Environmentally friendly laundry detergent bases

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According to the 2020 statistical data of the Ministry of Economy, Trade and Industry, the growth of the Japanese laundry detergent market is leveling off in terms of sales volume, whereas the sales ratio of liquid laundry detergents continues to increase annually with the increasing popularization of front load washing machines and concentrated liquid laundry detergents.

Meanwhile, there are growing global safety and environmental concerns, warranting further reduction of the environmental impact of liquid detergents.

This paper introduces liquid laundry detergent bases primarily focusing on our products EMULMIN CS-100W and MICELAND SCD-100 (under development), which are nonionic surfactants with excellent characteristics that can contribute to a reduced environmental impact.

Components of liquid laundry detergents

Table 1 shows representative laundry detergent components. The primary component is the detergent base, which is responsible for removing stains and reducing their interfacial tension. Generally, stains on clothes comprise sebum-based oily stains, protein deposits, and inorganic stains such as mud, for which nonionic and anionic surfactants are used in combination as effective detergent bases.

Nonionic surfactants generally have a lower critical micelle concentration (c.m.c.) and a greater ability to lower the interfacial tension of oils and fats compared with anionic surfactants, providing excellent detergency with a small amount. Because the detergency is unlikely to be affected by the hardness of water, lower foaming, and excellent rinsing property, nonionic surfactants are used as the primary component of liquid detergents. Typical examples include ethylene oxide (EO) adducts of higher alcohols (alcohol ethoxylates: AEs) and those partially containing propylene oxide (PO) to suppress foams in washing and improve low-temperature fluidity of liquid detergents.

Anionic surfactants can emulsify, disperse, and prevent redeposition of stains, and have high detergency against inorganic stains. Anionic surfactants generally have a detergency that is likely to be affected by the hardness of water. Among them, relatively unaffected ones are used for liquid detergents. **Table 2** shows representative surfactants used for laundry detergents.

Laundry detergents contain these detergent bases and auxiliary agents (builders), enzymes, and additives that enhance detergency. The builders themselves do not have surface-active properties but are essential to increase detergency. To eliminate the effects of hard water and electrolytes on detergency, they provide alkaline buffering, sequestrate metal ions in water and stains,

Table 1 Components of liquid laundry detergent

Component	Intended use	Powder detergent	Liquid detergent
Detergent base	Reduction of interfacial tension reduction, emulsification and solubilization of oils and fats	Nonionic surfactants Anionic surfactants	Nonionic surfactants Anionic surfactants
Builder	Supplementation of calcium ions	Zeolite, polycarboxylate	Citrate
	Enhancement of detergency against oils and fats	Sodium silicate, sodium carbonate	Alkanolamine
	Prevention of stain redeposition	Zeolite, polycarboxylate, and carboxymethyl cellulose	—
Enzyme	Decomposition of protein/oils and fats	Protease	Protease
Additive	Whitening, and bleaching of colored stains	Fluorescent whitening agents, bleaches, and perfume	Fluorescent whitening agents, pH adjusters, solubilizers, and perfume

Table 2 Representative surfactants used for laundry detergents

Ionic	Representative surfactant	Structure	Applicability	
			Powder detergent	Liquid detergent
Anionic	Long chain fatty acid (soap)	$R-COO^-Na^+$	○	△
	Long chain alkyl benzene sulfonate	$R-C_6H_4-SO_3^-Na^+$	◎	○
	Alkyl ether sulfate	$R-O-(CH_2CH_2O)_n-SO_3^-Na^+$	◎	○
Nonionic	Polyoxyethylene alkyl ether	$R-O-(CH_2CH_2O)_n-H$	○	◎
	Polyoxyalkylene alkyl ether	$R-O-(AO)_n-H$	△	◎
	Polyoxyalkylene alkyl amine	$R-N-\{(AO)_n-H\}_2$	○	○

