Reconstructing formulas

A three-year study of commercial laundry liquids in Western Europe and the United States traces the evolution of surfactant systems.

Heliana Kola

In laundry detergents the single most consequential change in marketing form has been the introduction of compact powders. The revolution started in Japan, where compact powder products were introduced in 1987. They were such a success that, within two years, the Japanese powder market had converted to compacts. Compact powders spawned concentrated liquids, which first appeared in Europe in 1991 and in the United States in early 1993. The growth in sales of liquid concentrates in Western Europe was accelerated by the introduction of encapsulated liquid detergent doses in 2000, while in 2006 the shift of the market balance toward liquids in the United States became even more pronounced (72% liquids vs. 28% powders in terms of volume); the encapsulated liquid detergent doses were available through mass merchandisers, presented either by multinational brands or private labels.

The development of more environmentally friendly products led to the introduction in 2006 of super-concentrated liquids. These are an example of the cleaning industry's efforts to enforce its commitment to deliver valuable products to consumers while reducing both consumption of resources and waste from packaging excess. Such super-concentrated liquids provide advantages for consumers–in that they can be used more easily and in smaller amounts—and manufacturers and distributors—by lowering transportation and warehousing costs. The growing success of super-concentrated laundry liquids in North America and Western Europe prompted a three-year study by Battelle's analytical lab that compared the surfactant systems of a number of commercial products sold in the United States and Europe during 2006, 2007, and 2008.

Study methods

Western European (WE) and US markets were selected for study, as they can be considered mature and similar in many respects, such as domination by the same manufacturers and similarity with respect to their retail structures and consumer bases. For this study, 30 to 40 commercial liquid laundry detergents were selected for each of three years (2006, 2007, and 2008). Germany, France, Spain, UK, and Italy were selected; their total combined market represents about 80% of the WE market. Detergent producers selected included multinational companies such as Procter & Gamble, Unilever, Henkel, and Reckitt Benckiser for both geographical areas; private labels or national companies such as McBride, Persan, Bolton Manitoba, Realchimica, and Italsilva, for Western Europe and Henkel , Church & Dwight, Hiush, Method, Seventh Generation, and Phoenix for the United States; and finally retailers or generics manufacturers such as Tesco, Carrefour, Auchan, Sainsbury's, Lidl, and Dalli for Western Europe and Walmart for the United States.

Several state-of-the-art analytical techniques were combined to perform reverse engineering of formulations in order to determine quantitatively and qualitatively the different surfactants (i.e., hydrocarbon chain length, oxo- or oleo alcohol-based surfactants), builders, solvents, hydrotropes, complexing agents, enzymes, and foaming agents present in each formulation with the aim of reconstructing their complete formulas.

