Moving Toward Sustainability: Household Product Research, Development, and Engineering

The Greenlist™ Project; An Innovative Process

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Abstract

Innovation in designing consumer products is not an abstract ideal, but a month-by-month necessity for a company to maintain success in the marketplace. Achieving any substantial degree of sustainability will require a new level of innovation. However, innovation toward sustainability can only succeed if it is an integral part of the product development process, and not at odds with the core requirements of scientific, engineering, manufacturing, and marketing processes. This case study will draw upon the experience of SC Johnson, a 117-year old family-owned and managed consumer packaged goods company, to provide some concrete examples. Although the company's culture has deep roots, recent efforts have facilitated more sustainable product design by addressing information, training, procedural, and motivational aspects. The Greenlist™ program institutionalizes recognition and tracking of better choices for the environment and society, promoting incremental movement toward the ideal of "sustainability." The necessity and accompanying benefit of innovation is illustrated by the company's effort to eliminate chlorine-based packaging, including PVC bottles. Although most uses of PVC had been easily avoided in recent years by choosing alternative materials, the chemical and physical properties of a popular metal polish had made a PVC bottle seem essential. Determined to eliminate the PVC container, RD&E scientists developed a new formula that can be packed in a non-PVC bottle (PET) that uses less chemicals, matches the

performance of the old product, and avoids the need for the product to carry the new EU “Dangerous for the Environment” hazard label (the "dead fish / dead tree" warning symbol), that would have been required for the old product. The fragrance used in the new formula is more environmentally advanced, and additionally, the new product can be warehoused with our other products, whereas the old product was required to be stored in its own separate building. Finally, the new product represents a cost saving for the company at ~€30,000 each year: a win for business and a win for the environment!

Introduction

Innovation is a topic currently receiving much attention in many fields. Innovation in designing consumer products is not an abstract ideal, but a month-by-month necessity for a company to maintain success in the marketplace. Achieving any substantial degree of sustainability will require a new level of innovation. However, innovation toward sustainability can only succeed if it is an integral part of the product development process, and not at odds with the core requirements of scientific, engineering, manufacturing, and marketing processes.

SC Johnson has maintained a successful and growing consumer packaged goods company through five generations of family ownership since 1886. The company has been recognized for environmental and sustainable leadership initiatives for decades, including CFC-free aerosols and cleaner / safer products and processes. It was also a founding member of the World Business Council for Sustainable Development. During the past decade company efforts emphasized progress in eco-efficiency. More than 60 percent of process waste was eliminated while production was increased more than 50 percent. Packaging requirements overall were reduced, recycled content was increased more than 30 percent, PVC packaging was phased out, and virgin material use in packaging was cut by a third. Large volumes of solvents were eliminated from products, and the company received the first Innovative Product exemption awarded by the California Air Resources Board that is now one of nine such exemptions for SC Johnson products. Innovation went beyond technology: The company led a national grassroots coalition for aerosol recycling, resulting in more than 5,000 communities in the US actively recycling aerosol cans.

However, gains in eco-efficiency of the sort seen in the last decade are increasingly difficult to achieve. Our attention has been turned to "eco-effectiveness": using better materials to do the job. Our approach is appropriate for our business. It takes advantage of the fact that as we develop consumer products we make many choices, selecting the raw materials that go into household cleaning formulations, and products for home storage, insect control and personal care. We do not generally design new chemicals or produce them, but rather we are formulators. We choose raw materials that give us the performance, aesthetics, and cost that we need to be category leaders but beyond that we can also improve the footprint on the environment. Consumer products generally

enter the environment ultimately in some form. A large portion of our products enters the environment via wastewater, some enter the atmosphere, and others enter the solid waste stream for recycling or disposal. Our total footprint on the environment includes aspects of the full life cycle: raw material production, product development and use, as well as disposal. Although we have many constraints, we are in a position to make choices with real consequences.

The Greenlist™ Process

The "Greenlist™" process is our method of institutionalizing eco-effectiveness, to ensure that we do use more materials that are better for the environment and its inhabitants. The Greenlist™ process establishes comparative criteria that rate the environmental and biological impact of our choices. It allows product designers to minimize the environmental footprint while still maximizing product efficacy. The process is forward-looking, taking advantage of the type of innovation that occurs in our business. Although totally new products are developed from time to time, most innovation is incremental. Nearly all of our consumer products are subject to some type of reformulation or redesign within a five-year period. Thus by requiring a consideration of the impact of material choices at each reformulation / redesign the company is able to move in the direction of more sustainable products on a continuous improvement basis. The Greenlist™ process does not take the place of our traditional human health and environmental toxicology assessments that continue to be done. The Greenlist™ process is also not intended specifically for legal compliance, although in the long run this "beyond compliance" approach will help to avoid problems due to potential future regulations.

