Permeation of substances into the stratum corneum model membrane on an ATR prism for FTIR analysis

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The intercellular lipid layers in the stratum corneum (SC) is known to play a key role in the skin barrier function, preventing foreign substances from penetrating into our body. Artificial lipid membranes including typical SC lipids have been used as model membranes for permeation analysis of the intercellular lipid layer. These membranes were usually prepared on a porous filter. In this study we developed a new method for permeation analysis of SC model membranes. We formed an SC model membrane directly on an ATR prism for FTIR analysis by spraying a mixture of ceramide, cholesterol, and free fatty acid dissolved in an organic solvent (chloroform:methanol=2:1) to obtain a homogeneous membrane. The structure of the membrane formed by spraying was checked by X-ray diffraction.

When a substance which gives a clear FTIR signal is put onto the SC model membrane on the ATR prism, the FTIR signal grows gradually and reaches a saturation level because the evanescent light detecting the permeated substance molecules decays exponentially with distance from the prism surface. First we examined the permeation of heavy water D_2O as it gives an FTIR signal at 2500 cm^{-1}, which can be easily distinguished from signals from lipid molecules. Figure 1 shows the growth of the peak intensity at 2500 cm^{-1} after mounting a small drop of D_2O onto the SC model membrane. There appeared a lag time, depending on the thickness of the membrane. After the lag time, the intensity increased exponentially and reached a saturation level. It should be noted that we put a small cover on the SC membrane since the FTIR signal from H_2O sometimes grows during the experiment probably due to the influence of atmospheric humidity. The time constant for the intensity growth also depended on the thickness of the membrane, which we estimated from the reachable distance of the evanescent light. We also estimated the diffusion constant from the time constant. However, the intensity growth sometimes took place in several steps; the fast initial step may be due to cracks in the membrane.

We examined the permeability of other substances and will discuss the relationship between membrane structures and permeation of these substances.

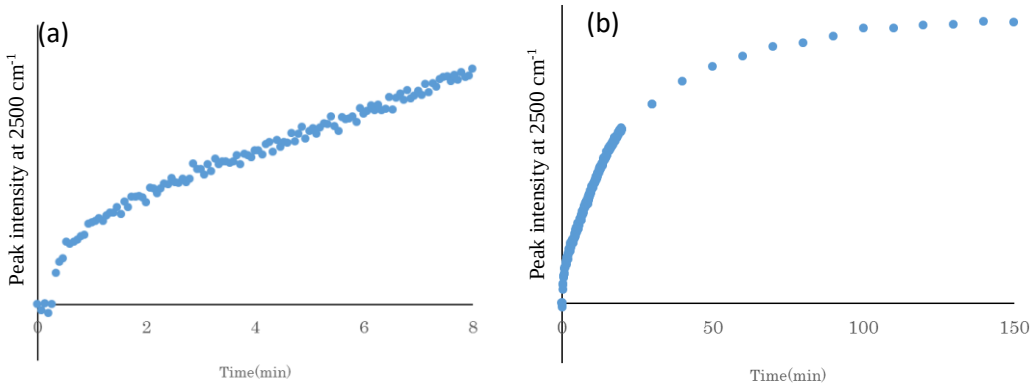

Fig. 1 Permeation of D2O into the SC model membrane composed of ceramide, cholesterol, and free fatty acid. (a) There appeared a lag time and a fast step in the initial part of the intensity growth. (b) The intensity reached a saturation level after about an hour.