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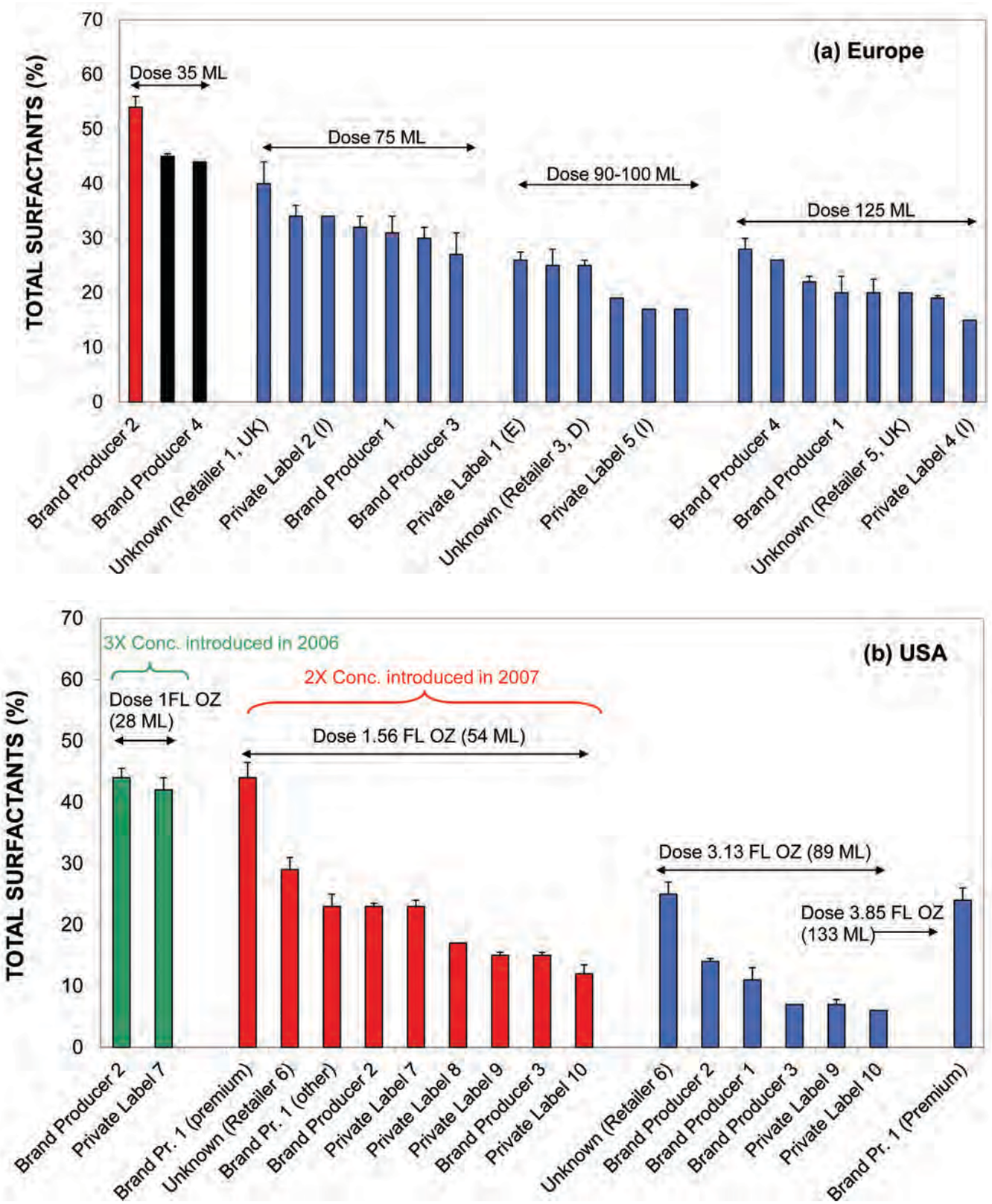

FIG. 1. *Total surfactant content of laundry liquids in (a) Western Europe (UK, Germany, Spain, France, Italy) and (b) USA introduced by different producers in 2006 (green), 2007 (red), and 2008 (black). Blue bars represent formulations existing before 2006 but analyzed during the study period. The market was covered in a comprehensive manner (i.e., 30 to 40 products were acquired in Western European and US markets each year). Products are grouped according to their dosage and by descending order of total surfactant content. Each bar represents the average of the surfactant content in formulations of the same brand analyzed in one, two or three consecutive years. Up to eight products were summarized for brands that have important market share.*

