Contact Lens Update
CLINICAL INSIGHTS BASED IN CURRENT RESEARCH

"Chemical nose" for the visual identification of emerging ocular pathogens using gold nanostars

October 28, 2015

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Contact lenses are an excellent option for effective vision correction for people who would like to avoid wearing spectacles or would like to change the appearance of their eyes. However, contact lens wear can be associated with microbial keratitis (MK)[1] which is a serious eye infection and can result in vision loss as a consequence of corneal scarring. Contact lens-related acute red eye (CLARE), contact lens peripheral ulcer (CLPU) and infiltrative keratitis (IK) are the other main ocular complications associated with microbial contamination during lens wear.

Despite good compliance with care regimens, contact lens cases can be contaminated with pathogenic micro-organisms for up to 92% of all asymptomatic wearers[2] and contact lenses can act as carriers for these microorganisms, transferring them onto the eye and infecting the ocular surface.[3] Currently, our ability to identify ocular pathogens relies on laboratory-based microbial culturing or genetic analysis. These methods are time-consuming, need extended laboratory assistance and are unsuitable for screening the level of lens case contamination, especially during uneventful asymptomatic lens wear. This article summarises research by Verma *et al.*[4], showing that gold nanoparticles can be used in a simple and inexpensive way to visually detect the presence and type of bacteria that are contaminating lens cases, with 99% accuracy.

Verma MS, Chen PZ, Jones L, Gu FX. "Chemical nose" for the visual identification of emerging ocular pathogens using gold nanostars. Biosensors & bioelectronics 2014;61:386-390.

Methods

This study used gold nanoparticles to identify four potential ocular pathogens: *Staphylococcus aureus*, *Achromobacter xylosoxidans*, *Delftia acidovorans* and *Stenotrophomonas maltophilia*. Of these, *S. aureus* is one of the most commonly identified microorganisms in ocular infection and has been often associated with contact lens-related MK and CLPU. The other three Gram-negative bacteria have been recently reported to be associated with polymicrobial keratitis and contact lens case contamination. Each bacterial species has unique cell surface characteristics, including charge, and this study utilised this distinctive bacterial characteristic to identify them.

The exclusive distribution of surface charge in each bacterial species is due to the varying composition of cell surface and membrane proteins, carbohydrates and lipids. The gold nanoparticles interact with the bacterial cell surface electrostatically and produce distinctive aggregation at the cell surface, thus generating a different colorimetric response. The shapes and sizes of the gold nanoparticles are tailored such that separate colorimetric responses are easily detectable.

The authors used two types of gold nanoparticles for bacterial detection: branched nanoparticles that have a blue

color in saline and spherical nanoparticles that are red in saline. In addition, a combination of the two types was used to investigate any further benefit. Transmission electron microscopy was used to observe the aggregation of nanoparticles around bacterial cells and to validate the colorimetric response.

Results

All three colored nanoparticle solutions changed significantly in the presence of *S. maltophilia* and *S. aureus*. The lightening of the colors in the presence of *A. xylosoxidans* was also visually detectable.

However, the change of colour with *D. acidovorans* was not substantial and hence, a factored training set was suggested for the red and blue nanoparticle combination, which could easily be used with 99% detection accuracy.

Microscopy images were in accordance with the visual colour change, confirming that this distinct signal was determined by unique gold nanoparticle clustering around different bacterial cell surfaces.

Conclusion

The significance of this research is the unique nature of these gold nanoparticles, which can be exploited to detect bacterial contamination in contact lens cases. Furthermore, it provides an opportunity to precisely identify the type of ocular pathogen, which could be very useful in clinical practice: a simple change in colour, or fading of bright colour to varying degrees, would suggest that a lens case is contaminated and needs replacement. In conclusion, gold nanoparticles can be selectively "tuned" to visually identify bacterial presence with >99% accuracy. This concept is highly promising and has great potential to be implemented into lens care cases.

REFERENCES

1. Szczotka-Flynn L, Ahmadian R, Diaz M. A re-evaluation of the risk of microbial keratitis from overnight contact lens wear compared with other life risks. *Eye Contact Lens* 2009;35: 69-75.
2. Willcox MD, Carnt N, Diec J, et al. Contact lens case contamination during daily wear of silicone hydrogels. *Optom Vis Sci* 2010;87: 456-464.
3. Dutta D, Cole N, Willcox M. Factors influencing bacterial adhesion to contact lenses. *Mol Vis* 2012;18: 14-21.
4. Verma MS, Chen PZ, Jones L, et al. "Chemical nose" for the visual identification of emerging ocular pathogens using gold nanostars. *Biosens Bioelectron* 2014;61: 386-390.