Lung Surfactant Collapse and Recovery

Emily Kang
Mentor: Tim Alig
Faculty Advisor: Joe Zasadzinski
Dept. of Chemical Engineering
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Overview

- Purpose
- Background
- Methods
- Results/Discussion
- Conclusion
- Future Work
Purpose

General Goal:
- To develop a lung surfactant that can be artificially produced and work with greater efficiency than natural surfactant.

Specific Goal:
- To study the properties of three clinically used lung surfactants:
  - Survanta (bovine)
  - Curosurf (porcine)
  - Infasurf (calf)
Lung Surfactant coats the inner lining of the alveoli. It reduces the surface tension of the alveoli so that the lungs may expand and compress without collapsing.

LaPlace’s Law:
\[ P = \frac{2\gamma}{R} \]

Premature infants do not synthesize surfactant and may suffer from Respiratory Distress Syndrome (RDS)—
- poor lung expansion, inadequate gas exchange, and a gradual collapse of the lungs.
Surface tension of water in the lungs in the absence of surfactant is ~72 mN/m.

Surfactant reduces water’s surface tension. Thus, the lungs require less energy to breathe.
Lung Surfactant Composition

- Lung Surfactant consists of:
  - **93% Phospholipids** (molecules with a hydrophilic head and hydrophobic tail)
  - **5% Cholesterol** (fluidizes the surfactant)
  - **1.5% Proteins** (transport of molecules, catalysts?)

- DPPG (1,2-Dipalmitoyl-sn-Glycero-3-[Phospho-rac-(1-glycerol)]

[Diagram showing the structure of DPPG]
Langmuir-Blodgett Trough

- The trough expands and compresses to simulate alveolar expansion and compression.
- Its trough area ranges from 127 sq.cm to 20 sq.cm.
Methods

- Fill trough with subphase. Subphase typically consists of:
  - 150 mM NaCl
  - 2 mM CaCl$_2$
  - 0.2 mM NaHCO$_3$

- Add LS as a film to the surface of the subphase with a syringe

- Compress and expand sample to study changes in surface pressure
“Deposition” is the term used for affixing LS to a mica disc in order to observe it under the AFM.

Mica is organized into thin sheets. Each sheet is composed of one molecular layer. We use mica because it is even and smooth.
AFM Imaging

Now that we have depositions on mica discs, we can see what they look like using an Atomic Force Microscope (AFM)
AFM Images

At 85% Trough Area

Survanta at 30C

Solid | Liquid | Subphase
Survanta at 30C

At 45 % Trough Area

Digital Instruments NanoScope
Scan size 50.00 μm
Scan rate 5.086 Hz
Number of samples 512
Image Data Height
Data scale 100.00 nm

solid
vesicle?
subphase
At 23% Trough Area
Survanta at 30C

At 33% Trough Area

Digital Instruments NanoScope
Scan size 50.00 μm
Scan rate 5.086 Hz
Number of samples 512
Image Data Height
Data scale 1.0000 μm

?? subphase
Survanta in high salt buffer
Survanta in 1M NaCl buffer at 30°C

% Trough Area
Pressure (m N/m)

Cycle 1
Cycle 2

Survanta in Saline Buffer

Survanta in high salt buffer (1M NaCl)
Survanta in high salt buffer (1M NaCl)
Conclusion

- An increase in the concentration of NaCl in the subphase led to an increase of surfactant recovery.
- The Na+ and Cl- ions may minimize the repulsive forces between the surfactant molecules.

Further Study

- Make depositions of LS from chloroform to study monolayer dynamics on the surface of the subphase.
- Cycle pressure within one area of the isotherm to measure hysteresis
- Fluoresce mini-B to investigate the role of proteins in surfactant.
Joe Zasadzinski’s Molecular Engineering Lab Group Members working on Lung Surfactants

- Coralie – Viscosity of LS
- Rya
- Derek – Coralie’s summer intern
- Joonsung – LS study using Fluorescence
- Tim – my mentor
- Emily
Joe’s Lab Group members working on vesicles

Cecile
Ryan

Andi