R: alkyl group, AO: alkylene oxide (ethylene oxide, propylene oxide, etc.)
◎: Very commonly used as main component; ○: relatively commonly used as main component;
△: sometimes used

disperse stains, and prevent stain redeposition.
Enzymes are contained to decompose stains including proteins, lipids, and starches.
Other components contained are fluorescent whitening agents, bleaches, solubilizers, pH adjusters, preservatives, pigments, and perfume.
For liquid detergents, limited components can be used to ensure the main characteristics of "liquid form." For example, the builders playing active roles in powder detergents, such as inorganic alkali and zeolite, reduce fluidity and thus are unsuitable for use in liquid detergents. Therefore, polyvalent carboxylic acids such as citrate and organic alkali such as alkanolamine are used for liquid detergents.
Given these restrictions due to their form, liquid detergents are produced by ingeniously selecting and combining the detergent bases, builders, and other additives.
We have a wide selection of surfactant products as liquid detergent bases **(Table 3)**, among which we focus on nonionic surfactants, the primary component of liquid laundry detergents playing an important role to ensure high performance.

Sanyo Chemical's nonionic surfactant-based liquid laundry detergent bases

We have released the EMULMIN NL series with EO adducts of lauryl alcohol, which are our representative nonionic surfactant-based liquid laundry detergent bases.
Our product portfolio also includes the NAROACTY CL and ID series with enhanced detergency, emulsification, and penetration, which were achieved by narrowing the molar distribution of EO adducts using our proprietary synthesis technology; SANNONIC SS series with enhanced penetration, which was achieved by using EO adducts of secondary alcohols; and SANNONIC FN series with excellent low temperature fluidity.
Sebum stains, one of the target stains of laundry detergents, primarily comprise fatty acid and triglyceride, and removing these will be vital to enhance detergency. We have released the EMULMIN FL series with increased affinity for oils and fats to enhance detergency by replacing part of the EO, a hydrophilic chain of general AEs, with PO that has slightly higher hydrophobic property.

Detergent bases contributing to the reduction of environmental impact

(1) Detergent bases with excellent detergency and biodegradability

Table 3 Major liquid laundry detergent bases from Sanyo Chemical

Ionic	Product name	Primary component	Characteristics
Nonionic	EMULMIN NL series	Polyoxyethylene lauryl ether	EO adducts of natural alcohol
	NAROACTY CL series	Polyoxyalkylene alkyl ether	Good detergency and emulsification achieved by narrow molar distribution of EO adducts compared with traditional AEs
	NAROACTY ID series	Polyoxyethylene alkyl ether	Good penetration achieved by narrow molar distribution of EO adducts compared with traditional AEs
	SANNONIC SS series	Polyoxyethylene alkyl ether	EO adducts of secondary synthetic alcohols. Good permeability
	SANNONIC FN series	Polyoxyalkylene alkyl ether	Alkylene oxide adducts of synthetic alcohols Excellent low temperature fluidity
	PUREMEEL series	Polyoxyalkylene alkyl amine	Alkylene oxide adducts of primary alkylamine Good rinsing property and permeability Suitable for compact liquidlaundry detergent base
	EMULMIN FL series	Polyoxyalkylene lauryl ether	Low fluidity and excellent solubility in cold water
	EMULMIN CS-100W	Polyoxyalkylene alkyl ether	Excellent detergency and biodegradability
Anionic	SANDET EN, END	Polyoxyethylene alkyl ether sodium sulfate	Good foaming property, excellent detergency against inorganic stains such as mud

Contact our sales department to use our products. Ensure that the safety data sheet (SDS) is read before use.
Determine the suitability and safety of the products intended for use at the user' s discretion.

There is a growing demand for environmentally friendly laundry detergent bases with a high concentration and biodegradability in addition to the basic performances such as detergency.
However, increasing affinity with oils and fats for enhanced detergency typically interferes with biodegradability. Utilizing our unique surfactant technology, we have developed and launched EMULMIN CS-100W, which offers enhanced detergency without significantly lowering the excellent biodegradability of AEs. Although EMULMIN CS-100W, like EMULMIN FL series, is a polyoxyalkylene alkyl ether produced by replacing part of the EO in AEs with PO, it has significantly enhanced biodegradability, which is achieved by optimizing its molecular structure.

