A STRATEGIC APPROACH TOWARDS SUSTAINABILITY FOR VINYL ADDITIVES

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ABSTRACT

Rohm and Haas has started participating several years ago in a sustainability program with one of its key customers (Hydro Polymers), a major PVC supplier and compounder in Europe, recently acquired by INEOS. This program started as an outgrowth of a sustainability assessment on PVC with representatives of major UK retailers. This analysis used a rigorous framework developed by The Natural Step (TNS), leading to the definition of 5 main sustainability challenges for the PVC Industry. In line with PVC challenge N° 5 "to raise awareness about sustainable development across the industry", Hydro Polymers organised several workshops with their key suppliers focusing on the sustainability challenges of the industry and the introduction of the TNS methodology, which they had decided to adopt as part of their strategy for sustainable development within their own company.

In this paper we describe that, although Rohm and Haas was doing already a lot in the traditional areas of sustainable development like Responsible Care, water- and energy efficiency, waste reduction, the use of the 12 principles of Green Chemistry, the development of environmentally advanced products, Life Cycle Assessments and participation in voluntary programs, the use of the TNS systems approach allows for a fuller, more fundamental and aligned approach to sustainability. In this paper we will also show how a qualitative Sustainability Life Cycle Assessment (SLCA) tool, which applies the 4 system conditions of the TNS framework to the various life cycle stages of a product during its entire life, can be a useful screening tool to help make decisions in product development, on products manufactured and on the actual supply chain and use of products. As an example we will show how the SLCA was applied on PVC heat stabilisers, comparing tin stabilisers to organic based heavy metal free stabilisers.

Sustainability, TNS framework, SLCA, PVC heat stabilisers, tin stabilisers, heavy metal free stabilisers

INTRODUCTION

Rohm and Haas has a long history of sound financial performance, combined with both environmental and social responsibility, which form the three pillars of Sustainable Development [1]. This is reflected in many of its technological and business choices over time, along with the development and use of management directives, such as our Code of Business Conduct and Ethics, and our seven guiding principles for Environment, Health, Safety, Security and Sustainable Development [2]. Recently 8 long term Sustainable Development goals have been defined for the Company (table 1). These streamlined goals will help us anticipate the needs and responsibilities we will have to fulfil as we expand our product line and geographical presence around the world, and will help us to measure our progress more easily.

Table 1 – The 8 Long Term Sustainability Goals of Rohm and Haas Company

- Zero occupational illness or injuries
- Zero discharges
- Zero incidents
- Continuous improvements in energy and water use efficiencies
- Continuous reduction in absolute waste, energy and water use
- Robust compliance with external regulations and voluntary commitments
- Intentional design of products to be reusable, recyclable or made from renewable raw materials
- Value creation through delivery of safer solutions that meet the ultimate needs of our customers and society

Furthermore Rohm and Haas plays a very active role in Responsible Care and started to implement the new Responsible Care management systems throughout its plants and businesses worldwide. Many of our sites across all regions of the world are already certified to ISO 14001, RCMS or RC 14001.

Our employee and contractor safety performance measured as the Occupational Injury and Illness rate (OII rate) continues to improve year on year. The global employee OII rate in 2007 was 0.83. We continue our efforts toward the goal of zero injuries and illnesses through training, behaviour and culture change, risk evaluation and our health surveillance program.

Our overall energy efficiency and water consumption metrics continue to improve, expressed as energy and water usage per unit of production [2].

Over the years we have launched a series of environmentally friendly products, some of which were analysed through full Life Cycle Inventories, estimating the energy inputs, global warming potential and water consumption of products as applicable for relative comparisons to other technologies.

The 12 principles of Green chemistry [3, 4] (table 2) are being used to screen many of our new product developments.

Table 2 – The 12 Principles of Green Chemistry

- It is better to prevent waste than to treat or clean up waste after it is formed
- Synthetic methods should be designed to maximise the incorporation of all materials used in the process into the final product
- Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment
- Chemical products should be designed to preserve the efficacy of function while reducing toxicity
- The use of auxiliary substances should be made unnecessary whenever possible and, innocuous when used
- Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure
- A raw material feedstock should be renewable rather than depleting whenever technically and economically practical
- Unnecessary derivatization should be avoided whenever possible
- Catalytic reagents are superior to stoichiometric reagents
- Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products
- Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances
- Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires.

