Safety & Environmental Assurance Centre

Rheological characterisation of human lung surfactant monolayers and the effects of exposure to inhaled compounds

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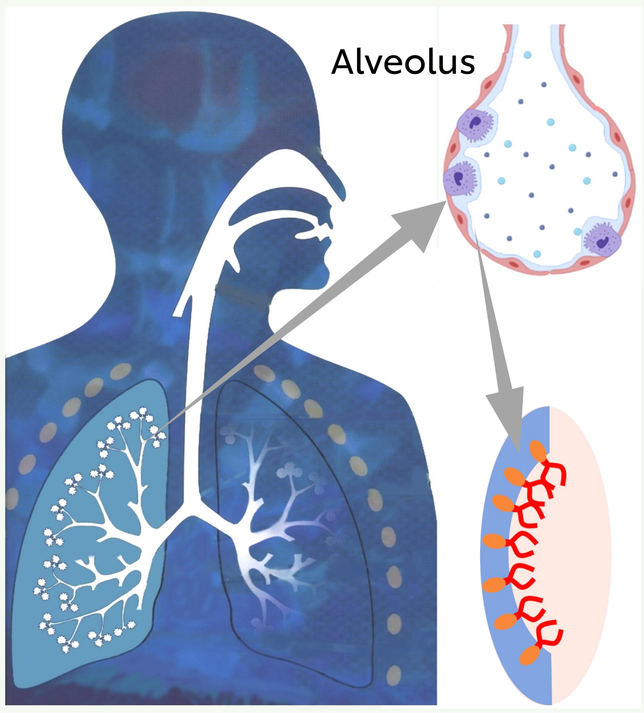
1) Lung Surfactant



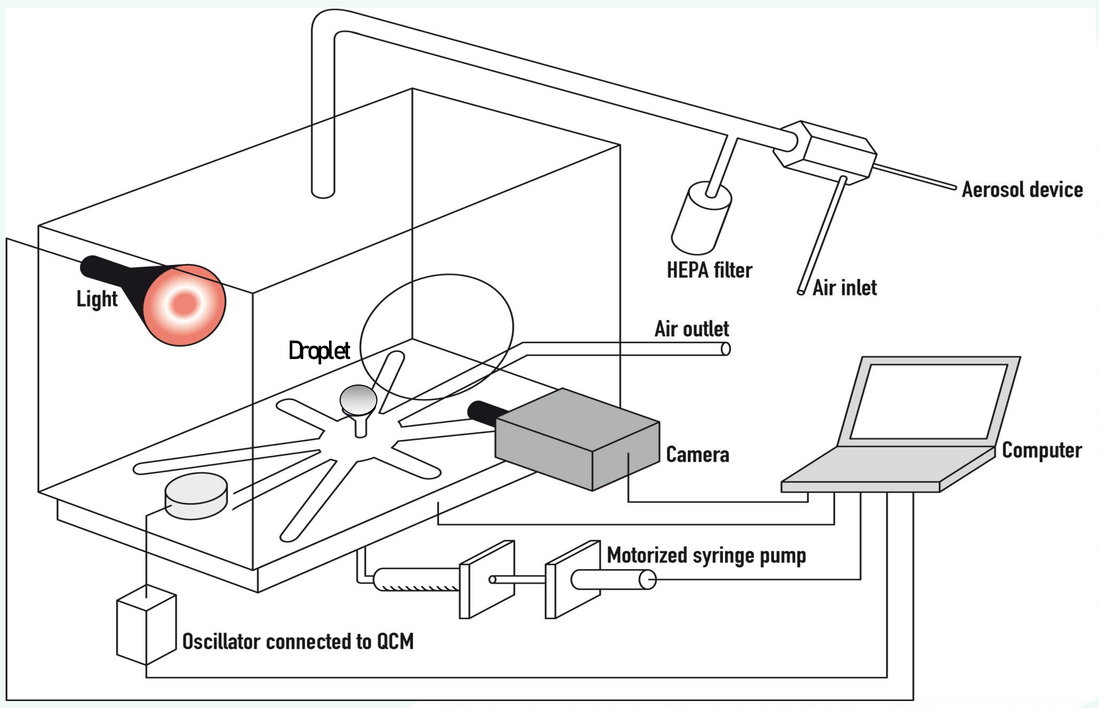
- The lung surfactant (LS) lining is a thin liquid film composed of phospholipids and proteins which covers the air-liquid interface in the alveoli.
- LS modifies the surface pressure in the deep lung which reduces mechanical work during inhalation.
- Exposure to certain chemicals (e.g. hydrophobic polymers) is found to disrupt the function of lung surfactant, causing lung collapse [1-4].