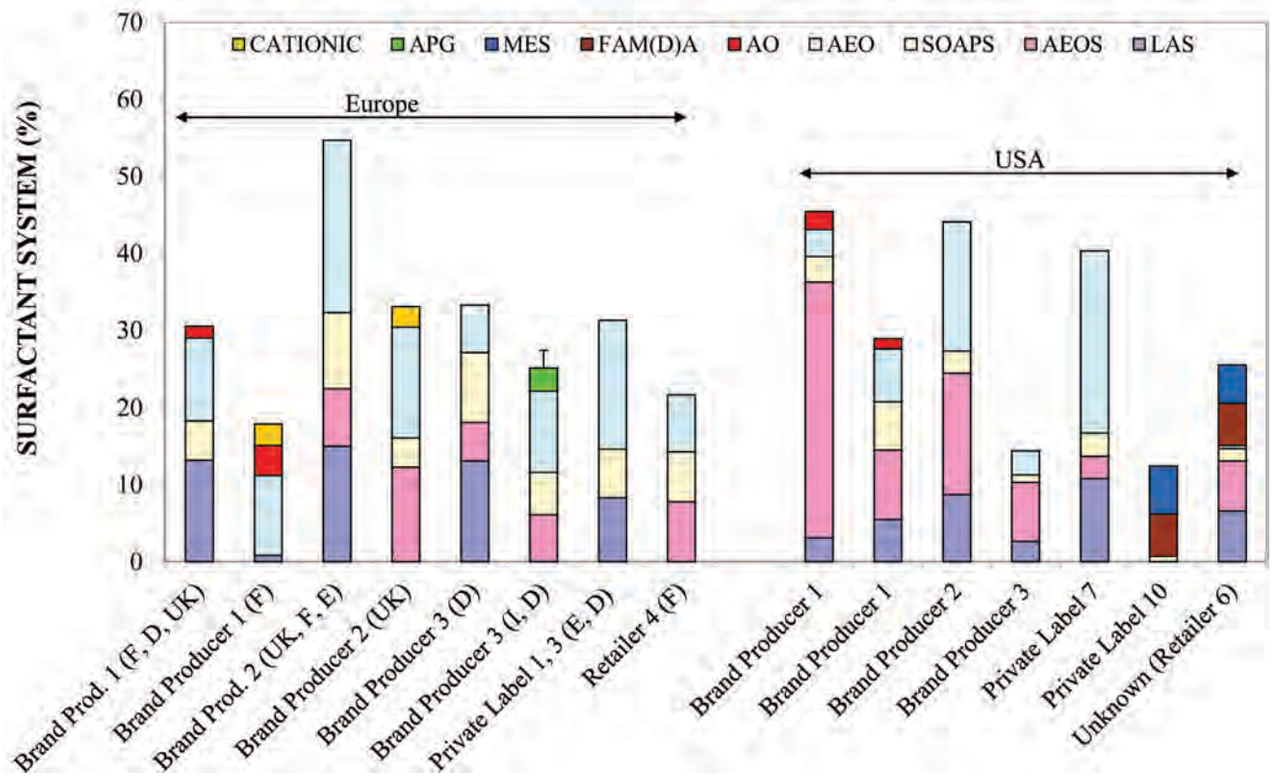

FIG. 2. *Representation of surfactant mixtures in a number of laundry liquid brands produced in 2007 by different manufacturers in Europe and the United States. Abbreviations: LAS, linear alkyl benzene sulfonates; AEOS, alkyl ether sulfates; AEO, alcohol ethoxylates; AO, aminoxides; FAM(D)A, fatty acid mono(di)ethanol amines; MES, methyl ester sulfonates; APG, alkyl polyglucosides.*

Total surfactant content

During 2006–2008 the level of surfactants in European laundry liquids varied from 15% to 55% (Fig. 1a) vs. 6% to 45% in North America (Fig. 1b). In 2006, super-concentrated versions were first introduced by Brand Producer 2 and a Private Label (3× conc. ~45% surfactants) in North America (shown in green bars) followed by Brand Producer 1 (2× conc. ~45% surfactants) and Private Labels (2× conc. ~12–25%) in 2007 (shown in red bars). During the same year, Brand Producer 2 expanded its "3× or 2x" concentrated versions (~55% surfactants) into Europe (France, UK, Spain). All products introduced in 2008 are shown in black.

Before 2006 (formulations shown in blue bars) in Europe, the dosage varied from 125 mL (regular conventional liquids) to 75 mL (concentrated conventional liquids) while the newly introduced super-concentrated liquids have doses about two times smaller than concentrated liquids and only ~1.5-fold increase in surfactants. On the other hand in the United States, Brand Producer 1 and Brand Producer 2 decreased the dose and increased the surfactant level by factors of ~2 and ~3, respectively, achieving at the end the same surfactant concentration (45%).

