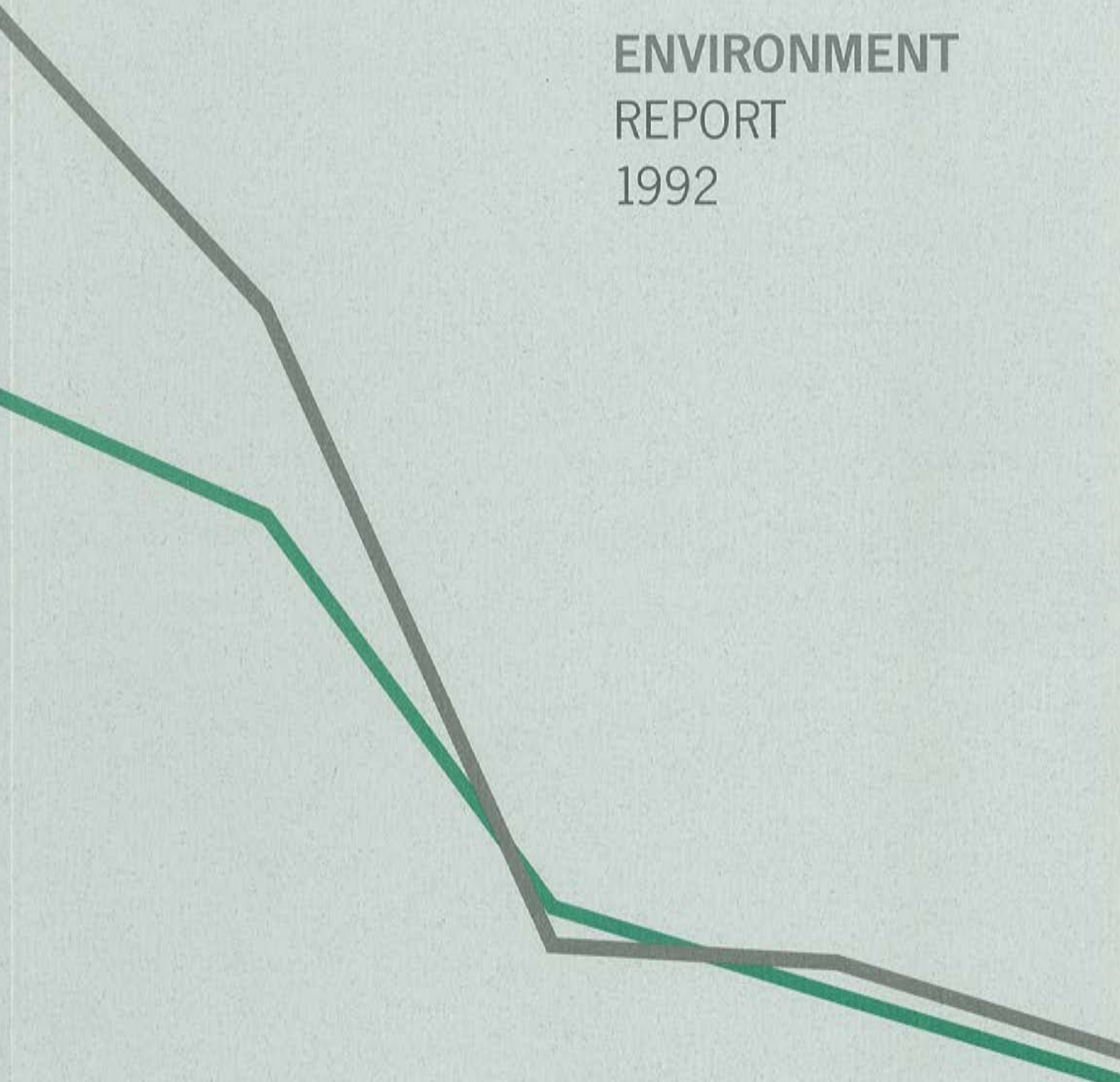
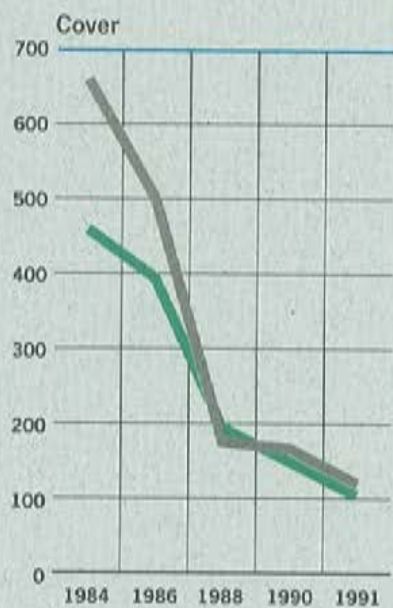


# ENVIRONMENT REPORT 1992





This graph shows by way of example two environmental protection trends at Henkel KGaA's largest production site in Düsseldorf-Holthausen. The gray curve represents the decline in organic substance emissions (measured as carbon); the green one, the reduction in dust emissions at the Henkel parent plant (in metric tons).

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## Preface

During the past ten years, from 1982 to 1991, sales of the Henkel Group have increased from DM 8.2 billion to DM 12.9 billion; net earnings have risen from DM 83 million to DM 443 million.

During this same period there has been a dramatic reduction in the impact of Henkel's products and production processes on the environment.

We are convinced that growth, generating profits and environmental compatibility are not irreconcilable. Henkel is committed to the principles of the Business Charter for Sustainable Development as formulated by the Commission on Environment of the International Chamber of Commerce.