Several of our sites have received outside sustainability awards either based on strong EHS or Community focussed programs and achievements. Recently launched products and technologies providing advanced environmental profiles, have also been recognized. In this context it is worthwhile mentioning that Rohm and Haas received the US Presidential Green Chemistry Challenge award in respectively 1996 and 1998 for an environmentally advanced biocide and for a new family of insecticides, as well as the Italian INCA green chemistry award in 2004 for acrylic emulsions, and in 2006 the French Government's Pierre Potier award for "Innovation in Chemistry to the benefit of the environment" for the breakthrough acrylic binder Avanse technology, allowing the formulation of high quality, low VOC, low odour paints and coatings.

Our preparation efforts related to REACH have shown that we are using less than 50 concern substances in products made or sold in Europe and that the volume of concern substances has constantly reduced over the past 3 years.

Our Responsible Neighbour Community programs advance the economic, social and environmental quality of life in the communities where we operate through donations, community dialog, volunteerism, and emergency response networks, in general promoting science education, and increased awareness for environment and safety concerns.

Rohm and Haas has defined principles for its human rights expectations and that of its suppliers [2] and has been admitted during 2006 to the Domini 400 social SM index and the Ethibel Sustainable Index.

THE 5 PVC SUSTAINABILITY CHALLENGES

Parallel to the programs, activities and use of tools described above, Rohm and Haas started to participate in a sustainability program with one of its key plastics additives customers: Hydro Polymers. Hydro started their sustainability journey in the 90's when they, and the whole PVC industry, experienced strong pressure for phase out of PVC. In 2000 a sustainability evaluation of PVC was carried out by The Natural Step (TNS) [5], and representatives of the PVC industry, retailers and environmental organisations in the UK gathered around the same table. With the use of the TNS framework, five key sustainability challenges were identified for the PVC industry, to make PVC sustainable (table 3). In line with PVC Challenge N° 5, Hydro Polymers organised a number of workshops with key strategic raw material suppliers, focussing on the sustainability challenges of PVC and of the Chemical Industry at large. As a result, Rohm and Haas was interested to learn more about the TNS framework and particularly how the TNS systems approach could allow for a fuller, more fundamental and aligned approach to sustainability.

Table 3 – The 5 PVC Sustainability Challenges

- Challenge 1 : The industry should commit itself long-term to becoming carbon-neutral
- Challenge 2 : The industry should commit itself long-term to a controlled-loop system of PVC waste management
- Challenge 3 : The industry should commit itself long-term to ensuring that releases of persistent organic compounds from the whole life cycle do not result in systematic increases in concentration in nature
- Challenge 4 : The industry should review the use of all additives consistent with attaining full sustainability, and especially commit to phasing out long term substances that can accumulate in nature or where there is reasonable doubt regarding toxic effects
- Challenge 5 : The industry should commit to the raising of awareness about sustainable development across the industry, and the inclusion of all participants in its achievement

THE TNS FRAMEWORK

The Natural Step, founded in 1989 by Dr. Karl-Henrik Robèrt, is a non profit research, education and advisory organisation specialised in developing systematic science based approaches for organisations to become more successful through integration of sustainable development within their business model and strategy (www.thenaturalstep.org).

In articles published by K.H. Robèrt in the Journal of Cleaner Production [6, 7], the writer argues that because of the existence of a growing number of different approaches, methods and tools now commonly used in the field of sustainable development, there might be a risk that these tools are perceived as being in competition with each other or contradictory, resulting sometimes in conflicting suggestions for policy and management. To solve this problem, TNS proposes a hierarchical 5 level model providing a structured approach for planning and decision-making for strategic sustainable development implementation in any complex system [8].