Surfactant blends

Typical surfactant mixtures for both geographical areas are shown in Figure 2. In Europe, formulations vary widely from country to country. For example, Brand Producers 1, 2, and 3 sometimes manufacture different formulations not only for different countries but also for different brands and brand extensions for the same country. Brand Producer 1 generally uses a mixture of LAS (linear alkyl benzene sulfonates), AEO (alcohol ethoxylates), soap, and AO (aminoxides) in its European brand, while its North American counterpart contains in addition a high level of AEOS (alkyl ether sulfates). Brand Producer 2 used the same surfactant mixture in its super-concentrated formulations for both continents with higher levels of AEOS in the United States than in Europe. Brand Producer 3 used the same surfactant mixture in both continents, but the surfactant content was three times smaller in the United States compared to Europe (dose: 3.13 fl. oz. or 89 mL vs. 75 mL). Finally, a distinctive mixture of surfactants was identified in some US formulations containing MES (methyl ester sulfonate)/FADA (fatty acid diethanol amine) in addition to other surfactants (Fig. 2).

Evolution of formulations

As product innovation continues to drive the laundry detergent business, detergent manufacturers and ingredient suppliers are keen to follow the balance between the market share of individual brands, physical presentation changes, and the composition of detergents as they are the prime factors for determining the market for chemical ingredients incorporated in detergents.

A few examples on the evolution of laundry liquid formulations covering the period between 2005 and 2008 are shown in Figure

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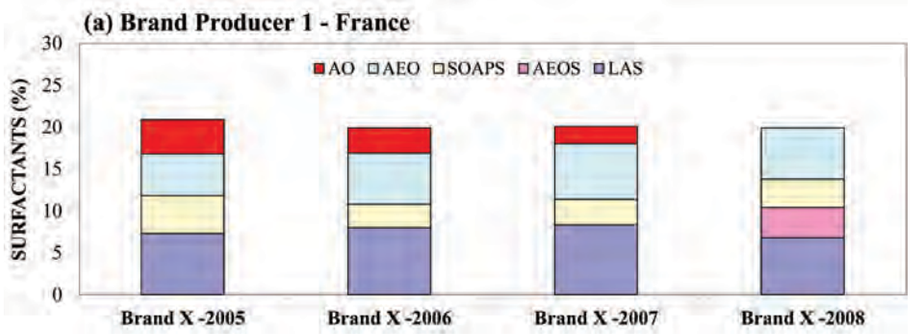

