Trends and Technological Developments in Laundry Products in Japan

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Abstract : Since launching the first compact powder detergent that had a dosage of 25 grams/30 liters, sales of these compact powders have taken over conventional powders and liquids. In the middle of 1990s have seen a further progress in compaction. At present ultra-compact detergents, having a dosage of 20 g/30 L and 15 g/30 L, have captured a dominant market share.

The spreading of compact and/or ultra-compact detergents has led to a change in consumption of surfactants. Although LAS is still a main ingredient for compact powders, alcohol ethoxylates and α -sulfo fatty acid esters have gained a stronger position in surfactant markets.

Other recent developments and trends include detergents formulated with bleach employing various types of bleach activators, which meet hygiene requirements and bleaching performance. Also, in 2000, tablet detergents and sheet type detergent have also been introduced into the Japanese market.

In the fabric softener market, concentrated products are gradually becoming dominant. Most of them are sold in eco-type packages, which make a significant contribution to save resources. As well, a readily biodegradable softening agent has been employed as a main ingredient in Japan.

Another exciting major innovation has been seen in bleach. Since 1990, the use of liquid oxygen bleach has been increasing steadily. In 1996, the first liquid oxygen bleach, formulated with a long alkyl chain activator satisfying both superb bleaching performance and activator stability, was launched. It has gained a strong position in the market.

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1 Introduction

Japan is said to be one of the markets where competition is keenest in the world. Japanese consumers demand a high level of quality. In order to get deeper customer satisfaction, it is necessary to continue providing good products through continuous improvement and innovation. In the meanwhile, consumers of Japan have become more value-conscious than before, thus pressure for price cutting is high. It is difficult for a product to become a bigger hit merely by improving it. Consumers will vigorously test whether such an improvement has a truly distinguishable difference and is worth paying more money for. In this paper, trends and technological developments in laundry products in Japan during the past ten years will be reviewed.

2 Market Overview

After the collapse of the "bubble" economy in around 1990 in Japan, the Japanese economy entered a long tunnel of recession. We are still now in a serious recession of consumption because of a negative future outlook due to a high unemployment rate, anxiety caused by corporate downsizing and property deflation. Although business conditions are said to be on the way to recovery, consumption is still low. However, with regard to laundry detergent in 1999, the sales quantity was 645,665 tons (an 8% increase compared to 1998) and the sales amount was 201,929 million yen (a 3% increase compared with 1998) (1). Thus laundry detergent sales have at last turned upward and we can begin to see the light at the end of the tunnel.

The above increases are greatly due to a success in value-added products featuring benefits such as fragrance, deodorization and sanitization. In addition, in the field of fabric softeners, value-added products featuring long-lasting fragrance or antibacterial properties have won many loyal consumers despite a higher price. This is helping to slowdown the trend towards price reduction while contributing to the expansion of the market.

3 Laundry Detergent

Figure 1 shows sales statistics of laundry detergent (1). Annual sales were at their peak from 1992 to 1994 and, after that, they gradually came down, being affected by a decrease in the price. As previously mentioned, both sales volume and value turned upward in 1999 but even still they are around 90% of the peak sales level. The present market share of compact detergent is about 90% and stable. This high market share, when compared to other countries, is characteristic of the Japanese market.

When first introduced in 1987, the standard dosage of compact detergent was 25 g/30 L and, as a result of further progress in compaction, two generations of ultra-compacts detergents have been developed. The standard dosage of the ultra-compact detergent sold in 1995 was 20 g/30 L while that sold in 1996 was 15 g/30 L. In view of the composition, the initial compact detergent was achieved by a large reduction of sodium sulfate (previously used as a filler in large quantities) and new enzymes such as an alkaline cellulase and lipase. The ultra-compacts were achieved by the advancement in high performance materials and new

manufacturing process. Multifunctional builders and surfactants that have a high detergency level even at lower concentrations were employed in these processes. At present, three types of compact detergents are sold: 25 g/30 L, 20 g/30 L and 15 g/30 L, with the 20 g/30 L being the most popular.