This first Environment Report published by the Henkel Group reviews the progress made and shows the problems yet to be solved.

To make environmental protection efforts successful and affordable in the long term, it is essential to assign priorities and to verify the effectiveness of all individual measures.

A second Environment Report will be published in about two to three years from now.



Helmut Sihler  
President and  
Chief Executive Officer



Hans-Dietrich Winkhaus  
Deputy President

## The Henkel Group – a global commitment

As a Specialist in Applied Chemistry, Henkel is widely diversified both nationally and internationally in its products and product ranges. The Henkel Group includes 196 companies and more than 140 production sites in 53 countries. Group sales in 1991 reached DM 12.9 billion. For some years now, over one half of sales has been generated outside the Federal Republic of Germany, mainly in Europe, and increasingly in the United States and the Pacific region. More than 3,000 of the Company's 41,000 employees are engaged in research and development.

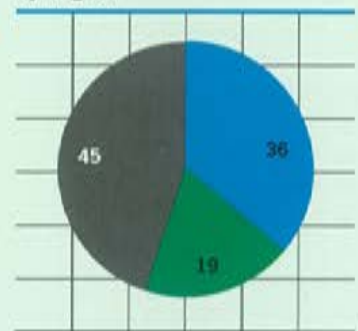
On September 26, 1876, Fritz Henkel, a 28-year-old businessman, formed his own company, initially in Aachen. Fritz Henkel's first product, in 1876, was a "universal detergent." Only two years later he moved to Düsseldorf, where communications were better, and was soon extremely successful with his detergents and cleaning agents. Now more than a century later, household products still play a major though no longer dominant role in the Group's activities.

Products for a wide variety of industries, for commercial and institutional clients and for processors have taken the front seat and today account for the major part of Group sales.

Henkel is one of Europe's major producers of detergents and cleaning agents, cosmetics and toiletries. As the leading manufacturer, Henkel offers the world's broadest and most diversified range of adhesives. In the institutional hygiene and industrial cleaning sector, the Henkel-Ecolab joint venture holds a prime position on the world market. Henkel is the world's major producer of oleochemicals based on vegetable and animal oils and fats. The Group assigns special priority to researching the chemistry and technology of oils and fats, a field in which it has attained a preeminent position in recent years.

The Group is headquartered in Düsseldorf, where a strong central R&D capability has developed during the 115-year history. Globally active, the Research and Process Development/Technology divisions carry out fundamental research to further scientific know-how, generate new momentum, and create the groundwork for innovations. These activities are reflected in the Group's modern, efficient and ecological production facilities and products.

Henkel Group Sales  
by region

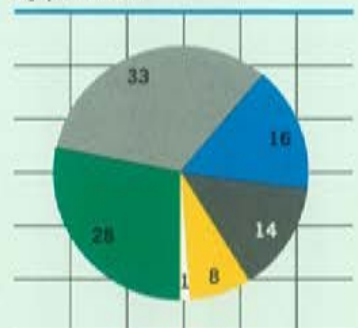


as percentage

- Europe (excl. Germany)
- Germany
- Overseas

Source: Henkel KGaA.

Henkel Group Sales  
by products

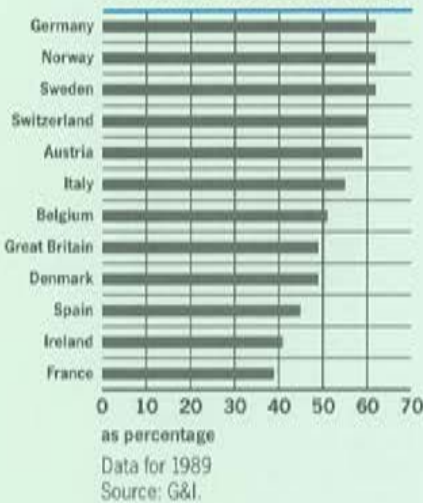


as percentage

- Chemical Products
- Detergents/Household Cleansers
- Industrial Adhesives/Technical Consumer Products
- Institutional Hygiene/Metal Chemicals
- Cosmetics/Toiletries
- Miscellaneous

Source: Henkel KGaA.

Environmentally oriented households in Western Europe



## Henkel's principles of environmental protection

In 1991, the until then most important international environmental conference of industry took place in Rotterdam – the Second World Industry Conference on Environmental Management (WICEM II).

The central purpose of WICEM II was to formulate and adopt principles of environmental management. The outcome was a Business Charter for Sustainable Development, designed to provide comprehensive guidelines for a wide variety of industries throughout the world.

Henkel is committed to the principle of sustainable development, of environmentally compatible corporate, product and research policies.

This stance is also articulated by the Principles of Environmental and Consumer Protection in the Henkel Group, principles adopted by Company management back in 1981 as mandatory yardsticks for the Group's activities worldwide. Regularly updated, they define the major objectives of the Henkel Group as:

- to satisfy the wishes of consumers;
- to aim for and achieve compatibility between production processes, products and systems, on the one hand, and the environment, on the other;
- to ensure safety for customers and users, employees, and the general public.

Henkel acknowledges the following principles:

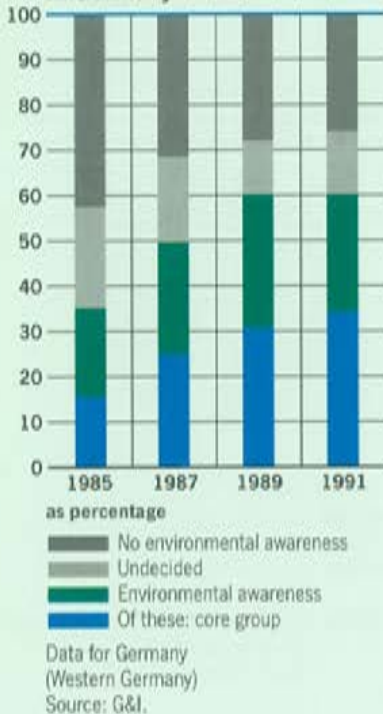
### Responsibility to society

As a leading company and specialist in applied chemistry, Henkel fully accepts its responsibility to society. With its products and systems, Henkel contributes toward improving the quality of life.

