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Study on two intercellular lipid lamellar structures in stratum corneum

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The outermost layer of skin, the stratum corneum (SC), is composed of keratinized cells called corneocytes and intercellular lipids. The flattened corneocytes are embedded in the intercellular lipid matrix. The lipid matrix works not only as the main barrier but also pathways for water, drugs, etc. A molecular structural study of the intercellular lipid assembly is highly desired to solve their molecular mechanism. The intercellular lipid assembly forms lamellar structures.

By the SAXD study on mammalian SCs the long lamellar structure with the repeat distance of about 13 nm has been observed dominantly and the short lamellar structure with the repeat distance of about 6 nm also has been observed although sometimes the diffraction intensity is weak. Bouwstra et al.[1] have claimed that since the long lamellar structure present in all species examined until now has a characteristic molecular organization within framework of their speculation, the structure seems to play an important role in skin barrier function.

However, from the SAXD study on hairless mouse SC performed by BL 15A we have found that with increasing water content in SC the diffraction peak positions for the first to the fifth order diffraction for the long lamellar structure are almost unchanged in consistent with the result of Bouwstra et al.[1] while the positions of the first and the second order diffraction for the short lamellar structure markedly shifts towards the lower angle[2], suggesting that the short lamellar structure exhibits swelling against the water content in SC. This is the first evidence for the swelling behavior in SC.

Furthermore, we found that the widths of the diffraction profile of both the long lamellar and the short lamellar structures become narrow simultaneously at the water content of about 20-30 wt%. This result indicates that the long and the short lamellar structures interact with each other and as a result, when the short lamellar structure swells, the both long and short lamellar structures are stabilized simultaneously at the water content of 20-30 wt%. Here it should be stressed that in SC almost all water is stored in the corneocytes, but a small part of water stays in the water layer of the short lamellar structure. The amount of water in the water layer is very little but plays an important role in regulation of the water content in SC.

Based upon the above result we propose that the interaction of the long and the short lamellar structures works in functioning in SC, e. g., sine the long lamellar structure has hydrophobic character and the short lamellar structure has hydrophilic character the transport of molecules in SC takes place through the favorable structure and is regulated by the counter structure. To carry out this study further it is quite important to find a condition that we can always observe the diffraction profile of the short lamellar structure in SC. However at present we could not find out the condition yet. Recently the existence of the short lamellar structure has been confirmed by neutron diffraction study.[3] Under the condition that SC is hydrated by heavy water, the diffraction only for the short lamellar structure has been observed notwithstanding the considerably broad profile. Furthermore indirectly the swelling of the short lamellar structure has been observed although the Charalambopoulou et al. has not stressed this fact. In the further structural study on SC it is useful to use SAXD and neutron diffraction.

References

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