Another trend in laundry detergents is the incorporation of a detergent with activated bleach (**Table 1**). The market share of the detergent containing bleach was about 10-15% until five years ago, but at present, it has increased to 20-25%. Hydrophobic organic peracids produced from a bleach activator and hydrogen peroxide effectively whitens undergarments even under Japanese conditions of low water temperature and short washing time.

There has been no big change in the market of heavy liquid detergents, and both quantity and value have been stable. On the other hand, the market scale of light duty detergents is expanding. In 1995, a cycle exclusively for 'dry cleaning only clothing' was installed in almost all new automatic washing machines. Since then, the sales of light duty detergents suitable for such clothing have been boosted. Along with this, a specially designed laundry mesh bag has been introduced whereby the above can be washed even in conventional washing machines.

There are some new trends in laundry detergents this year. One is a tablet type detergent and another is a sheet type detergent (**Fig. 2**). Although the technology of the tablet detergent is basically the same as that in Europe, its solubility is improved. On the other hand, in the sheet-type detergent which has been on the market since October 2000, a water-soluble, quick dissolving film is employed. Its featured

Fig. 1 Sales Turnover of Laundry Detergent in Japan.

Table 1 Listed Ingredients on Carton of Powder Laundry Detergent in Japan.

	A	B	C	D	E	F
Standard Dosage	20 g/30 L	25 g/30 L	15 g/30 L	25 g/30 L	20 g/30 L	20 g/30 L
Surfactant Content	36%	35%	34%	32%	28%	30%
Surfactant	LAS-Na AE AS-Na Soap	LAS-Na AE Soap	α -SFE-Na LAS-K Soap	LAS-K AOS-K AE	LAS-Na	LAS-Na NOBS-Na
Builder	Zeolite Carbonate Silicate	Zeolite Carbonate Silicate	Zeolite Carbonate	Zeolite Carbonate	Carbonate Polycarboxylate	Carbonate Polycarboxylate
Bleach	—	LOBS/PC	—	DOBA/PC	NOBS/PC	NOBS/PC
FWA	+	—	+	+	+	+
Enzyme	Protease Cellulase	Protease Cellulase	Protease Lipase	Protease	Protease	Protease

Attack Sheet-type
(Kao) **Top Power Tablet**
(Lion) **Cube-type Ariel**
(P&G) **Fig. 2** New Type Laundry Detergents in Japan 2000.

selling point is that there is no need to break open any package unlike tablets, thus simplifying its use.

4 Technology Overview

4.1 Surfactants

Moving from compact detergents to ultra-compact ones, the amount of polyoxyethylene alkyl ether (AE) used was increased. This is because, since the critical micelle concentration (cmc) of AE is low, excellent detergency is available in a small amount, and further, since it has an excellent resistance to hard water, AE is

suitable to ultra-compact detergent where the amount of active ingredients is severely restricted.

New surfactants that have been put in use during the past ten years are as follows.

4.4.1 Sugar-base surfactant

Alkyl polyglycoside (APG) and N-methylglucosamide (MEGA) were sugar-based surfactants which came into practical use in liquid laundry detergents.

APG is manufactured from a saccharide and a higher alcohol and it is possible to balance its HLB by selecting the alkyl group of the higher alcohol and also

the molar ratio in the reaction of the saccharide to the higher alcohol. Since it causes less damage to wool fabrics, it was employed in a light duty detergent to wash fine fabrics. It is also receiving public attention because it has a high biodegradability, both lipophilic and hydrophilic groups can be manufactured from vegetables, which are renewable resources.

MEGA is manufactured by the reaction of a saccharide with methylamine under a reducing condition followed by subjecting it to a condensation reaction with a fatty acid ester (2). Since it also exhibits a high detergency as a result of an interaction with anionic surfactants, it is used as a co-surfactant with LAS, AS and AES (3).

4.1.2 α -Sulfo fatty acid ester salt (α -SFE)

α -SFE is synthesized by sulfonation of fatty acid methyl esters. It has received attention because of its low manufacturing cost and for being highly biodegradable. With regard to detergency, C_{16} is best, but commercially, carbon numbers of C_{12} to C_{16} are being used (4). As the cmc of α -SFE is lower than that of LAS, it shows good detergency even at a low concentration. On the other hand, α -SFE is hydrolyzed under an alkaline condition. Therefore, during both the detergent manufacturing process and on-the-shelf storage, the suppression of the ester hydrolysis must be achieved when using α -SFE.