### Safety

Safety for users and consumers is assured by state-of-the-art technology. Where there is a conflict of interests, safety enjoys priority over product performance. Henkel only manufactures such products and systems and uses such production processes which ensure that employees and members of the public are not exposed to health hazards. Henkel develops, manufactures, and markets only such products and systems which, if used for the purpose intended, will not harm the health of anyone. In planning new installations and in the development of new products, environmental protection and safety factors must be considered right from the beginning.

Environmental awareness in Germany

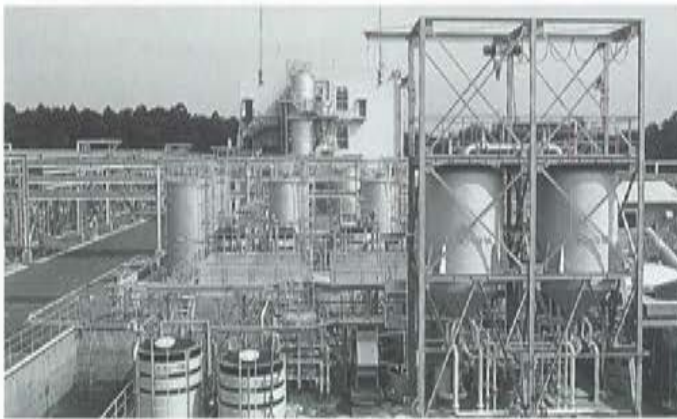


### Quality

Henkel develops, manufactures, and markets quality products and systems which satisfy customer needs and solve customer problems to an optimum degree.

### Ecological responsibility

Henkel develops, manufactures, and markets products and systems which according to acknowledged scientific criteria are compatible with the environment. The environmental compatibility of production processes and products is continuously undergoing improvement.



Safe and environmentally compatible production worldwide: Henkel Hokusui's production site in Osaka, Japan.

### Willingness to cooperate

Henkel practices interdisciplinary cooperation in the fields of research, product development, toxicology, microbiology, ecology, production, and marketing in order to make available to each individual product the entire potential of expert knowledge. Henkel contributes this expert knowledge to outside scientific, technical, and political bodies. Executives and employees cooperate closely with in-house units created for the organization and implementation of measures for company-wide environmental protection and occupational safety.

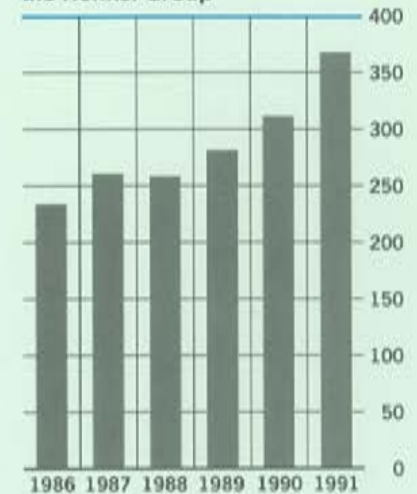
### Willingness to communicate

Henkel is committed to openness in public information and communication. Henkel is willing to inform consumers and the public about the quality, safety and environmental compatibility of its production processes and its products.

### Responsibility of employees

It is the duty of every employee on the job to contribute to the fulfillment of these objectives. Every single one is required to conscientiously comply

Worldwide expenditure on environmental and consumer protection within the Henkel Group



in million DM

Source: Henkel KGaA.

with the rules and regulations for the protection of the environment and for the safe operation of installations.

Managers are under special obligation to further environmentally safe production processes and the development of environmentally safe products and systems. In addition, they are responsible for the appropriate guidance, support and motivation of their employees.

On all management levels, executives are responsible for the protection of the environment and are given the necessary authority, sufficiently qualified personnel and the means to achieve environmental protection goals.

The Company, through appropriate measures, especially by proper training, actively supports the strengthening of environmental and safety awareness of employees and their qualifications.

### **Eco audit**

Environmental management at Henkel is based on the Group's



**Illertissen, Bavaria:  
Chemische Fabrik Grünau.**

own criteria, which go beyond statutory and voluntary obligations. The aim is to cement these criteria in uniform, Group-wide safety and environmental standards. For this purpose, the Management Board decided in November 1988 that an ecological audit should be carried out to provide a systematic and comprehensive overview of the actual environmental situation at all the Henkel Group's production sites, and with respect to all products. Audited were more than 140 production sites in 53 countries. The intent was to look beyond statutory obligations and to find out whether production processes exhibited weak points from the point of view of industrial safety and ecology, and whether environmental hazards

were linked with Group products, and if so, to take corrective action.

