past several decades. Procter & Gamble, Lever and Colgate-Palmolive dominate the marketplace in both the manufacture of primary ingredients and the final consumer products. In this decade, innovation and growth have occurred in the automatic dishwashing product category, highlighted with the recent liquid product launches. Advances in light-duty liquid formulations have provided incremental cleaning efficiencies and improved cost effectiveness. The observed changes in U.S. demographics and households have had little effect on dishwashing products offered to the consumer and no new regulatory activity has taken place. Formulation research efforts probably will continue to be directed toward offering the consumer added convenience with improved aesthetics and efficacy.

6.2 European Dishwashing Formulations

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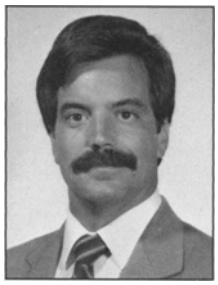
Cleanliness and hygiene are the most crucial criteria in the solution of daily dishwashing problems. Two different product types have established themselves in the market for the fulfillment of consumer preferences. First, there are manual dishwashing liquids that consist essentially of surfactant combinations. Their task is to clean dishes in connection with spotless drying so that cloth drying is not necessary. On the basis of surfactant concentrations a tripartition of the market arose in Europe, congruent with quality classifications. However, those markets are changing now. Second, there are machine dishwashing agents, usually offered as a combination of three components: (a) the cleansing agent, on the basis of triphosphate and silicates; (b) the rinse aid, on the basis of low sudsing nonionic surfactants; and (c) the regeneration salt, on the basis of sodium chloride. In comparison with manual dishwashing agents, the composition of machine dishwashing agents is less differentiated. The efficacy of manual agents is based on surfactant supported by mechanical agitation in the form of physical labor; the efficacy of machine dishwashing agents is based on the interaction of alkalinity, builders, mechanics and temperature. A comparison of manual and machine formulations with regards to water, energy and chemical consumption is interesting. This cost/benefit analysis is followed by a risk/benefit assessment. The biodegradability of surfactants in manual dishwashing agents deserves special attention. In the environmental risk assessment of machine cleaning agents, the biodegradability of the low sudsing surfactants and their phosphate content are of importance. An assessment of future developments shows the changes expected in the use and application of the most important raw materials and the factors important for those changes. Undoubtedly, consumer and environmental protection considerations will play a special role whereby manual and machine dishwashing agents will have to be considered separately. An optimal relationship between performance and consumer and environmental protection is sought.

6.3 Surfactants for Household Cleaners



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Although the household cleaner market has enjoyed only modest growth, manufacturers have been active in developing products aimed at more specific and economically attractive product areas. A greater number of surfactants is being used in order to fulfill the requirements made by these more specific and selective products. Specific performance criteria, acceptability (toxicity/biodegradability) have become more important. The effect these criteria have had, and will have, on surfactant usage is discussed. The ability of various surfactants to meet these criteria, as well as others, is also included.

6.4 European Industrial Detergents—Formulating for Performance and Biodegradability

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Many European detergents already meet requirements for biodegradability of surface active content. But developing suitable formulations for some institutional and industrial products is proving a challenge for formulators and raw materials suppliers alike. These products are those containing specialized low-foam nonionic surfactants, illustrated by heavy-duty spraywashing detergents for food and beverage industry use and rinse additives for industrial dishwashing machines. The properties of biodegradable nonionics available for possible use in the above examples are reviewed and contrasted with standard technology. There does not yet appear to be any surfactant that can satisfactorily replace the nonbiodegradable types used in heavy-duty cleaners, but there are biodegradable nonionics that can be and are used in rinse aid formulations. Compared, however, with traditional block copolymers, even these have performance deficiencies, and some of the auxiliary surfactant additives technologies developed to minimize these differences are briefly described. Finally, future material and formula possibilities are considered. There are opportunities to be explored, most effectively perhaps through a new combination of the individual skills of formulators and surfactant manufacturers.