4.1.3 Alkyl polyoxyalkylene ethers

A narrow range ethoxylate (NRE) and alkyl polyethyleneoxide-propyleneoxide-ethyleneoxide ether (REPE) are now being used in detergents.

In conventional alcohol ethoxylates, either sodium hydroxide or potassium hydroxide is used as a catalyst for the EO addition. NREs employ a metal oxide catalyst as a catalyst to sharpen the EO distribution (5).

The hydrophilic part of REPE is EO-PO-EO block. Compared to alcohol ethoxylates, REPE has a better low temperature fluidity, a far lower freezing point and wider formulation availability at a high concentration. Therefore, it is suitable for concentrated liquid laundry detergent.

4.2 Builders

The first compact detergent put on the market was achieved by increasing both the bulk density of the particles and the concentration of active components by reducing the sodium sulfate as a filler. For more compaction however, it is necessary to reduce the active components themselves. In today's ultra-compact detergents, new multi-functional materials are

compounded allowing ultra-compaction without sacrificing the performance. Multi-functional builders which came into use several years ago are crystalline silicate and amorphous aluminosilicate.

4.2.1 Crystalline silicate

Crystalline silicate is prepared by calcining amorphous silicate at a high temperature. In terms of the composition, it is equivalent to the disilicate, which is being used in detergents as an alkaline agent, but it has a layered crystalline structure with δ -phase crystals (6). A new crystalline phase type has also been developed (7). In such crystalline silicates, an alkali ion is exchanged with a polyvalent metal ion such as calcium or magnesium. It further has an excellent alkali buffering property, and therefore, it is a base material advantageous for ultra-compact detergents.

4.2.2 Amorphous aluminosilicate

Amorphous aluminosilicate is a multi-functional builder with both a high oil-absorbing ability and a medium ion-exchanging ability (8). The particle shape of zeolite A is cubic while this aluminosilicate is amorphous. Since the particle size of it is very small and the volume of interparticular space per unit weight is large, amorphous aluminosilicate has a high oil-absorbing ability and is suitable for the manufacture of a powder detergent where a large amount of liquid nonionic surfactant is used.

4.3 Enzymes

In the past 20 years, circumstances concerning detergents have greatly changed and enzymes have been established as an important component of detergents. The world market (total sales) of industrial enzymes in 1998 is presumed to be US \$1.5 billion, and of this, enzymes for detergents account for nearly 40%. Explanation for such a growth involves developments in biotechnology such as discovering new enzymes, mass production of enzymes by recombinant DNA technology, and improvements in the properties of enzymes by means of protein engineering.

In Japan, protease has been commonly used since 1979. In 1987, an alkaline cellulase from a *Bacillus* strain was incorporated for the first time and has strongly influenced household industries worldwide. After that, lipase, cellulase from a *Humicola* strain, and amylase from a *Bacillus* strain came into use as well. Today, it is common to compound one or more enzymes with protease.

Improvements in enzymes utilizing protein engineering are being vigorously carried out. Newly

developed enzymes such as protease and amylase are bleach resistant because the amino acids in them which are prone to oxidation have been replaced with other amino acids. Similarly, in the newly developed lipase, a negatively charged amino acid residue in the lipid contact zone of the enzyme is replaced with a neutral and hydrophobic one, resulting in improved adsorption of the enzyme to fatty stains. In addition, using evolutionary molecular engineering, a modified protease was recently developed to give high washing performance even in cold tap water.

Together with the search for new enzymes, the improvement of existing ones will be pursued vigorously utilizing protein engineering and evolutionary molecular engineering.

4.4 Bleach

In the 1980's, chlorine bleach was the mainstream, but, in the 1990's, oxygen bleach has become popular (1). There are two types of oxygen bleach. One is a liquid type where hydrogen peroxide is a main ingredient and the other is a powder type where sodium percarbonate or sodium perborate is a main ingredient. Recently, the sales of liquid oxygen bleach are increasing. This is presumably because of the movement towards a larger sized washing machine ; people are washing colors and whites together in one large load. Therefore there is a transition from chlorine type bleach to a color-safe oxygen bleach.

