F. Meier*, N. Stelter*, D.M. Lee**, N.J. Zeese**, J. Tolls*

Raw Material Supplier and Detergent Manufacturer Cooperate in Environmental Safety Assessment of a New Detergent Raw Material – A Case Study

Abstract

As part of their intended use as ingredients of detergent product, substances are discharged into surface waters. Environmental safety assessments are undertaken to ensure that such emissions do not cause undue impacts. The present case study illustrates how the supplier of a new detergent raw material and the detergent manufacture cooperate in compiling the base set of ecotoxicological and biodegradation information, in developing scenarios on detergent use and assessing the risk associated with the raw material use in the respective scenarios. For all scenarios addressed, the use of the new ingredient was shown to be safe.

Introduction

Detergent manufacturers have to be particularly aware of the environmental impact resulting from the use of their products. This is because these product are discharged into the environment as part of the intended use. This situation has been recognized by legislators in the EU and in 2004, the EU put the so-called detergent regulation into force (1). On top of fulfilling the corresponding legal requirements, Henkel as a detergent manufacturer conducts a biological approval of raw materials as a mandatory internal procedure. In this process, all new raw materials are screened for those properties which are relevant for human and environmental safety concerns prior to admitting them for use in detergent products. This paper presents a case study which demonstrates the added value of a close cooperation between Henkel and MonoSol, the supplier of a new raw material, in evaluating a new raw material for its environmental property profile.

Data Collection

The cooperation was triggered by the decision to qualify a new raw material (NRM), a material based on poly-vinyl-alcohol from MonoSol, as a constituent of a Henkel liquid laundry detergent formulation, in particular unit dose products. In the initial phase of the cooperation, the data requirements were agreed upon. The Henkel biological approval of raw material process requires that a set of aquatic toxicity data and biodegradation data be made available for the environmental safety evaluation.

Toxicity data

With this in mind, MonoSol and Henkel discussed what ecotoxicity data would be required and meaningful for this application. It was agreed that the toxicity of NRM against algae and *Daphnia magna* needed to be determined experimentally, using the OECD test protocols 201 (2) and 202 (3), respectively. Sacrificing vertebrates in fish testing was weighed against the benefit of gaining additional knowledge. It was determined that fish testing would be redundant since in many cases toxicity data for algae and *Daphnia* are also protective for fish.

Biodegradation data

In a similar approach, the generation of biodegradation data was initiated. Knowing that the majority of polymers do not degrade rapidly in the environment, the pros and cons of testing for ready biodegradability and inherent biodegradability were discussed. Finally, it was decided to perform two tests for inherent biodegradability. In one test, the standard OECD 302 test protocol (4, 5) was applied. In a second test the experiment duration was extended to 63 days and the test design was modified to measure CO_2-evolution as an indication of the conversion of the raw material constituents into their mineral building blocks **(Fig.)**.

NRM use in Henkel detergent

Third, four scenarios were conceived to simulate the potential amount of NRM used in detergent using Henkel sales data of liquid unit-dose products for Germany. The four scenarios differ in the assumed market share and the corresponding number of washloads in Germany per year. Scenarios 1, 2, 3, and 4 assume a market share of 1%, 2%, 3%, and 4%, respectively. The corresponding numbers of washloads are 30 million, 60 million, 90 million, and 120 million. In addition, it is assumed that 1g of NRM copolymer is used with each washload. Based on these figures, the amount of raw material used in Germany was calculated and divided by 82 million inhabitants to obtain the per capita consumption in Germany. According to the four scenarios, the per capita consumption amounts to 1, 2, 3, and 4 mg per capita per day.

Data Assessment

Toxicity data

Table 1 displays the acute toxicity data for algae and *Daphnia magna*. Toxicity is expressed as the concentration at which algal growth is reduced by 50% (EC_{50}) and as the concentration at which 50% of the *Daphnia* are immobilized (IC_{50}). The respective values are 1.4 mg/L and 3.2 mg/L.

Biodegradation

The **Fig.** shows the time scale of DOC-removal (for both biodegradation test methods) and CO_2-release in the biodegradation tests with NRM. The DOC removal in the standard test is 85% after 29 days. In addition, the modified test shows that 78% of the carbon contained in the polymer is released as CO_2 over a time period of 63 days. In combination, this indicates that a significant fraction of NRM is removed from the sewage in the treatment plant and undergoes biodegradation and conversion into mineral constituents.

Persistence in the environment

Various regulations have established persistence criteria. REACh (Registration, Evaluation, Authorisation and Restriction of Chemicals) is one example of such a regulation (6) and classifies persistent substances as those that display a half-life of 60 days or more in aquatic environments. As evident from **Table 1**, more than 60% of the raw material is degraded within 60 days. Hence it can be concluded that NRM is not persistent and does not accumulate in aquatic environments. In addition, the biodegradation results qualify the raw material as 'inherently biodegradable'. Following the EU technical guidance document for the risk assessment of chemicals, it is therefore assumed that biodegradation in the sewage treatment plant removes 41% of NRM (7).