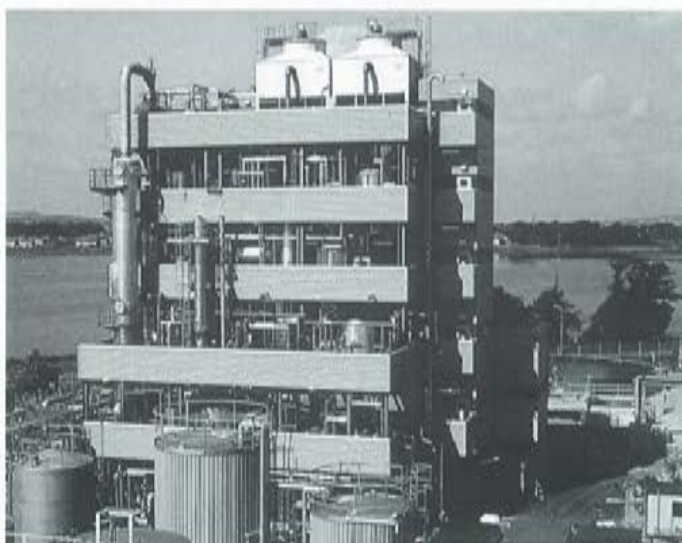
A standard procedure was applied to obtain specific information from all companies in the Henkel Group. Documented at Group headquarters in an "Eco Register," the findings were analyzed and appraised by a group of experts, in some instances after obtaining specific additional data.



### **Eco audit – products**

Altogether 116 substances were listed as a basis for the product audit. These were classified into the following groups:

- substances very dangerous for aquatic organisms;
- chlorofluorocarbons (CFCs);
- carcinogenic substances.



**Henkel Ireland  
in Cork:  
plant for  
manufacturing  
the detergent  
component TAED.**

The eco audit looked at all Henkel products in the light of these criteria. It found that, for Henkel's more than 10,000 products, almost no action was needed with regard to especially hazardous substances. Only in about ten cases did production sites report the use of hazardous ingredients, and in all these cases the substances concerned complied with local regulations. Meanwhile, these substances are no longer used in the manufacture of Henkel products. They were either replaced by harmless substitutes, or production was stopped. An example: in South Africa it was found that a substance used to impregnate wooden fence posts was manufactured from coal-tar oil (a carcinogenic substance). Henkel immediately withdrew this product from the market, without providing a substitute. The eco audit also revealed that throughout the world Henkel no longer uses CFCs as propellants.

Still, the Group does not intend to relax its efforts and does not regard the current state of affairs as final. A gradual study will be carried out into products based on less hazardous substances.

### **Eco audit – production**

The eco audit of production processes is based on the hazardous substances listed in the German regulations regarding environmental hazards

("Störfallverordnung"). The following substance groups were of relevance in the context of the Henkel study:

- substances very dangerous for aquatic organisms;
- highly toxic substances;
- flammable gases;
- liquids with very low flash points.

The list includes 130 substances and substance groups. The questions were formulated according to three main criteria:

- annual consumption;
- emission and waste disposal situation;
- average inventories.

A first important finding of this global audit is that the Henkel Group's production facilities maintain high safety standards. It also showed that at certain production sites, especially of acquired companies, some efforts are needed to raise safety levels. Initial steps have been taken in this direction.

Group-wide Henkel safety and environmental standards will also be drafted to cover the use of a range of other substances employed in production processes.

Everywhere the same basic principles of environmental and consumer protection: Henkel Corporation's Charlotte works in North Carolina, USA.



### Eco program

An eco program at the headquarters then followed up on the eco audit. This provides for a greater emphasis to be placed on pro-environment research and development activities. Chemists and engineers from Research and Process Development have cooperated with their colleagues in Application Technology and Production to draft project proposals. From this pool, projects at a cost of some DM 23 million started in 1991. The most important were:

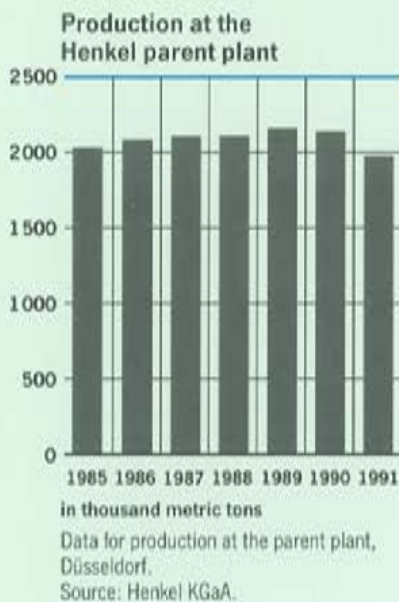
- the development of new compounds to replace substances very dangerous for aquatic organisms;
- the development of new, low-waste technologies that cause a minimum of atmospheric and wastewater pollution;

- 
- a search for possible methods of reducing energy consumption and conserving resources.

The experience gained will gradually be applied to our subsidiaries abroad.

### **Integrated know-how**

Headquartered in Düsseldorf, Cognis GmbH was founded in 1991 for the purpose of researching, developing and marketing biotechnologies and environmental technologies. Cognis integrates the Henkel Group's R&D and production experience in the fields of biotechnology and environmental technology. The company is also represented in California, a U.S. state that is regarded as a pacemaker in the environmental issues and is, along with Boston, the center of biotechnology. This makes it easier for the scientists at Cognis to access the state of the art and maintain ties with scientific institutions.



#### Fatty acids

Long-chain organic acids; one of the two main components of all vegetable and animal fats and oils. In the oleochemicals industry, starting materials for numerous other products.

#### Fatty acid methyl esters

Substances formed by reacting fatty acids and methanol; intermediate products of the oleochemicals industry; used for making other products, especially fatty alcohols.

#### Fatty alcohols

Long-chain alcohols produced at Henkel, based on fats and oils of animal and vegetable origin. Important intermediate products, especially in the manufacture of washing active substances (surfactants).

#### Glycerin

One of the two main components of all oils and fats; acts as a solvent and an intermediate product for numerous other substances.