The following three bleach activators are used in Japan : sodium nonanoyloxybenzenesulfonate (NOBS), sodium lauroyloxybenzenesulfonate (LOBS) and decanoyloxybenzoic acid (DOBA) (5). Until recently, all of them could be used only for powder detergents and powder bleaches because of stability issues, but, in 1996, a product where LOBS is compounded with a liquid oxygen type bleach was put on the market. In the past year, its concentrated version was introduced. In order to incorporate LOBS into liquid oxygen bleach, a new technology was developed to suppress hydrolysis and perhydrolysis. The key is the formation of mixed micelles in which LOBS aggregates with nonionic and cationic surfactants (9). Such technology is expected to boost sales of liquid oxygen bleach.

4.5 Fabric Softeners

There are two types of fabric softeners currently being used in Japan, a market-dominant liquid type and a sheet type. With regard to the liquid type, there are two kinds: regular (3-7% active matter) and concentrated (13-25% active matter). The concentrated liquid softener is the dominant seller in the

Japanese market. Most of the concentrated softeners are sold in an eco-package such as a pouch refill because it is a better choice in terms of the environment and, in addition, it can be sold at a lower price.

In Japan, fabric softener was first introduced in 1962 and quickly grew in popularity. Although there has been no change in its basic composition since its introduction, an intense technical development competition has been occurring since the latter half of the 1980's. In 1988, a concentrated type was launched, followed by a softener featuring improved water absorbency in 1989. In 1992, an improved biodegradable softener was put on the market.

As to the main ingredient for softeners, dihydrogenated tallow alkyldimethylammonium chloride (DHTDMAC) has been used for many years throughout the world. In the softeners with improved water absorbency, dioleyldimethylammonium chloride (DODMAC) is used. This is because when an oleyl group having an unsaturated bond is introduced into an alkyl group, molecule mobility is improved and water molecule penetration is accelerated. Because of environmental concerns, an amide ester (HEMPDA-EA) having a good biodegradability was put into practical use in 1992. In 1994, the use of dimethyl diester quaternary salt (MDEA-EQ) was implemented, followed by trimethyl diester quaternary salt (DMPD-EQ) and monomethyl ester quaternary salt (TEA-EQ) in 1996.

5 Summary

Trends and technological developments in laundry products in Japan during the past ten years are reviewed herein above. Although the long-lasting recession in consumption has made the Japanese consumers more value-conscious than before, their reaction to products featuring value-added benefits and to innovative new offerings is positive. Accordingly, we need to focus on predicting consumer's real needs and wants and on developing the necessary technologies to provide them with the desired products. Through this effort, development of laundry products will continue. We are eagerly anticipating the new developments that will occur in the forthcoming century.

References

1. Research and Statistics Department, Statistics Research Office for Iron and Steel, and Chemical Industries, Ministry of International Trade and Industry, Japan.
 2. Hildreth, J.E.K. (1982) *Biochem. J.*, **207**, 363-366.
 3. Katsura, R. (1998) *Proceedings of the 31th Hifuku Seirigaku Summer Seminar*, pp.11-19.
 4. Satsuki, T., Umehara, K. & Yoneyama, Y. (1992) *J. Am. Oil Chem. Soc.*, **69**, 672-677.
 5. Satsuki, T. (1999) *Proceedings of the 4th World Conference on Detergents*, pp.107-114.
 6. Showell, M.S. (1998) *Powdered Detergents*, Marcel Dekker, Inc., pp.58-62.
 7. Sakaguchi, M. (1995) *Powder Diff.*, **10**(4), 290-292.
 8. Saijo, H. (1999) *Proceedings of the 4th World Conference on Detergents*, pp.183-189.
 9. Ozaki, K., Ogura, N., Yamaguchi, N. & Aoyagi, M. (1998) *Proceedings of the 30th Symposium in Detergency*, pp.193-199.
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