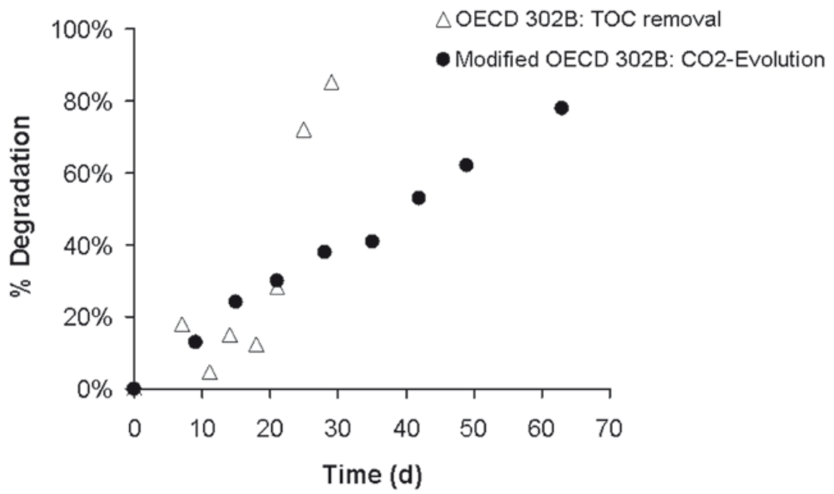

Fig. Time course of TOC removal in a standard OECD 302 (open triangles) and of CO_2-evolution in a modfied OECD 302 biodegradation assay for inherent biodegradability

Environmental risk assessment

The per capita consumption of NRM according to the four scenarios is outlined in **Table 1**. For the purpose of the environmental risk assessment, the commonly used unit town set of assumptions for the assessment of wide dispersive uses of substances (7) is employed. This scenario assumes that a town of 10,000 inhabitants discharges 2,000 m^3 of sewage (containing the raw material) to a sewage treatment plant, which in turn discharges the treated sewage into a river with a flow rate of 20,000 m^3/day. Taking biodegradation in the sewage treatment plant into account (see above), the predicted environmental concentrations of NRM in the hypothetical river

Parameter	Value	Method followed
Toxicity to algae (*Selenastrum capricornutum*)	E_rC_{50}: 1.4 mg/L	OECD Test Guideline 201 (OECD, 2011)
Toxicity to crustaceans (*Daphnia magna*)	IC_{50}: 3.2 mg/L	OECD 202 (OECD, 2004)
Predicted no effect concentration	PNEC: 0.0032 mg/L	EU TGD (EU, 2003)
Biodegradability	85% DOC removal in 29 days	OECD 302 B - (OECD, 1992)
Biodegradability	78% CO_2 evolution in 63 days	Modified OECD 302 B - (OECD, 1992)
Per capita consumption	Scenario 1: 1 mg/capita/day Scenario 2: 2 mg/capita/day Scenario 3: 3 mg/capita/day Scenario 4: 4 mg/capita/day	Henkel sales volume is divided by Henkel market share for liquid detergents to obtain per capita consumption.

Table 1 Parameters collected for the ecological evaluation of pH NRM

Scenario	Predicted environmental. concentration (PEC in mg/L)	Risk characterization ratio (RCR)
1	0.3×10^{-3}	0.21
2	0.6×10^{-3}	0.41
3	0.9×10^{-3}	0.62
4	1.2×10^{-3}	0.82

Table 2 Results of the environmental exposure and risk assessment for the four scenarios

for the four scenarios are detailed in **Table 2**. The values range between 0.3 and 1.2 µg/L.

In the risk assessment, this value is compared with the so-called 'Predicted No Effect Concentration' (PNEC). It is obtained by dividing the lower of the two toxicity data values from **Table 1** (i.e. 1.4 mg/L for the E_rC_{50} for the algae) by three safety factors. Each safety factor has the value of 10. They are used to extrapolate from acute to chronic effects, to account for the variation between species, and to account for variation within species. The resulting PNEC value is 1.4 µg/L.

Table 2 also displays the values of the risk characterization ratio. This ratio represents the quotient of the PEC divided by PNEC. For all scenarios, this value is below 1, indicating that PEC does not exceed the estimated threshold value (PNEC). This indicates that adverse effects of NRM on aquatic organisms are not expected for any of the four scenarios.

■ Conclusions

This case study is an example of a scientific cooperation for an extended environmental safety assessment between a raw material supplier and a detergent manufacturer. The mutual identification and prioritisation of the scientific data which is needed to fulfill Henkel's data requirements were the starting point for the studies issued. Both companies cosponsored the program and monitored the studies on the environmental impact jointly and shared the resulting data openly, thereby increasing the efficiency for both partners.

Finally, both companies benefited from the outcome of the biological investigations. MonoSol received more scientific evidence that the raw material has a favorable environmental profile. Henkel can use the information to demonstrate the thorough evaluation of the environmental impact of its detergent formulations. In fact, the data allows Henkel to market this particular type of liquid detergent with the claim of a minimized environmental impact.

References

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Authors' addresses:
* Frank Meier
Norbert Stelter
Johannes Tolls
Henkel AG & Co. KGaA
Henkelstrasse 67
40589 Düsseldorf
Germany
Email: johannes.tolls@henkel.com

** David M. Lee
Nicholas J. Zeese
MonoSol LLC – A Kuraray Company
1701 County Line Rd
Portage, IN 46368
USA

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