPs has been found to be an efficient way to transport nanoparticles through mucin solutions.
- Nanoparticle velocity needs to be tested in solutions that better mimic conditions present in the middle ear of infected individuals.
- Further research needs to be done to look at how the NPs interact with mucin molecules, and if the movement of these particles through the solution is affected by these interactions.

References

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