(2) Detergent bases with excellent detergency and biodegradability that are suitable for concentrated/compact detergents

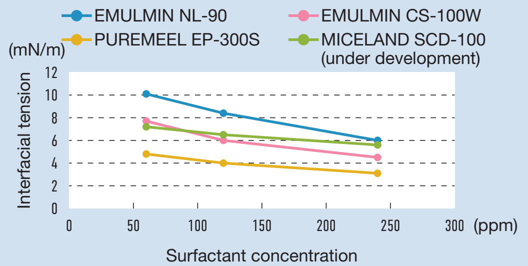
Recently, concentrated/compact liquid detergents that enable reduction of packaging materials and amount per use are becoming mainstream, and excellent low-temperature fluidity is required for them to contain highly concentrated surfactants. We have launched the PUREMEEL series of amine nonionic surfactants that ensure higher detergency, even with a small amount, than that of other nonionic surfactants. However, the PUREMEEL series are alkylene oxide adducts of primary alkylamine with less biodegradability compared with general AEs. AEs with excellent biodegradability and those replacing part of their components with PO cause gelation at low temperatures and are unsuitable for use in concentrated detergents.
From the perspective of reducing the environmental impact, there has been a growing demand for detergent bases with excellent detergency and biodegradability that can be used at a high concentration.
To satisfy these performance requirements, we have developed MICELAND SCD-100, a uniquely designed polyoxyalkylene alkyl ether. MICELAND SCD-100 has excellent biodegradability and interfacial tension-lowering ability similar to that of traditional AEs **(Figure 1, 2)**. In addition, it features low temperature fluidity equivalent to that of the PUREMEEL series **(Figure 3)**, which enables formulation at a high concentration and can thereby reduce the environmental impact compared with our conventional products.
In this paper, we evaluated the environmental impact resulting from the use (emission) of surfactants using the "environmental friendlinessl" **(Formula 1)**, our own measure considering the product biodegradability and environmental emission. Based on this measure, the products with high detergency and effectiveness with a small amount (low environmental emission) have a high "environmental friendliness" compared with that of other surfactants with the same level of biodegradability **(Figure 4)**.
The newly developed MICELAND SCD-100 is a detergent base with excellent detergency and biodegradability suitable for concentrated/compact use, and thus it can contribute to the environmental impact reduction efforts necessary to realize a sustainable society.

(3) Replacement with biomass raw materials

Environmental friendliness = (Biodegradability) / (Standard amount of use)

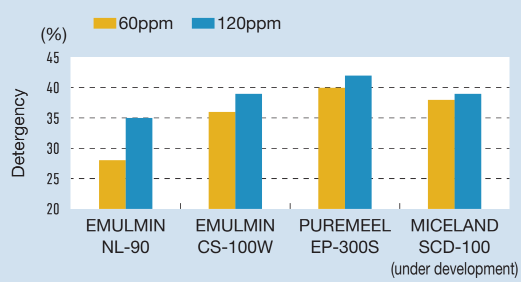
* The standard amount of use in Formula 1 refers to the lowest amount of surfactant necessary to provide certain detergency. The detergency was evaluated in accordance with the JIS K 3362 test method using clothes with artificial stains that have a similar composition to actual mixed stains.

Formula 1 Environmental friendliness (our own measure)



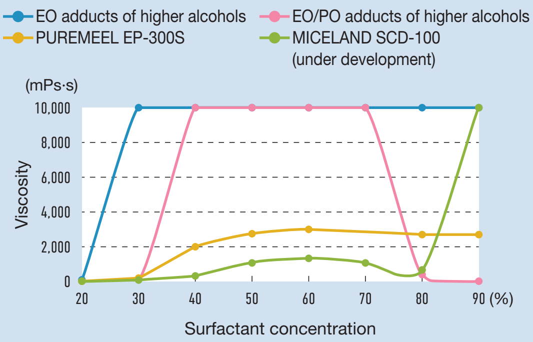
[Measurement method]
Pendant drop method: Surfactant droplets were ejected into 25°C oil from the tip of a needle and the interfacial tension was measured from the shape of the droplets.