The Greenlist™ process is innovative not because it is complicated, but rather because of its simplicity. It is easy to understand and to implement. The classification system establishes 4 to 7 criteria for each functional raw material category. Each material is given a classification:

- Best (3)
- Better (2)
- Acceptable (1)
- Restricted Use Material (RUM) (0)

The classification of each material is communicated to formulators and designers via our global databases. These systems are readily accessible and used daily in the normal course of product formulation. Formulators and designers can readily take account of the Greenlist™ classification

along with the scientific, engineering, manufacturing, marketing, and economic aspects that have long been considered. The burden of understanding the environmental issues is not borne by the formulator, but they are built into the system. "Sustainability" must be a built-in consideration; it cannot be an independent choice.

An appreciation for eco-efficiency, sustainability, and the Greenlist™ process in particular is integral to staff training, procedures, and motivation / rewards. All new employees are instructed within a few months of joining the company, and objectives and progress are reviewed with all research, development and engineering divisions periodically. Procedures provide positive reinforcement for good material choices, but justification and approval is required before using any materials of concern. Goals are set annually for the company, but personal performance and salary is also linked to progress on the Greenlist™ goals.

How The Greenlist™ Works

The Greenlist™ is different from some other classification systems in that it accounts for the specific function of the raw materials. Before classification, each material is placed into a functional category:

- Surfactants
- Solvents
- Propellants
- Insecticides
- Resins
- Packaging
- Chelants and Sequestering Agents
- Antimicrobials / Preservatives
- Fragrance Raw Materials
- Colorants, Dyes, Inks**
- Waxes & Candle Fuels
- Thickeners**
- Others** (** future category)

For each of these categories, 4 to 7 criteria were developed that would be meaningful and discriminating. The criteria must be based on types of data that can reasonably be expected to be available. These data are normally obtained from the supplier, open literature sources, or commercially available databases. The types of criteria that have been used include the following:

- Biodegradability
- Aquatic Toxicity
- Human Toxicity
- EU Environmental Hazard Classification
- Source / Supply
- Vapor Pressure
- Octanol / Water Coefficient
- Other Criteria appropriate for the functional category

Not all criteria are appropriate for each functional category. For example, aquatic toxicity and biodegradability are concerns for materials like surfactants disposed down the drain, and vapor pressure is relevant for organic solvents but not for the surfactants. The "source / supply" criteria allow a consideration of more sustainable resources, including renewable materials, and also recognition of suppliers that can demonstrate a higher level of responsibility as evidenced by ISO 14001 and other systems. Another advantage of using category-specific criteria is that cutoffs for a given parameter can be tailored to the category. For example, aquatic toxicity (measured by LC_{50}s) is a relevant parameter for both insecticides and surfactants, but the appropriate scale of toxicity is quite different.

If data are not available for a specific criterion, then it is given a default of 1, the lowest score. Incentive is built into the system for data collection. The classification score for each material is simply based on the mean of the scores (from 1 to 3) for each criterion appropriate to the category. The final score is lowered in some cases to account for "Other Significant Concerns." This is intended to account for concerns which are not usually expected for our raw materials, but if they occur they are considered sufficient to affect our raw material choices. Examples of "Other Significant Concerns" include the following:

- EPA / UN Classifications - PBT / POP
- Endocrine disruptors
- Carcinogenicity (IARC or Proposition 65)
- Reproductive toxicity (Proposition 65)
- Other “chemicals of concern” lists, e.g.
  - ⇒ Banned in one or more countries where SC Johnson markets products.
  - ⇒ Unofficial bans (trade, associations)

PBT Screening

As described above, the Greenlist™ process is designed to look ahead, so that better choices are made in the normal course of business with the expected result that the sustainability of all products will eventually be improved. It would not be possible in a short time to re-evaluate and redesign all of our thousands of products. This approach is based on the assumption that our traditional assessments of materials and product designs have led to uses of raw materials that are considered "acceptable" by usual legal, scientific, and market standards. As a check of our current product base, SC Johnson worked cooperatively with the U.S. Environmental Protection Agency (EPA) and Syracuse Research Corporation (SRC) to screen all of the chemical components of our raw materials to identify any potential "PBT" chemicals (Weeks et al., 2003). A "PBT" is a chemical that persists (P) in the environment, has the potential to bioaccumulate (B) to relatively high levels, and is toxic (T). Because of their potential for harm to health or the environment, the use of PBTs is being restricted worldwide through the cooperation of chemical manufacturers, formulators, and regulatory bodies. The US EPA recently released their PBT Profiler software and databases for public access (EPA, 2002). This software is an integrated set of screening tools designed to help the user identify PBT materials. SC Johnson, EPA, and SRC undertook this case study to test the PBT Profiler software, the practicality of its application to a large set of materials, and the feasibility of screening with the objective of eliminating all PBT chemicals. The screening of approximately 3,000 raw materials with this software was the first step in a process that also used subsequent data collection and expert judgement to narrow the list of potential PBT chemicals. At the completion of the process, ten materials remained that needed to be tested further or simply eliminated from our pallet of "acceptable" raw materials.

