Joint meeting between the Mersey branch of the Institute of Physics and the Liverpool Medical Institute held on 27th February, 2014

Biomaterials in the treatment of vision loss

Professor Rachel Williams
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Professor Williams’ talk concentrated on biocompatibility of materials used in the treatment of vision loss. She commented initially that corrections to vision loss can be external (spectacles and contact lens) but they can also be internal and the three internal corrective mechanisms she described were (i) cell transplantation to treat age-related macular degeneration, (ii) cataract replacement with a plastic lens and (iii) injection of tamponade agents to treat retinal detachment.

The extent and quality of the biological response to any implanted material depends on the surface properties of the material and the reaction of those properties to the biological interface. The end point of much of the research work that Professor Williams described is to modify the surface properties of the implanted material to optimise biocompatibility whilst not affecting the bulk properties of the material itself.

She explained how the surface energy of a material influences the cellular interactions and how increasing the hydrophilicity can enhance cell attachment.

(i) In the treatment of age-related macular degeneration (AMD), the goal is to transplant healthy retinal pigment epithelial (RPE) cells back under the retina. She described work in Liverpool which used a substrate based on expanded polytetrafluoroethylene (ePTFE) to achieve this goal.

In many respects, ePTFE is a good material for this goal but, being hydrophobic, it has poor biocompatibility. To overcome this difficulty, she described how the surface is modified with either a gas plasma or a plasma polymer to promote cell attachment without changing the bulk properties. She noted the Liverpool group’s use of autologous iris pigment epithelial (IPE) cells to replace the damaged RPE cells.

She described work on correlating contact angle measurements on the ePTFE with the attachment and growth of rat IPE cells cultured for up to 28 days on these surface modified substrates. This innovative work, though in its early stages, clearly has potential to take forward much needed research into the treatment of AMD.

(ii) Professor Williams described her research on aspects of cataract replacement by discussing the potential problem with intraocular lens (IOL) implantation of wrinkling of the posterior aspect of the capsule in which the IOL is implanted leading to opacification.

Her talk described research in Liverpool aimed at solving this problem, by modifying the surface of the IOL either with a polymer coating or using a microjet gas plasma (helium) to modify the IOL’s surface properties, particularly, the water contact angle.
This work is in conjunction with colleagues from Liverpool's Department of Electrical Engineering and Electronics.

(iii) Professor Williams concluded her talk by describing the use of tamponade agents in the treatment of retinal detachments.

She cited four possible tamponade agents: air (or an expanded gas), silicone oil, perfluorocarbon liquids and semi-fluorinated alkanes. The key properties of any possible tamponade agent are its interfacial energy, the specific gravity (SG) and viscosity.

Professor Williams concentrated her talk on the development of modified silicone oils. She discussed her work on the addition of high molecular weight silicone polymers to silicone oil, which increased the extensional viscosity and thus has the potential to increase resistance to emulsification. She found that these modified silicone oils were easily injected and that the commercial development of these has led to the Siluron® products and the potential for these to provide for high quality treatment of this condition. She also discussed the development of heavy silicone oils through the addition of silica nanoparticles. The differing specific gravities allowed for the injected bubble to float at the top of the eye or to settle in the lower part of the eye providing the opportunity to tailor the SG to treat retinal detachments at different positions in the eye. The need to match the refractive index of the oil and particles was stressed to preserve the transparency.