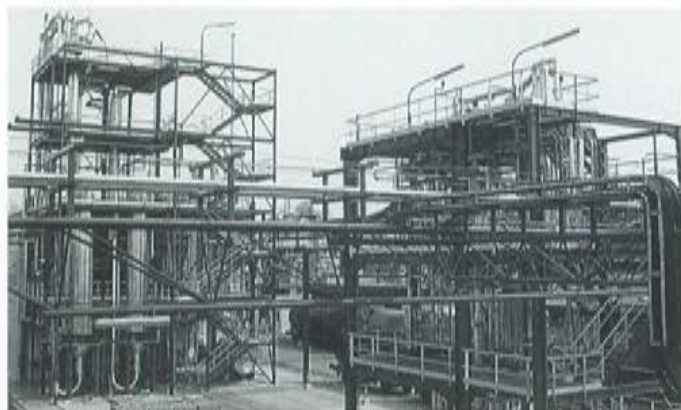
## Worldwide standards at a high level

Henkel has more than 140 production sites in over 53 countries. It is most strongly represented in Europe and North America. The largest site is the Henkel parent plant in Düsseldorf-Holthausen. The Company produces raw materials but also converts these and raw materials from external sources into intermediate products, specialty chemicals and brand-name products. The most important production sectors are:

- oleochemicals;
- organic specialty chemicals;
- detergents;
- adhesives.

These and their effects on the environment are described below.

**Oleochemicals production:**  
Sidobre-Sinnova's modern hydrogenation facility in Boussens, France.



### Production of oleochemicals

For producing oleochemicals Henkel operates large plant complexes throughout the world and most especially in Europe, the United States and South-East Asia. The world's largest oleochemical production complex is at the parent plant in Düsseldorf. The major raw materials processed are renewable oils and fats such as coconut oil, palm oil and palm kernel oil, soybean oil, rapeseed oil and beef tallow. Each year some 400,000 metric tons of fats and oils are processed in fully continuous plants in the "oil quarter" of the parent plant in Düsseldorf into basic products such as

- fatty acids\*
- fatty acid methyl esters\*
- fatty alcohols\*
- glycerin\*.

Processing the oils and fats starts by splitting them with water into fatty acids and glycerin or converting them with methanol into fatty acid methyl

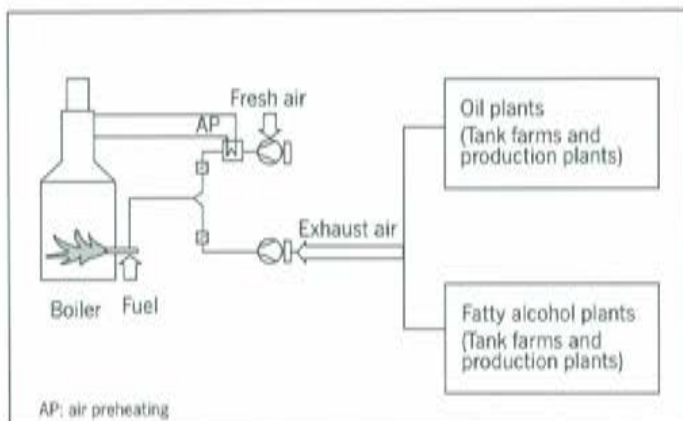
The terms marked with an \* are defined in the margin.

esters and glycerin. For this purpose, Henkel has developed its own low-pressure process, which works at low temperatures, therefore resulting in considerable energy savings.

A large share of the fatty acid methyl esters undergoes further processing in hydrogenation plants for conversion into fatty alcohols. Here they react with hydrogen on a so-called fixed-bed catalyst\*. Other processes refine the basic products into a large number of different fat derivatives for a wide range of applications. The hardening of unsaturated fatty acids\*, the distillation\* and fractionation\* of fatty acids, fatty acid methyl esters and fatty alcohols, and the refining of glycerin to pharmaceutical quality all play a central role here. Another important processing step is ethoxylation, which involves the reaction of fatty alcohols with ethylene oxide. Basic products refined in such a way are used in cosmetic and pharmaceutical preparations, in auxiliaries for textile, leather and food processing, and in softeners, adhesives and detergents.

### Waste gases

The fats and oils used as raw materials in oleochemical plants have an intense and characteristic odor. For this reason, the oleochemical plants and storage tanks at the parent plant in Düsseldorf are connected to a central waste gas system through which contaminated air is collected and burnt in the plant's own power station. A total of 30,000 cubic meters of waste gases is drawn off the oil and fatty alcohol plants each hour and passed through a widely branched pipeline system. In this way, both the local population and Henkel's employees are largely protected from the odors caused by the production processes.



**Burning off exhaust gases at the Henkel power station in Düsseldorf-Holthausen.**

The Japanese plant in Kitatone uses a somewhat different waste gas system. Here, all the production plants are linked to a central ventilation system where ill-smelling substances are absorbed by filters.

### Catalyst

Substance that accelerates a chemical reaction, without itself being consumed.

### Fatty acid hardening

Chemical reaction of the double bonds of fatty acids with hydrogen. The previously liquid to pasty fatty acids become solid.

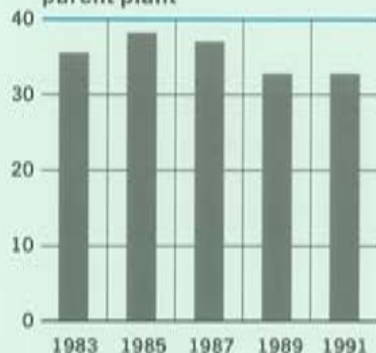
### Distillation

Process for splitting liquid mixtures by vaporization and subsequent condensation of the vapors.

