Intraocular lenses with functionalized surfaces by biomolecules in relation with lens epithelial cell adhesion

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Introduction

A cataract is pathology opacity of the lens or capsule of the eye, causing impairment of vision or even blindness. The cataract surgery, with lens extraction and intraocular lens (IOL) implantation, is still the only currently available treatment. Nowadays, the conventional materials for IOLs include PMMA, silicone, hydrophobic acrylic, and hydrophilic acrylic polymers.[1] The hydrophilic acrylic polymer, mainly composited by pHEMA (Poly(2-hydroxyethyl methacrylate)), has several superior characteristics. Surgeons benefit from its foldability and controlled unfolding behavior. Patients suffer less from glistening and glare phenomenon. For the manufacturers, the rigidity in dry state helps for easy machining. However, this material tends to induce secondary cataract.

Secondary cataract, or Posterior Capsular Opacification (PCO), is the most common postoperative complication of the cataract surgery. PCO is raised from the cells response to the implant: the lens epithelial cells (LEC) proliferate, migrate, transdifferentiate to mesenchymal cells which form a thick cloudy layer and enclose the intraocular lens, causing patients to lose vision again. Current treatment is using Nd:YAG laser capsulotomy. However, this also potentially creates other complications such as damage to the IOL, higher intraocular pressure, cystoid macular oedema, retinal detachment. In conclusion, to prevent the PCO is better than to treat PCO.

Objective

The sandwich theory[2] provides an idea to control PCO: LEC will remain attached, mitotically quiescent if the LEC can adhere to the surface of the IOL properly. The fact that hydrophobic acrylic material exhibits a higher LEC adhesion ratio and less incidence of PCO also gives a hint to prevent PCO.

Our strategy is to restore the normal cellular status by creating a bioactive surface of implant. In this study, we improve the surface property of the hydrophilic acrylic material by applying the well-known RGD peptide[3].

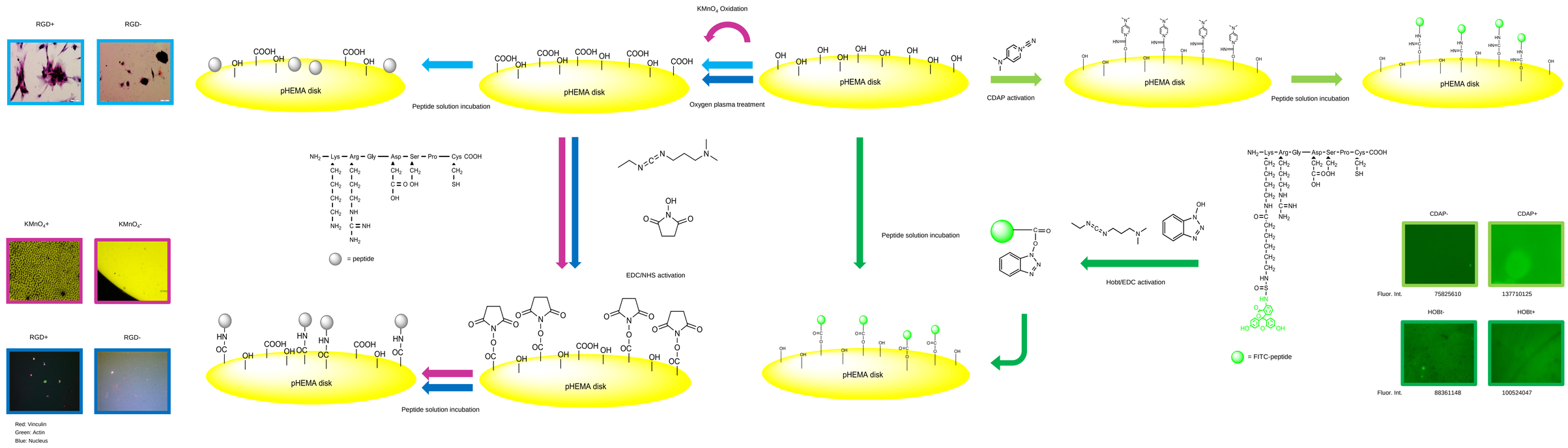
Conclusion

Several chemistry methods of surface modification in aqueous environment were tested and the oxygen plasma methods were chosen for further studies. The bioactive surface created by RGD peptide grafting exhibits improved LEC adhesion. The modification does not impede other properties (light transmittance, cytotoxicity, and hydrophobicity) required for an ophthalmic implant material..

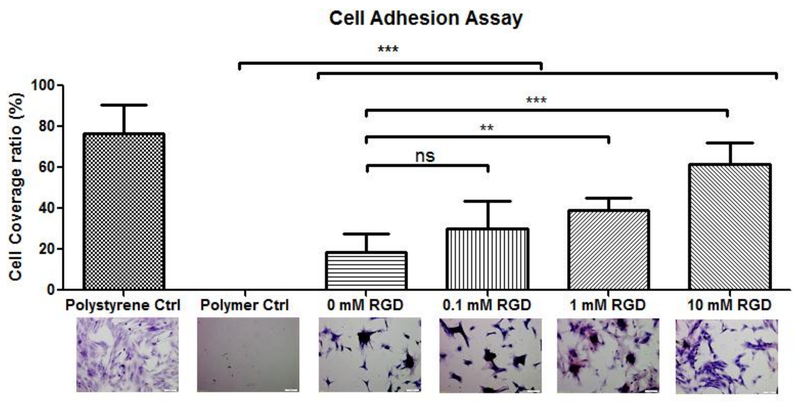
In order to confirm the PCO-controlling property of this new material, further investigation including *in vitro* epithelial-mesenchymal transition (EMT) assay and *in vivo* implantation study, as well as the mechanical properties study are needed.