Figure 1) Schematic of lung, alveolus (Biorender©) and phospholipid surfactant monolayer.

Can we predict the effects of certain inhaled compounds on human breathing by studying how chemical exposure changes surfactant monolayer rheology?

2) Experimental Setup

a)



b)

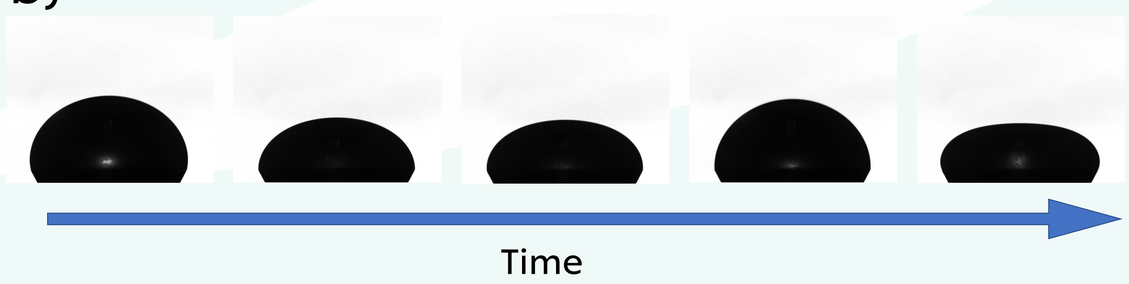


Figure 2. a) Illustration of the modified constrained drop surfactometer (CDS) setup [5]. LS (Curosurf©) solution droplet connected to syringe pump enabling dynamic cycling. Camera is used to measure curvature and wetting angle. Aerosol device replicates inhalation of chemicals in human lung.
b) Images of a droplet with volume cycled at fixed frequency allowing dynamic measurement of surface pressure at representative human breathing rate (0.3 Hz). Droplet oscillation replicates the dynamics of a human alveolus during inhalation.

3) Exposure Effects

- Droplets are exposed to aerosolised chemical.
- Response curve shows visible changes under chemical exposure, demonstrating reduction in elasticity.