Greenlist™ Goals

Our corporate annual goals include a desired increase in the accumulated Greenlist™ score weighted by total kg of material used. During the initial phase of the program, criteria were developed for the five functional categories representing the largest material usage: home storage resins, surfactants, propellants, insecticides, and solvents. The goal for the fiscal year 2002/03 was an 8 percent increase over the 2000/01 baseline year. Results are being finalized, but it is apparent that the actual increase achieved was greater than 15 percent. This approach to setting goals and measuring

progress emphasizes decreasing the total footprint of the company's products, but each business area is allowed to determine the most efficient way of obtaining the goal. This gives the formulators maximum flexibility to determine the best approach given the many trade-offs involved in material choices.

Example Projects

Reductions in Volatile Organic Compound (VOCs) Emissions

SC Johnson has been a leader in the development of innovative approaches to creating more environmentally friendly aerosol products. This was true in the 1970's when SC Johnson voluntarily led the industry away from use of chlorofluorocarbon (CFC) propellants. This proactive environmental action continues to be true today as SC Johnson develops new approaches to substantially reduce the amount of hydrocarbon propellants required to produce effective aerosol products. Today SC Johnson has a goal to reduce VOCs globally.

The propellant assumes multiple roles in aerosol formulations. The propellant is firstly responsible for dispensing the contents of the package. Furthermore, the propellant disperses in the formula as part of an emulsion system and consequently participates in spray formation (i.e. particle breakup) through flashing (boiling) as the liquid mixture contacts the air. Therefore, reduction in propellant content can lead to both incomplete dispensing and poor spray characteristics in the final product.

Many alternative technologies exist to the standard aerosol package. These can suffer from cost or performance problems, or both. Compressed gas systems offer the potential for hydrocarbon-free aerosols, but suffer from reduction in package pressure through the life of the can and a propensity to prematurely dispense the pressurized gas if the product is misused. Bag-in-can technologies can be highly efficient in their usage of propellant, but tend to be more expensive and subject to greater complexity in manufacturing**.** Other technologies offer the consumer the ability to pressurize the product by hand pumping the package to the desired pressure. These systems can perform well, but tend to be costly and labor intensive for consumers.

SC Johnson has recently launched a reduced-propellant air freshener product. This was accomplished through innovative reformulation and packaging component changes. This product will reduce the amount of hydrocarbon released to the atmosphere since it has 16.6 % less VOCs than the current product. The new innovative formula not only reduces VOCs but also results in a better performing product with a finer spray that is preferred by our customers.

The Greenlist™ process helped drive innovative ongoing research for VOC reduction in aerosol products, and it has shown that further significant reductions in VOC can be accomplished. We now have a goal of reducing the VOC emissions by as much as 50 %. The challenge is to reduce VOCs while maintaining the consumer desired attributes.

Aerosol products are not the only source of VOCs. Cleaning products in trigger sprayers also may contain VOCs. Often the ingredient that is the source of the VOCs is added to provide a specific performance attribute. Eliminating the VOCs is often a significant challenge. Windex® Glass Cleaner was reformulated to reduce VOCs in the U.S. An estimated 180,000 kgs of VOCs will be eliminated with the low VOC formula. A new All Purpose Cleaner recently introduced in the U.S. was formulated as a VOC-free product. This formulation was accomplished by the innovative use of surfactant blends and solvents that are not VOCs. As we develop additional new products there will be an emphasis to formulate with non-VOC ingredients.

Surfactants

Traditionally synthetic surfactants have been the primary surfactants used to formulate consumer cleaning products. There are many reasons that the synthetic surfactants have been the formulators' choice. These include: variety of carbon chain lengths, wide range of HLB (hydrophilic-lipophilic balance), cloud point, and cost.