### Fractionation

Separation of several components by distillation into individual components (fractions).

**Daily COD load in the wastewater at the Henkel parent plant**



in metric tons

Yearly average of the daily COD load\*

Source: Henkel KGaA.

#### COD

Chemical oxygen demand. Measure of the sum of all organic substances in water, including those that are not readily degradable. It serves to quantify the organic contaminants in wastewater. COD indicates how much oxygen is needed to oxidize these organic substances completely.

#### COD load

Amount of organic contaminants in wastewater, expressed as the percentage by weight of oxygen that would be necessary to oxidize the contaminants completely.

#### Additives

Substances that are added for the purpose of imparting specific properties to a product.

#### Drilling fluids

Liquids used to lubricate and cool the rods of oil drills and to remove the drillings.

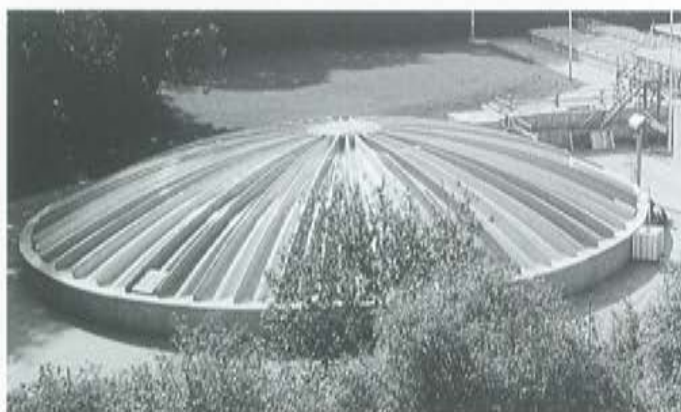
#### Surfactants

Surface-active substances which, as a result of their special molecular structure, are able to improve the wettability and solubility of substances otherwise insoluble in water.

#### Wastewater

In the oleochemical production complex, as in other production facilities at the Düsseldorf parent plant, wastewater is monitored closely at source. This is done by specialized laboratory analyses. Permanently installed sensors also give warning when a predefined threshold is exceeded.

In recent years, the pollution of wastewater by organic contaminants has been reduced considerably by various measures. High priority is also given to the treatment of wastewater at Henkel production sites outside of Germany. At the Kitatone plant in Japan, for instance, wastewater is not only treated in a biological stage after passing a preliminary separation, but is even purified by an activated carbon filter. After this, the treated wastewater is almost potable.



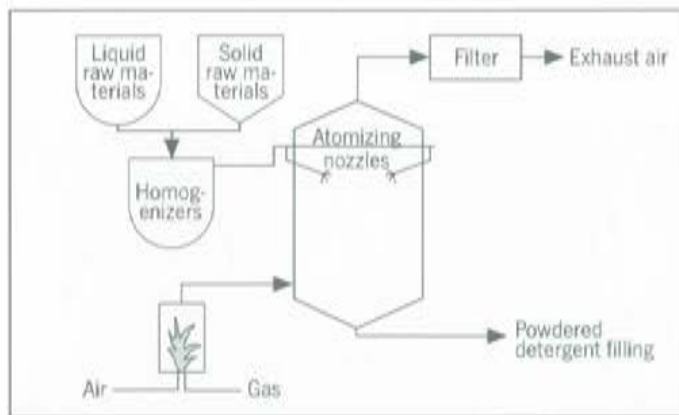
**Precleaning: all wastewater from Henkel's parent plant in Düsseldorf is given preliminary purification treatment.**

#### Production of organic specialty chemicals

Henkel produces organic specialty chemicals at 49 sites in 34 countries. These products are used mainly in the textile, paper and leather industries, and as additives\* for drilling fluids\*, plastics, paint and coatings. The most important production processes are sulfation and esterification. In sulfation plants, fatty alcohols are reacted with sulfur trioxide to produce surfactants.\* Here, sulfur is burnt to form sulfur dioxide, which is then oxidized to sulfur trioxide. However, the reaction is incomplete. The sulfur dioxide contained in the waste gas must be removed in a scrubber. The sodium sulfate solution formed is used again in the production process.

A subsidiary, Neynaber Chemie, at Loxstedt near Bremerhaven, specializes in esterification and finishing. Here, the resulting wastewater passes through equalizing basins and is neutralized before discharged into the local sewage treatment plant. Wastewater containing glycerin is treated in Düsseldorf. Other aqueous and filter residues with sufficient heating values are incinerated in the company's own power station. Henkel Process Development is currently

constructing a biological waste-gas scrubber at Kepec in Siegburg, which will treat the waste gases and exhaust air from all production facilities. This is regarded as a pilot plant for the whole Henkel Group.



Drying in hot spray drying towers for making powdered detergents.

### Detergent production

Henkel manufactures detergents and cleaning agents at 22 production sites in 11 countries in Europe. The emphasis is on the manufacture of powdered detergents. Some 400,000 metric tons are produced annually in the parent plant in Düsseldorf alone. Hot spray drying is the characteristic process here. This involves mixing accurately measured amounts of all temperature-resistant liquid and solid raw materials to form a paste, which is then passed through homogenizers\* and high-pressure pumps and sprayed through nozzles at the top of a spray drier. The high pressure causes the paste to convert into fine particles, which are dried by hot air. Energy consumption, the rinsing water from production plants, and the air used for drying are all factors of environmental relevance.