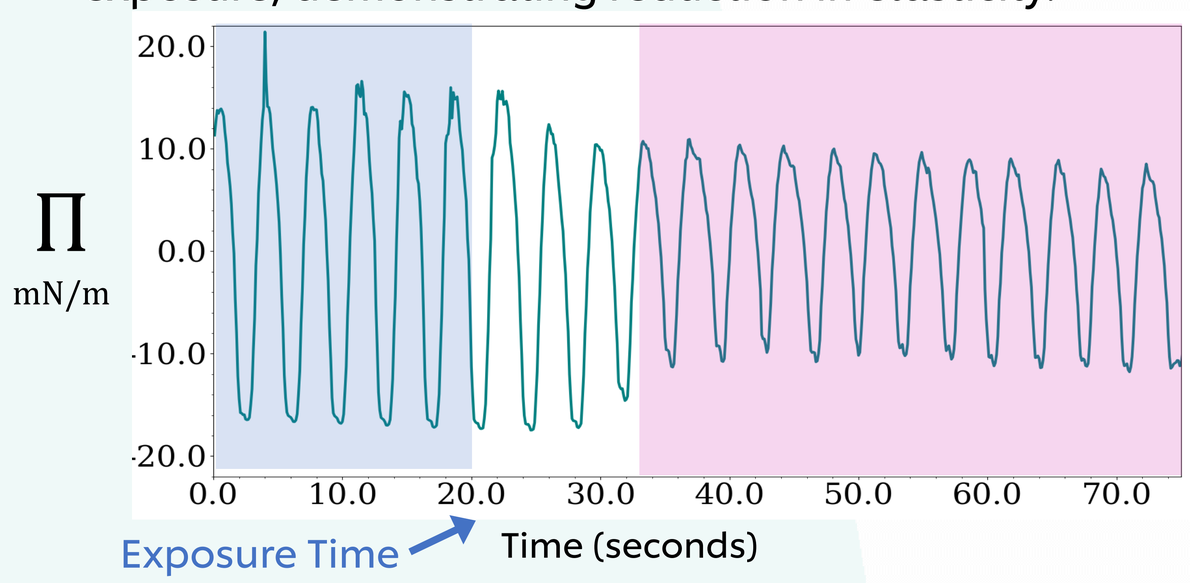


Figure 4) Response curve measured for several cycles for LS solution droplet before, during and after exposure to aerosolised methyl dihydrojasmonate. Overlaid areas denote regions subjected to Fourier analysis.

4) Analysis

- Surface pressure behaviour accurately captured by fitting single Fourier mode thereby demonstrating the response to be within the regime of linear rheology.
- Method is effective to quantitatively assess the change in mechanical properties post-exposure.

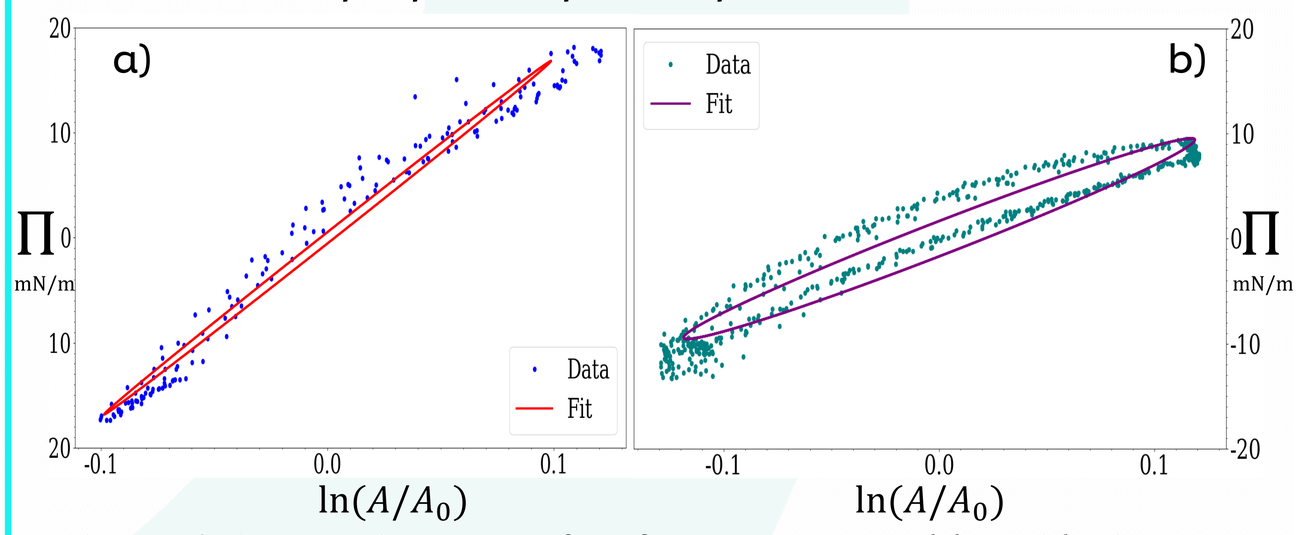


Figure 5) Parametric curves of surface pressure and logarithmic area normalised by average area A_0. Solid lines correspond to single mode fit. a) Pure LS b) LS+Chemical (methyl dihydrojasmonate)

5) Conclusions & Future Work

- We have developed a novel method to quantitatively measure the effects of inhaled chemicals on LS rheology.
- Characterisation of rheology pre and post exposure for a variety of chemicals may link effects to physicochemical properties in order to develop predictive model.
- Procedure to be added to current approaches for Next Generation Risk Assessment.

References

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