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低濃度のオゾンに曝露する不飽和リン脂質分子単分子膜の構造研究

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Structural Characterization of the Unsaturated Phospholipid Monolayers Exposed to Low-level Ozone

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1. Introduction

Ozone (O_3) is a universal pollutant in the troposphere and mainly produced via photochemical reaction of nitrogen oxide (NO_x) and violated organic compounds (VOC) by irradiation of ultraviolent (UV) light.[1] The concentration of O_3 in the ambient is typically a few tens of ppb.[1] Elevated levels of O_3 may become a reason to induce some diseases to the living body, such as cancer, atherosclerosis, and Parkinson's disease. Because of its high oxidation activity, O_3 has been regarded as a potential danger to the cell which is the basic functional unit of all known living organisms. Cell membrane, surrounding the living cells, plays crucial roles in the functionality of the cell. The cell membrane normally contains both saturated and unsaturated lipids, which show different stability to oxidants such as O_3. However, the influence of O_3 on the lipid molecules have been mainly investigated in high concentration range (0.3 ~ 10 ppm), much higher than the level in the environment.[2,3] In the present study, the concentration of O_3 is controlled to a level close to that in normal ambient (~20 ppb). The structure and stability of model cell membranes, lipid monolayers containing single or binary components of saturated lipid and unsaturated lipids, were studied by π-A isotherm, atomic force microscope (AFM) and sum frequency generation (SFG) vibrational spectroscopy.[4]

2. Results and Discussions

A saturated lipid, dipalmitoylphosphatidylcholine (DPPC), and two unsaturated lipids, l-palmitoyl-2-oleoyl-*sn*-glycero-3-phosphochol (POPC) and 1,2-dioleoyl-*sn*-glycero-3-phosphocholine (DOPC), have been studied in the work. The single or binary mixed monolayers of DPPC, POPC and DOPC were prepared by LB method on the water surface (22℃) in a chamber under environment control. Figure 1 shows the changes in the surface area as a function of exposure time to N_2 (0 ~ 60 min) and low-level O_3 (60~400 min) at a surface pressure of 30 mN/m. All the monolayers are stable in the nitrogen environment and show only very small decreases in the initial 60 min. However, when a small amount of O_3 (~20 ppb) is introduced into the

chamber, the monolayers of unsaturated lipids, POPC and DOPC, become unstable in different ways. DOPC monolayer shows fast decays in the surface area and almost constant after a certain period (ca. 1hr). The decrease of the surface area indicates the loss of molecules from the water surface and implies that DOPC monolayer is partially decomposed by O_3 and left trace amount of residuals on the water surface.[4] On the other hand, POPC monolayer shows a fast increase first and then a slow decay in the surface area. It implies that unlike DOPC, most of POPC oxidation products still remain on the water surface after the O_3 exposure. The different behaviors suggest that the two lipids have different oxidation mechanisms and stabilities in the low level of O_3 environment. It was also found that as DOPC is mixed with saturated lipid of DPPC in the monolayer, DOPC is selectively oxidized while its oxidation partially prohibited by the existence of DPPC.[4]

Morphology and structure of the monolayers were further characterized by AFM and SFG measurements, respectively. SFG observations demonstrated that most of the oxidative products from DOPC were dissolved in subphase and only a trace amount of oxidized lipid (oxPL-DOPC) remained to stay on the water surface.[4] These results were consistent with those observed in Figure 1. In the case of POPC, after the C=C moieties in the unsaturated chain are attacked by O_3, the oxidized residues (oxPL-POPC) still keep to stay on the subphase surface (see Figure 2).

Detailed results and discussion will be given in the presentation.

References:

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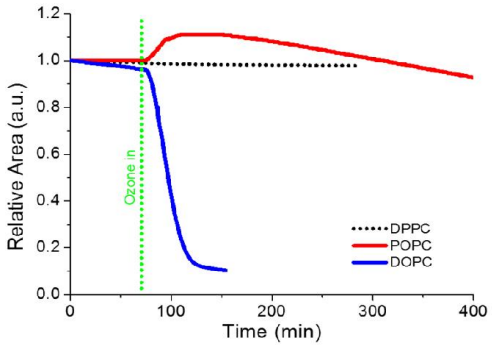

Figure1. Stability of surface area for the DPPC, POPC and DOPC monolayers at 30 mN/m exposed to N_2 (0~60 min) and O_3 (60~400 min).

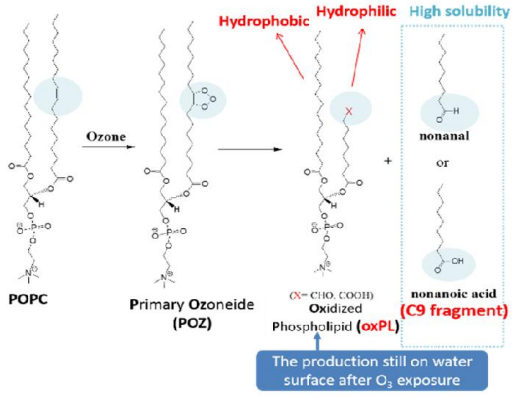

Figure 2. Possible oxidation mechanism of POPC by O_3.