Result

Peptide Immobilization strategies

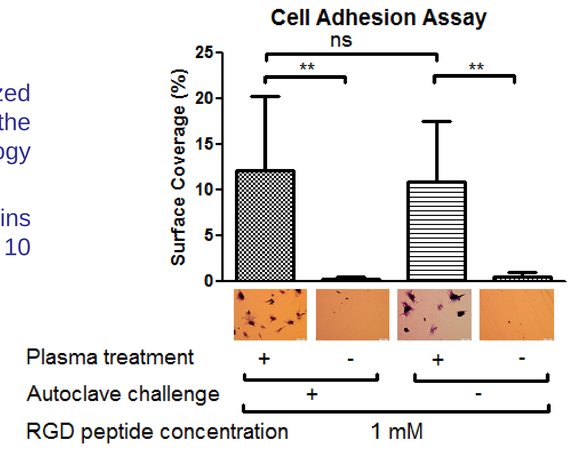


Surface Property Analysis: Grafting of peptide greatly enhance LEC adhesion



The RGD peptide immobilized surfaces significantly facilitate the adhesion as well as the morphology maintenance of the porcine LEC.

The peptide grafted surface retains its biological function even after 10 times of autoclave sterilization.



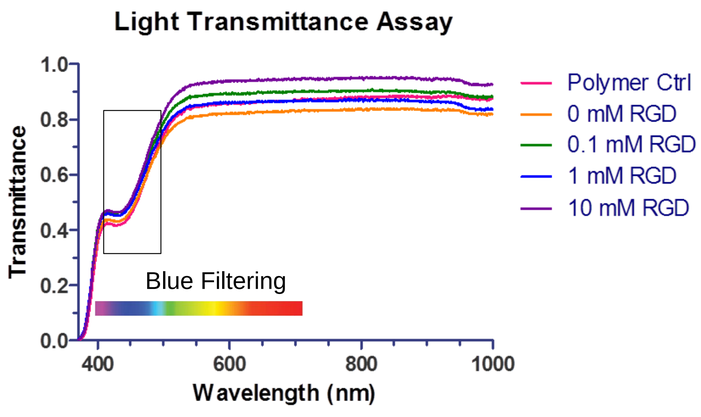
Surface Characterization

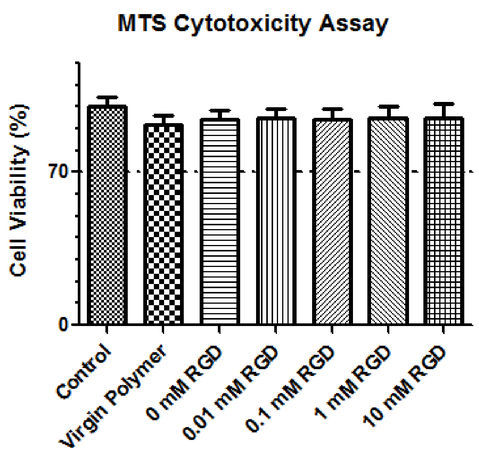
Atomic Percentage (%)

Atomic %	C	O	N	C/O	C/N
Polymer control	68.9	31.1	-	2.21	-
0 mM RGD	68.9	31.1	-	2.22	-
1 mM RGD	72.1	27.0	0.9	2.67	80.16
10 mM RGD	67.6	29.9	2.5	2.26	27.32

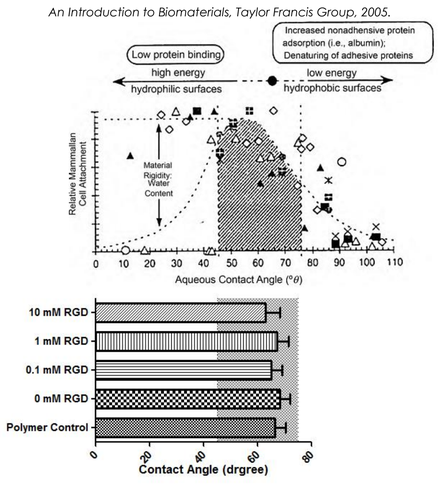
Nitrogen, indicator of peptide, increases its atomic percentage along with the increasing concentration of peptide solution in the RGD conjugation reaction.

Surface Property Analysis: Grafting of peptide do not alter its functions required for IOL implantation.





According to ISO 10993-5 (2009), the cytotoxicity potential is considered < 70% of blank control and is comparable to the virgin polymer, which has proved to be non-toxic in clinical cases.



The grafted peptide does not alter the hydrophobicity of the surface.

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References

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