### Energy

The spray drying process for detergents is characterized by high energy consumption. However, in recent years the specific energy requirement has been reduced by 30 percent by energy recovery and targeted reduction of the exhaust air temperature. The energy consumed during the production of zeolite\*, a phosphate substitute, has been halved during the last 10 years.

### Wastewater

Scarcely any contaminated water is discharged into the sewage network as a consequence of detergent production processes in Düsseldorf. In the production plants themselves, great emphasis is placed on ensuring that product streams are kept separate and that high levels of cleanliness are maintained in order to keep the number of washing operations to a minimum.

#### Homogenizer

Device that thoroughly mixes different substances to form an even and uniform mixture.

#### Zeolites

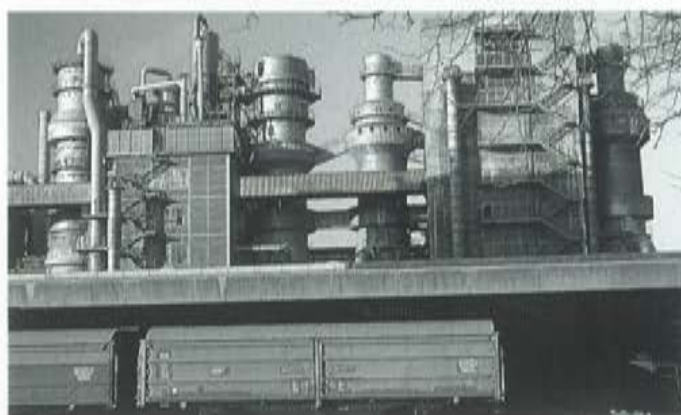
Sodium aluminum silicates whose three-dimensional structures contain cavities that enable them to combine with the ions that cause water hardness.

**Aerosols**

Very finely distributed suspension of solid or liquid particles in air or other gases, for example smoke or fog.

**Waste gases**

Filters reduce the amount of dust in the waste gases to a level well below the permissible maximum of 20 milligrams per cubic meter of waste gas. Lowering the amount of organic aerosols\* is still a problem, but some progress has been made by making adjustments to production processes.



**Spray drying towers in the Düsseldorf detergent plant; filters reduce the amount of dust in the exhaust gas.**

The detergent factories in Italy, France, Belgium, Austria, Spain and Switzerland are designed for the same processes and environmental requirements. They also set the standards for the production plants of joint ventures in eastern and southern Europe and apply to the Genthin detergent plant in Saxony-Anhalt acquired in 1990.

**Water glass production**

Henkel has been producing water glass since 1884. Today, on its site in Düsseldorf, Henkel operates the world's largest integrated plant for making this important chemical raw material. Water glass is still indispensable, even in modern detergent formulations. It is also used to produce precipitated silicas, which are of special importance as fillers in the rubber industry, and are used primarily in the manufacture of Sasil\*.

Henkel has four melting furnaces available for the production of water glass. High temperatures of about 1,500 degrees Celsius are needed for the sand and soda melt. In order to achieve the best possible energy exchange the furnaces function on the regenerative principle\*.

**Emissions**

Extensive technological measures have been taken since 1982 for the purpose of reducing the emission of waste gases from the furnaces. Two dust collectors, each comprising an electrofilter and an exhaust gas cooler, were built between 1985 and 1987 to reduce dust emissions. The dust extracted by the

**Sasil**

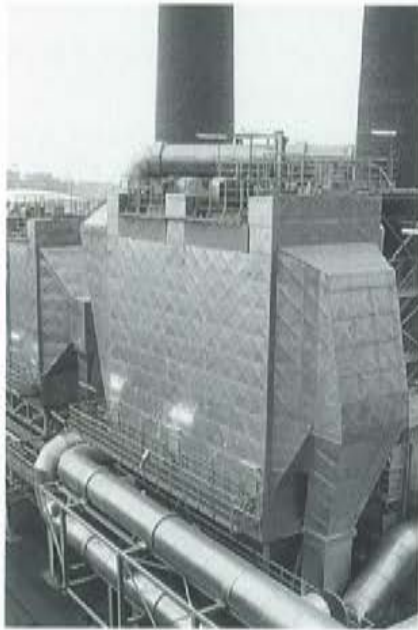
Henkel brand name for the phosphate substitute zeolite.

**Regenerative principle**

Energy-saving process. The thermal energy of the hot finished products and waste gases serves to preheat the cold starting materials.



electrofilters is recycled to the water glass melt. Sulfur dioxide emissions were reduced appreciably by the use of low-sulfur fuel oils and natural gas. At the high combustion temperatures that prevail, and because there is excess oxygen present, nitrogen oxides tend to form in water glass furnaces.



Reducing dust emissions: electrofilters and exhaust gas coolers in the Düsseldorf water glass plant.

Because no industrial-scale technology had until now been available to reduce nitrogen oxide emissions from water glass furnaces, a research program was carried out from 1988 to 1990 with the support of funds from the German Federal Ministry of Research. One of the aims was to study the feasibility of high-temperature reduction of nitrogen oxides by adding ammonia to the waste gas. It proved possible to reduce nitrogen oxide emissions by 50 to 60 percent. It is planned to equip all water glass furnaces with this noncatalytic technology in the years ahead, so that nitrogen oxide emissions will be reduced permanently to a low level.

### Adhesives production

Henkel operates adhesives production facilities at 52 sites in 31 countries. They range from simple blending units for solvent and water-based adhesives to more complex installations for the production of sealants, hotmelt adhesives, glue sticks and other adhesives.