The traditional choices of surfactants include a wide range of chemistries including alcohol ethoxylates, esters, betaines, alkoxylates, alkylamides, and block copolymers to mention a few. A newer class of surfactants is the biosurfactants. These are surfactants that are produced by bacteria in a fermentation process then sterilized and proteins removed. The biosurfactants have some very

interesting characteristics which include: high efficacy, lower concentration required than some other surfactants; low CMC (Critical Micellular Concentration); readily biodegradable; very low environmental impact; low human toxicity; and when used with synthetic surfactants they reduce the amount of synthetic surfactants required in a formulation. SC Johnson is early in evaluation of the biosurfactants. We are currently looking at formulation flexibility and what cleaning products may benefit by using the biosurfactants.

Chelants

Chelants or sequestering agents have been used for years to help reduce the effects of hard water, improve soap scum cleaning, and improve lime scale removal. In recent years several chelants have been the target of environmental concern. Ethylenediaminetetraacetic acid (EDTA) is one of the most common chelants used in formulated products. Environmental concerns have been raised due to its poor biodegradability. Additionally concerns have been raised that EDTA could possibly be mobilizing heavy metals in the environment. There are a number of countries that have imposed restrictions or bans on the use of EDTA.

Another traditionally popular chelants is nitrilotriacetic acid or NTA. NTA is more biodegradable than EDTA but it has been linked to concerns of causing cancer, effects on metabolism and it is on some restricted lists in the U.S. and other countries. There has been pressure exerted not to use NTA by some industry and non-governmental organizations (NGOs).

The need for chelants has not disappeared so it was necessary to find chelants that are readily biodegradable, have low aquatic toxicity, reduced potential for heavy metal mobilization in the environment and are not of concern by either industry, governments or NGOs.

SC Johnson in collaboration with its suppliers has identified several biodegradable chelants that are much better choices for the environment. One of the newer chelants being evaluated is N-(2-hydroxyethyliminodiacetic acid), disodium salt (CAS Number 135-37-5), also known as HEIDA. It is an efficient replacement for EDTA or NTA, it has good chelation ability, and it is readily biodegradable and has a favorable aquatic and human toxicity profile.

On an active basis, HEIDA shows similar chelation values as EDTA. HEIDA passes the inherent biodegradability tests (OECD 302A, 302B) and ready biodegradability tests (OECD 301B, 301D, 301E 301F) HEIDA passes the extremely stringent seawater biodegradation test, (OECD 306 – North Sea water and Gulf of Mexico water).

Another chelant, methyl glycine diacetic acid, trisodium salt is readily biodegradable based on OECD test methods (301A, 301C). This chelant also has favorable environmental and environmental toxicology profile. It is a good candidate for an EDTA / NTA replacement.

As we search for chelants that meet our Greenlist™ process criteria we are identifying addition chelants that are better choices for the environment than EDTA and NTA. The challenge is to get information on these better choices to the formulators so they can start using them as they formulate new products.

Packaging: PVC, Chlorine Bleached Paperboard, Recycling

SC Johnson uses large volumes of packaging and this is therefore a large area of opportunity. Three areas have been focused on for packaging: recycling, elimination of PVC packaging and elimination of chlorine bleached paperboard or corrugated paper.

One of the key elements in sustainability is recycling and use of recycled packaging materials. We currently use and specify the use of recycled materials in resins for bottles, chipboard and corrugated cardboard. Identification of the highest volume opportunities to increase recycle content in SC Johnson components is a key packaging goal.

Eliminating the use of PVC resins in bottles and chlorine bleached paperboard was a major goal in 2002-03. This is important because the use of PVC and chlorine bleached paperboard can result in the release of dioxins to the environment. By the end of 2002 SC Johnson exited the use of PVC bottles globally. This resulted in the elimination of the use of 1705 metric tons of PVC. Chlorine

bleached paper was also eliminated by the end of 2002. This resulted in a reduction of about 100 metric tons of chlorine bleached paperboard.

SC Johnson will continue to focus on using recycled materials in our product packaging, and we are evaluating innovative methods to influence consumer recycling of our products such as aerosol cans and food storage bags.

Summary

Innovation in the consumer products industry sometimes occurs in large steps, but more typically many small advances occur at frequent intervals. The Greenlist™ process institutionalizes recognition and tracking of better choices for the environment and society, promoting incremental movement toward the ideal of "sustainability." It has proven to be practical and easy to implement even with our thousands of raw materials and frequent formulation / reformulation. It considers the function of raw materials, making fair comparisons. It emphasizes the total footprint of products on the environment, allowing developers to determine where best to shift materials. It is hazard-oriented to aid early decisions; it does not replace risk-based assessments. The Greenlist™ is an effort to sustain our Environment because it is our moral and corporate responsibility.

References

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