Modeling the Effect of Blood Proteins on Condensation and the Hydro- and Pepto-affinity of Surfaces: Medical Implant Devices and Surgical Lenses

R.B. Bennett-Kennett, A.M. Murphy, D.A. Sell, B.W. Hughes, A.J. Acharya, T.T. Kutz, A.J. Orr, E.R. Morgan

ARIZONA STATE UNIVERSITY: Physics, Chemistry and Biochemistry, and School of Life Sciences & SiO_2 NANOTECH LLC.

Problem

Motivation

Post-Cataract Eye Surgery Complications:

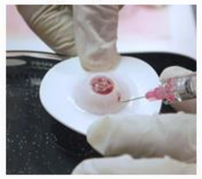
- 3-D condensation (fogging) on silicone & hydrophobic acrylic lenses

Laparoscopic/Arthroscopic Lenses:

- 3-D condensation (fogging) on cameras during surgery

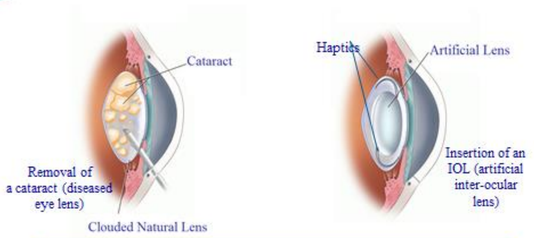
Why is fogging an issue?

- Inhibits surgeons' ability to see in the eye chamber during retina repair
- Current droplet removal techniques fail to inhibit further fogging
- Leads to prolonged surgeries



Prevalence

Importance of Cataract Surgery



Most common surgery in the world
15 million cataract surgeries performed
each year

Physical Model

Understanding Hydroaffinity

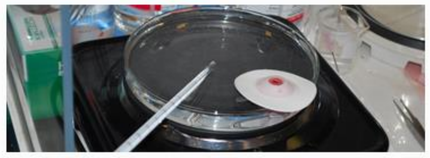
Hydrophobic (Fogging)
Water molecules interact with each other as electrical dipoles

Hydrophilic (Wetting)
Water dipoles interact with FREE charges, defects, ions

Simulating Surgery

Experimental Setup

- Goal: Measure inhibition of fogging quantitatively
- Set up: artificial rubber eye in saline heated ~ 40°C
- Mimics vitro-retinal surgery: conditions in the human eye's posterior chamber after vitreous body removal.
- Key conditions: enclose air/Intraocular Lens (IOL) interface with H2O evaporation from human tissue at body T

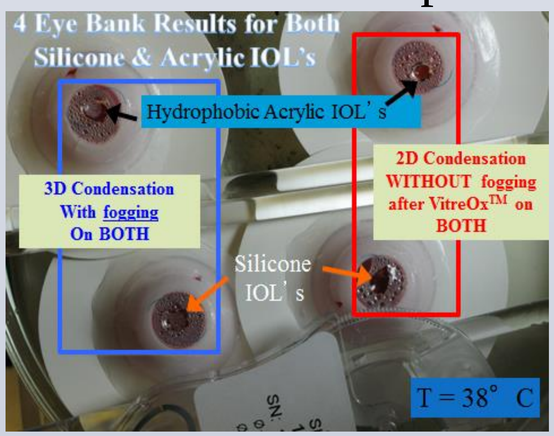


Foundational Solution

Simulation of VitreOx™ Application to IOL Lenses During Surgery

- IOL lens on top of artificial eye.
- H_2O condenses on untreated IOL in less than 5 seconds at 38 - 40° C
- Needle insertion near IOL mimics surgery port
- VitreOx™ Syringe reaches lens posterior surface
- Thickness control by extraction of excess VitreOx™ via alternate syringe

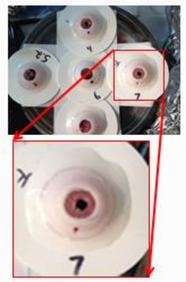
Proof of Concept



Surgical Complications

Effects of Blood on Transparency

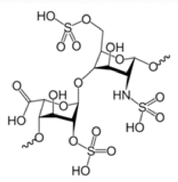
- VitreOx™ has shown to be effective in 80% of emergency surgeries.
- Surgeons report that the application fails in the presence of blood.



Heparin

Effect of Blood Proteins on Hydroaffinity & VitreOx™ Model: Heparin

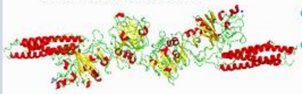
- Potent **anticoagulant**
- **Most electronegative** biological molecule
- Used in many medical procedures, IV
  - **Present in all trauma situations, and open wounds/cuts during surgery**
  - Cataract surgery, near IOL, implants, and near laparoscopic surgery optical lenses
- Effect of hydroaffinity investigated alone, with VitreOx™ both as initial layer & post applications

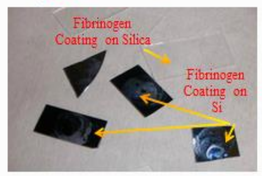


Fibrinogen

Fibrinogen

- Soluble blood glycoprotein
- Synthesized by the liver, converts into fibrin





Fibrin

- When activated by an enzyme (i.e. thrombyne) fibrinogen generates:
- Fibrin = fibrous protein
- Fibrin polymerizes in a wound
  - In a mesh
  - With blood platelets
  - Forms blood clot

Results with Blood

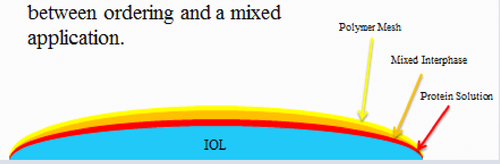
ProteinKnox™ in the Presence of Blood

- VitreOx™ with fibrinogen tested in the presence of animal blood
- Blood applied to the surfaces before, after, and in combination to simulate surgical scenarios
- Prevented condensation on the surface while repelling blood
- Overall, this greatly reduced the opacity of the lens during simulated surgery

TFFD™ and Conclusions

Thin Film Fluid Device™

- Further tests
  - Must determine if the application order of each device changes performance.
  - Also must test for the difference between ordering and a mixed application.



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