- the Systems level, including people, organisations, communities in society, all linked to each other and to the biosphere
- the Success level, defined through basic Sustainability principles: the so-called "4 system conditions" (table 4)
- the Strategy level, of which the TNS framework is a key element
- the Action level, such as energy or water savings
- the Tools level, including for instance: EMS, Ecological footprint, and the SLCA tool described hereunder

Table 4 – The 4 TNS System Conditions
In a sustainable society, nature is not subject to systematically increasing :
- concentrations of substances extracted from the earth's crust **(SC1)**
- concentrations of substances produced by society **(SC2)**
- degradation by physical means **(SC3)**
and in that society people are not subject to:
- conditions that systematically undermine their capacity to meet their needs **(SC4)**

In 2006, TNS developed the SLCA, Sustainability Life Cycle Assessment tool [9, 10]. This can be described as a methodology that provides a strategic overview of the full scope of social and ecological sustainability at the product level. The tool enables a quick, rigorous and effective qualitative assessment of sustainability aspects of any product by applying the four TNS system conditions over the full lifecycle of the product. This decision making tool could be used to identify very early in the product development process of a product what the potential sustainability issues are, so that they can be effectively overcome throughout the innovation process. The key aim is to enable designers and decision makers to focus upon the sustainable development potential of the product, providing a guide as to where resources, innovation and effort should be targeted.

The SLCA process is a participatory process with the involvement of relevant key functions, exploring for each life cycle stage the adherence to the 4 system conditions. The end result is a matrix presenting the results of the analysis in the form of colours, that allow to immediately seeing where the major impacts of today's product are. Underpinning each square in the matrix are a number of questions assessing the key impacts as they relate to each life cycle stage and system condition. A possible output of an SLCA is presented in Table 5.

Table 5 – Example of possible SLCA outcome

Life Cycle Stages	**System Conditions (SC)**			
	SC1	**SC2**	**SC3**	**SC4**
1. Raw materials				
2. Production				
3. Packaging & distribution				
5. Use of articles				
6. End of life				

Very bad	Bad	Quite bad	Quite good	Good	Very good

PVC HEAT STABILISERS

PVC heat stabilisers are an integral part of the processing of PVC, because they prevent PVC degradation and discoloration through substitution of the labile chlorine and the neutralisation of acids. No PVC end-products can currently exist without the use of heat stabilisers. Four main technologies are available today: lead based, mixed metals (Ca-Zn), organo-tins and organic base. Use of a particular technology mainly depends on region and application. Rohm and Haas is providing tin stabilisers to the PVC industry for many years, and more recently, a new organic based and heavy metal free technology has been developed, mainly targeted to replace lead based stabiliser systems. Although certain PVC heat stabilisers have been assessed against the four TNS system conditions before [11, 12], a full SLCA assessment has to our knowledge not been conducted before with the support of TNS to guarantee rigor and objectivity all along the exercise.

In this paper we are presenting the results of the SLCA assessment on both our organotin and our organic based heavy metal free heat stabilisers. Preliminary results were also presented recently at the ECMSA conference on Collaboration in Innovation [13] and at the PVC Andean Forum [14].

The PVC heat stabilizers technologies that have been screened using the SLCA tools are the following:

<u>Organotin stabiliser</u>: Advastab™ methyl tin stabilisers, based on mono and di-methyl tin thioglycolate esters, or mono and di-methyl tin mercaptoethanol reverse esters.

<u>Organic based, heavy metal free heat stabiliser</u>: Advapack™ NEO, based on latent mercaptide technology and calcium species.

SLCA ON PVC HEAT STABILISERS

Vision of The Sustainable PVC heat stabiliser

As a basis for any TNS framework assessment, the first step in the SLCA has been the definition of what a sustainable PVC heat stabiliser would look like, allowing "back casting" from this vision and the definition of strategic improvement goals:

A sustainable heat stabiliser for rigid PVC applications is a system that would be [15]:
- free of mined materials that are scarce in nature
- free of persistent substances
- based on natural resources from well managed ecosystems
- based on low energy consumption and low emissions processes
- without health effects on people exposed to the stabiliser all along its life cycle
- bringing benefits with respect to human needs, by improving product life-time, utilisation properties of finished articles, and ease of recycling
- using renewable energy for raw material extraction, production, supply and end-use

Description of the process followed

With respect to the life cycle stages to be assessed in the SLCA, we selected: Raw materials, Stabiliser synthesis, Packaging & Distribution, PVC processing, Use of rigid PVC articles, End of life for heat stabilisers in rigid PVC.