Figure 1 Interfacial tension of surfactant solutions in oil



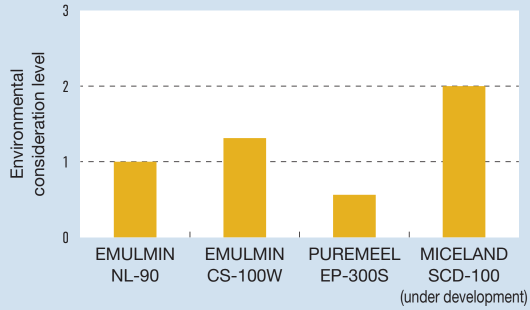
[Measurement method]
Washing method: Tergotometer; temperature: 25°C; time: 10 min. Detergency was calculated from the reflection rate of test clothes before and after washing.

Figure 2 Detergency of surfactants



[Measurement method]
Surfactants were diluted with water and the viscosities at each concentration at 5°C were measured using a Brookfield viscometer.

Figure 3 Low temperature fluidity of nonionic surfactant solutions (at 5°C)



[Measurement method]
Environmental consideration level = (Biodegradability) / (Standard amount of use)
Calculated proportionally with the environmental consideration level of EMULMIN NL-90 as 1.

Figure 4 Environmental consideration level of surfactants

The reduction of environmental impact is a global issue that should be addressed along with the improvement of product performances and the cooperation of the entire supply chain.
In October 2020 the Japanese government declared "Carbon Neutrality by 2050" to achieve net zero greenhouse gas (GHG) emissions by 2050, and in April 2021 it announced the plan to reduce GHG emissions by 46% in fiscal 2030 compared with fiscal 2013 levels.
While our product portfolio encompasses a full range of synthetic higher alcohol-based nonionic surfactants, we will need to promote replacement with biomass raw materials towards carbon neutrality.
Taking our synthetic higher alcohol-based SANNONIC FN as an example, we assumed to replace the raw material with natural alcohol (biomass raw material) and evaluated the environmental impact using the amount of CO_2 emissions from the procurement of the raw material, manufacturing, to disposal as a measure **(Table 4)**.
Natural alcohol-based surfactants emit higher amounts of CO_2 compared with synthetic alcohol-based ones, as the process of producing natural alcohol from plants requires energy. However, in natural raw materials, atmospheric CO_2 is immobilized by photosynthesis during plant growth, and the amount of CO_2 emissions at disposal can be reduced by carbon offsetting, which results in negative CO_2 emissions in total and contributes to the reduction of environmental impact.
Carbon neutrality is difficult to achieve. To accomplish this, we believe it is necessary for people at all levels of society, from the industry and consumers, to the government, to make collective efforts.

Future issues

As described above, the demand for detergent bases that can contribute to reducing environmental impacts will further increase in the future. There is also an increasing requirement for high performances such as prevention of odors due to accumulated stains and residual bacteria. We will continue to develop high-performance, environmentally friendly laundry detergent bases that meet these needs.

[Contact (about the product)]
In Japan
Sales & Marketing Dept. of Surfactants Division
https://www.sanyo-chemical.co.jp/eng/

In U.S.A
Sanyo Chemical America Incorporated
https://sanyochemicalamerica.com/

Table 4 Increase and decrease in CO_2 emissions associated with the change in raw materials (calculated for SANNONIC FN)

Item	Description	Increase/decrease in CO_2 emission by replacement with natural alcohol ($t\text{-}CO_2$/Product-t)
Emissions from raw material procurement	Calculated for each raw material of the product using database value (*1)	+0.31
Emissions during production	(No increase/decrease during production)	±0
Emissions at disposal	Calculated for disposal of used product using database value (*2)	-0.54
Total		-0.23

*1: Life Cycle Inventory (LCI) Database IDEAv2
*2: Emission intensity database ver 2.1 (Ministry of the Environment)