Surface Active Properties of Heptyl β-D-Xyloside Synthesized by Utilizing the Transxylosyl Activity of β-Xylosidase

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Synopsis. The surface-active properties of heptyl β-D-xyloside were investigated. The critical micelle concentration of this surfactant was determined to be 30 mM ($M=mol\,dm^{-3}$). The corresponding molecular area at saturation adsorption, the micellar weight and the aggregation number were 43 Å, 20700 and 78, respectively. This surfactant was found to have a surface activity similar to that of octyl β-D-glucoside.

The nonionic surfactants, octyl β-D-glucoside (octyl glucoside), heptyl β-D-thioglucoside (heptyl thioglucoside), sucrose monodecanoate, etc., are being increasingly utilized for solubilization, reconstitution of biological membranes and the preparation of lipid vesicles.[1—7] Based on a similar point of view, we have developed a new enzymatic process to synthesize alkyl β-D-xyloside homologues by utilizing the transxylosyl activity of *Aspergillus niger* β-xylosidase.[8,9] In the present studies, the authors have tried clarify the relation between the surface activity and the hydrophile-lipophile balance of alkyl β-D-xyloside molecules, such as heptyl β-D-xyloside (heptyl xyloside). The results were compared with other detergents, such as octyl glucoside and heptyl β-D-glucoside (heptyl glucoside).

The homologues of heptyl xyloside[9] were synthesized as previously described. All other chemicals used were of the highest grade commercially available. Two typical methods were employed to determine the critical micelle concentration (cmc) of heptyl xyloside. In the first procedure the effect of the detergent concentration on the fluorescence intensity of solubilized ANS (8-anilino-1-naphthalenesulfonic acid) was measured at 50 °C. In the second procedure, cmc was determined from a break in the surface tension vs. concentration curve, as measured by Shimadzu Surface Tensiometer ST-1 at 50 °C. Light-scattering measurements were also carried out in order to estimate the micellar size at 40 °C with a wavelength of 633 nm, using a light-scattering photometer (Ootsuka Photoelectric Co. DLS-700). Scattered light was observed at 90 degrees relative to the incident beam.

Figure 1(A) shows a sudden rise of the fluorescence intensity of solubilized ANS at concentrations of heptyl xyloside higher than 30 mM, while a break appeared at 22 mM for octyl glucoside and 67 mM for heptyl glucoside. Surface tension-log concentration curves are shown in Fig. 1(B). The inflection (30 mM) in the curve corresponds to the cmc of the surfactant.[10] Thus, the two results agreed very well, and the cmc of heptyl xyloside was determined to be 30 mM. This value was higher than those obtained for sucrose monodecanoate, triton X-100 and SDS, and was similar to that for octyl glucoside (Table 1).

From the slope of the curve in Fig. 1(B), the surface

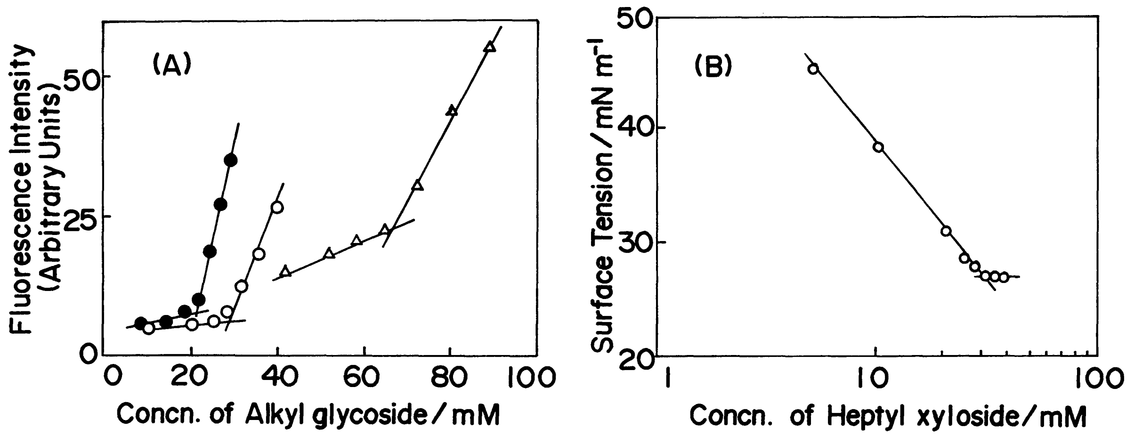

Fig. 1. Determination of cmc of heptyl xyloside. (A): Assay mixture (2.0 ml) contained 10 μM ANS and various concentrations of surfactants. Fluorescence intensity of ANS was measured at excitation wavelength of 345 nm and emission wavelength of 480 nm. (○), heptyl xyloside; (△), heptyl glucoside; (●), octyl glucoside. (B): The surface tension-log concentration curve of heptyl xyloside.

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Table 1. Surface Active Properties of Alkyl Glycosides and Some Other Surfactants

Surfactants	cmc/mM	A/Å	Micellar wt. (Agg. Numbr.)
Heptyl xyloside	30	43	20700 (78)
Octyl glucoside	22	41**[10]	25800**[11] (87)
Sucrose monodecanoate	2.52**[5]	—	10500**[5] (22)
Triton X-100	0.25**[12]	52.4**[12]	63000**[12] (100)
SDS	8.1**[13]	45**[13]	23000**[14] (80)

**, From literatures.

excess (Γ) at saturation adsorption and the corresponding molecular area (A) were calculated by applying Gibbs adsorption isotherm, $\Gamma=-(1/RT)(\partial\gamma/\partial\ln C)_T$, where the notations used have their usual meanings. The obtained results are listed in Table 1. The A values of heptyl xyloside and octyl glucoside are almost the same. The micellar weight and the aggregation number, as obtained from light-scattering measurements for heptyl xyloside, are 20,700 and 78, respectively, which are comparable to the values for octyl glucoside (Table 1). This suggests that these compounds are similar in nature.

Among the surfactants currently used in membrane biochemistry, octyl glucoside is an excellent one[1] and has been used for the extraction and purification of the lactose carrier of *Escherichia coli*,[2] as well as for the preparation of lipid vesicles.[7] The above-mentioned applicability of heptyl xyloside to membrane biochemistry will be tested in a follow-up study. The xylose group of alkyl xyloside seems to show a fundamental difference in its properties from that of glucose in alkyl glucoside. Namely, heptyl xyloside has a Krafft point of 33.7 °C, whereas the heptyl glucoside does not show a Krafft temperature phenomena. The difference in the hydration of these compounds may cause these characteristics. A further comparison should also be made regarding the xylose and glucose groups in various glycoside.

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