For each square (= Life-Cycle-stage/SC combination), the 7 most pertinent questions were developed, to be able to assess compliance with, or violation of, the system condition for the product in question. The number of 7 questions was determined to give sufficient precision and rigor, without being overly burdensome. For each heat stabiliser a total of 168 sustainability questions linked to sustainability were thus raised and answered. The results of the SLCA assessments are presented in the tables below.

Table 6 - Tin Stabilisers

Life Cycle Stages	System Conditions (SC)			
	SC1	SC2	SC3	SC4
1. Raw materials				
2. Stabiliser synthesis				
3. Packaging & distribution				
4. PVC processing (Stabilisers in rigid PVC)				
5. Use of rigid PVC articles				
6. End of life for stabilisers in rigid PVC articles				

Table 7 – Organic based heavy metal free stabilisers

Life Cycle Stages	System Conditions (SC)			
	SC1	SC2	SC3	SC4
1. Raw materials	Quite bad	Bad	Very bad	Quite good
2. Stabiliser synthesis	Good	Good	Good	Quite good
3. Packaging & distribution	Quite good	Quite good	Quite good	Quite good
4. PVC processing (Stabilisers in rigid PVC)	Quite good	Quite bad	Good	Very good
5. Use of rigid PVC articles	Very good	Very good	Very good	Very good
6. End of life for stabilisers in rigid PVC articles	Quite good	Quite bad	Quite good	Good

Very bad	Bad	Quite bad	Quite good	Good	Very good
(black)	(dark grey)	(hatched \\\\)	(hatched //)	(light grey)	(white)

Conclusions

Through this SLCA assessment on both tin and organic based heavy metal free stabilisers technologies, we have drawn the following conclusions:

1/ From a technological standpoint, the organic based heavy metal free PVC heat stabilisers are providing significant progress towards sustainability mainly related to:

- reduced usage of heavy metals and more generally mined materials that are scarce in nature
- increased usage of vegetal based raw materials
- simplified manufacturing process leading to reduction of energy consumption and associated emissions
- enabling easier recycling related to their compatibility with all other types of PVC heat stabiliser technologies

2/ The organic based heavy metal free stabilisers constitute a "flexible platform", i.e. additional progress towards sustainability can rather rapidly be made through:

- selection of vegetal based raw materials from well eco-managed sources
- local production reducing transportation related environmental impacts

3/ The technology standpoint is only part of the sustainability assessment. The "whole picture" must be considered when talking about a "more sustainable alternative", including aspects that are not specific to the product such as:

- sustainability criteria for purchasing guidelines and supplier selection
- use of renewable energies all along life cycle stages
- packaging, transportation and logistics options
- systematic R&D orientation towards sustainability

4/ Significant shifts towards sustainability require to implement a holistic "extended enterprise" approach to consider the sustainability performances not only in our organisation, but in the whole value chain of the products we provide to the Vinyl Industry. The way we market and manage our products in Society, the way we support sustainability efforts of our customers, and the way we integrate the impact of our products on end-users and communities.

SUMMARY

Using the TNS framework allows Rohm and Haas to have a clearer, more consistent corporate definition of what sustainability means for Rohm and Haas, and how all our existing sustainability projects, initiatives and tools can be aligned under the same hierarchical systematic model for Strategic Sustainable Development. A definition that Technology, Marketing and Strategic Planners can work from and align with, allowing the definition of clear objectives, criteria and metrics more easily, against which to measure progress of processes, products and the research portfolio. For the latter Researchers might need a better toolkit and competencies for developing sustainable products. The SLCA tool described in this article could possibly address this need and might become an important element of our Sustainability Journey, allowing for a more strategic approach towards sustainability for Vinyl additives, in line with PVC challenge n° 4.

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