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Airborne Pollutants and Lung Surfactant: Biophysical Impacts of Surface Oxidation Reactions

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Abstract : Lung surfactant comprises a lipid-protein film that coats the alveolar surface and serves to prevent alveolar collapse upon repeated breathing cycles. Exposure of lung surfactant to high concentrations of airborne pollutants, for example tropospheric ozone in smog, can chemically modify the lipid and protein components. These chemical changes can impact the film functionality by decreasing the film's collapse pressure (minimum surface tension attainable), altering it is mechanical and flow properties and modifying lipid reservoir formation essential for re-spreading of the film during the inhalation process. In this study, we use Langmuir monolayers spread at the air-water interface as model membranes where the compression and expansion of the film mimics the breathing cycle. The impact of ozone exposure on model lung surfactant films is measured using a Langmuir film balance, Brewster angle microscopy and a pendant drop tensiometer as a function of film and sub-phase composition. The oxidized films are analyzed using mass spectrometry where lipid and protein oxidation products are observed. Oxidation is shown to reduce surface activity, alter line tension (and film morphology) and in some cases visibly reduce the viscoelastic properties of the film when compared to controls. These reductions in functionality of the films are highly dependent on film and sub-phase composition, where for example, the effect of oxidation is more pronounced when using a physiologically relevant buffer as opposed to water as the sub-phase. These findings can lead to a better understanding on the impact of continuous exposure to high levels of ozone on the mechanical process of breathing, as well as understanding the roles of certain lung surfactant components in this process.

Keywords : lung surfactant, oxidation, ozone, viscoelasticity
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