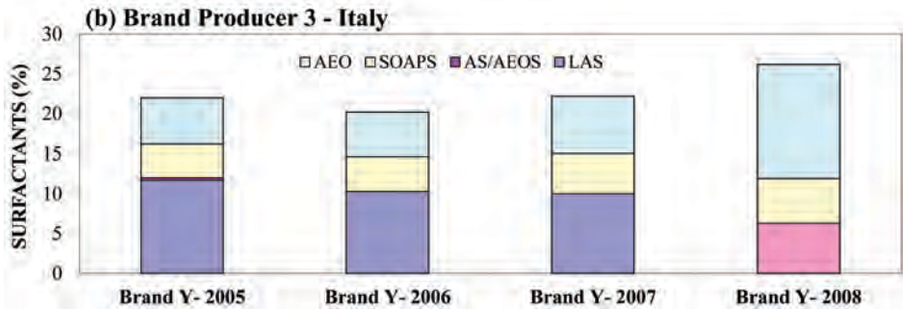

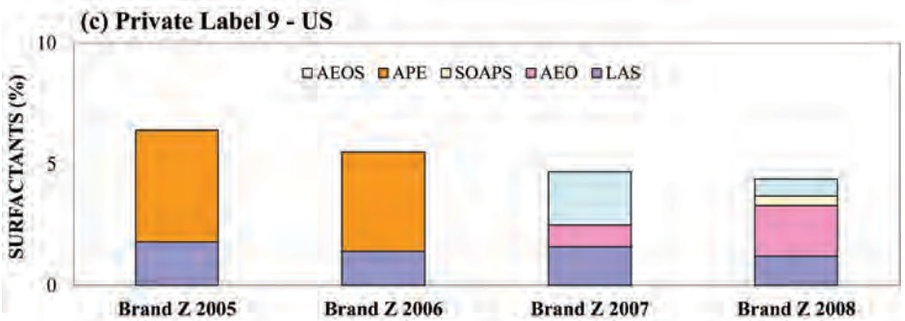

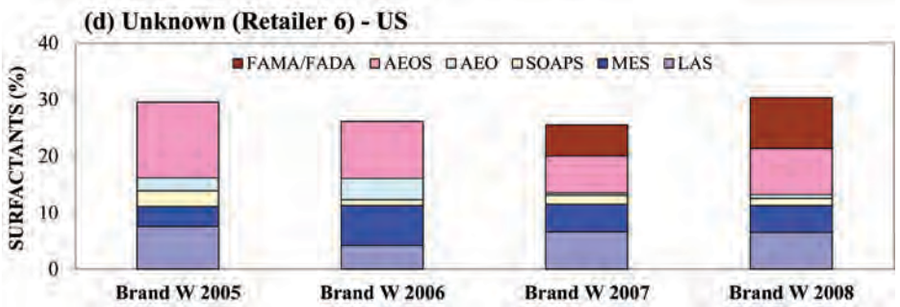

FIG. 3. *Representation of the evolution of some formulations manufactured during 2005–2008 by (a) Brand Producer 1 in France; (b) Brand Producer 3 in Italy; (c) Private Label 9 in the United States; and (d) an unknown Producer but distributed by Retailer 6 in the United States. Producer names on the x axis and values on the y axis are not shown for reasons of confidentiality. APE, alkyl phenol ethoxylates; for other abbreviations see Figure 2.*

3. For the Western European market in 2008, Brand Producer 1 withdrew AO from its brand in the French market (Fig. 3a), while Brand Producer 3 replaced LAS with AEOS in its Italian brand (Fig. 3b). The search for more ecologically acceptable ingredients, while keeping functionality and performance of the detergent, led to the withdrawal of APE (alkyl phenol ethoxylates) from the formulation of Private Label 9 in the US market during 2007. Lastly, in 2007 Retailer 6 changed the surfactant mixture in its formulation by replacing AEO with FADA and decreasing the levels of AEOS.

Worldwide, there are substantial differences in detergents formulation from region to region. Western European laundry liquids often have more surfactants than those in North America. This is due in part to the extremely hard water found in most of Europe that requires higher level of surfactants, but also to their different wash philosophy and technology. Whereas the cleaning process in an American top-loading washer relies on strongly agitating the clothes for a few minutes in 50 gallons of water and on using pre-treatment chemicals (e.g., chlorine bleach), a European wash system (front-loader) relies instead on extended wash cycles at optimal temperatures and gentle agitation, thus using less water (e.g., 15 gallons) and less energy. Recently, due to growing awareness of environmental concerns, energy crunches, water shortages, and new rules, front-loading, high-efficiency washers are becoming more common in North American homes. Consequently, detergent producers are adapting the detergent formulations.

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Heliana Kola is a freelance consultant in chemistry providing technical and business development support related to multiclient analytical programs on detergent formulations and their trends worldwide. During 2009 she assisted in the transfer of the Geneva-based Battelle Research Institute analytical program to the United States and then consolidated the technical and business model of the new organization. From 2005 to 2009, she was program manager of the Battelle World Detergent Program on detergent composition and technical leader in the Analytical Chemistry Laboratory at Battelle-Geneva (Switzerland). She can be reached at Kola@battelle.org.