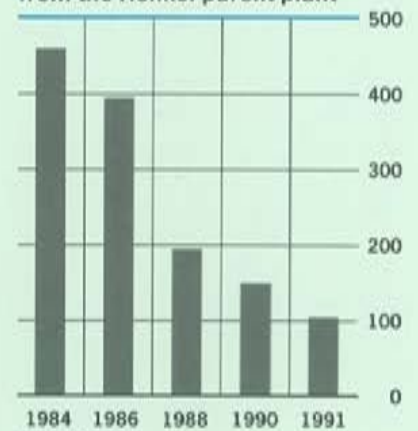
### Cellulose ether production

At the cellulose ether facility in the parent plant in Düsseldorf, water-soluble polymers\* are manufactured from cellulose – a renewable raw material – in a multistage process. Besides various reaction steps, a large number of physical processing stages (milling, washing, drying, sizing, blending) are necessary before the finished product, for example wallpaper pastes, is ready.

### Dispersion adhesives production

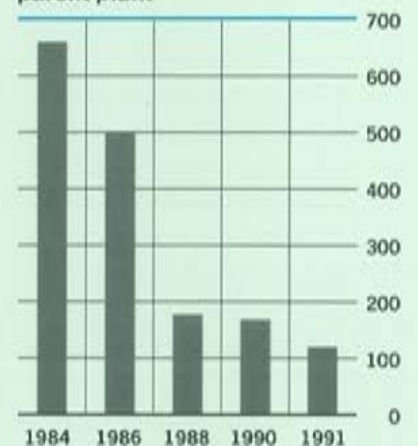
The dispersion adhesives facility in Düsseldorf produces adhesives based on aqueous synthetic resin dispersions\*. For some years, Henkel has been

Dust emission from the Henkel parent plant



in metric tons  
Source: Henkel KGaA.

Emission of organic substances from the Henkel parent plant



in metric tons  
Data expressed in terms of carbon  
Source: Henkel KGaA.

#### Polymers

Substances that are composed of a large number of repeated molecules, for example plastics.

#### Dispersion

System comprising two or more phases in which one substance is finely distributed in another.



#### Chlorinated hydrocarbons

Organic solvents that have lost their combustibility as a result of the chemical insertion of chlorine. This advantage in terms of safe handling is unfortunately matched by the disadvantage that such substances contribute greatly to destroying the ozone layer.

#### Aromatics

Class of organic compounds derived from benzene.

#### Gas recirculation

System that transfers the air expelled while a tank is being filled into the emptied tank of the tank-car in such a way that none of it escapes into the atmosphere.

#### Inert gas blanketing

Filling containers with oxygen-free gases, e.g. inert gases such as nitrogen, to avoid any danger of explosions.

engaged in an extensive program aimed at reducing the impact of such products on the environment. Avoidance is the primary concern.

As a result of joint efforts by Product Development and Production, chlorinated hydrocarbons\* are no longer used. The use of volatile organic solvents, which are added to the dispersion adhesives in small amounts, has been reduced by 25 percent since 1985. Since April 1992, no more volatile aromatic\* solvents have been used. These efforts are continuing.

A project is in preparation which will reduce water consumption. The levels of impurities contained in effluent wastewater have been halved since 1987 with the aid of blending technologies that facilitate better cleaning, and by using improved filtration and modern high-pressure cleaning processes. Moreover, wastewater from the facility runs into two retaining basins, from where it may only be discharged into the works sewage network after thorough checks have been carried out in the plant laboratory.

Computerized process control: a modern control room in the adhesives plant.

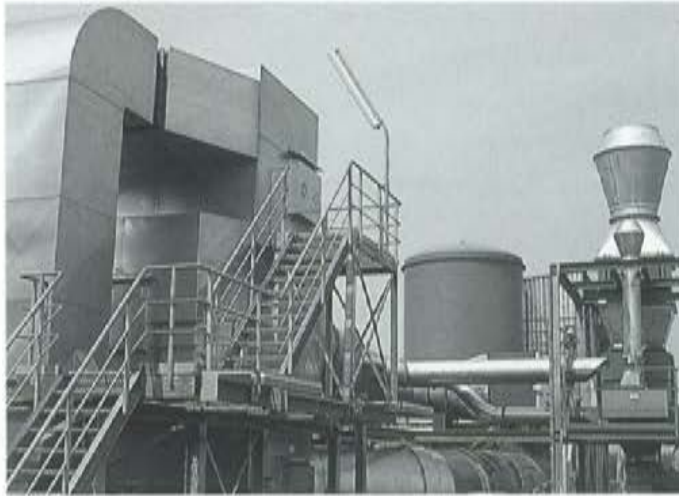


#### Production of solvent-based adhesives

Solvent-type adhesives still continue to play a major role in a modern range of adhesive products. In order to comply with safety and environmental requirements, equipment was installed to enable a closed system production process. For instance, the underground tanks are emptied by means of gas recirculation.\* From there the various solvents are pumped through flow meters into the production tanks, which are blanketed with inert gas\* like nitrogen. When raw materials are added to the reaction vessels, a slight vacuum and an increased nitrogen flow make sure that no solvent vapors can escape into the production zone. The waste gas is removed from the vessels by suction and collected before being fed into a thermal incinerator.

Three waste gas incinerators work on this principle in Düsseldorf. The heart of each comprises three combustion chambers in which the constituents of the waste gases are oxidized at high temperatures. The production areas

are designed as collecting zones and have no direct access to the effluent system. Solvent residues from cleaning processes are separated in accordance with clearly defined criteria and properly disposed.



Clean air in the Henkel-Holthausen adhesives plant: exhaust air containing solvent is burnt in the thermal reactor.

Produced by chemical reaction in organic solvents, polyurethane adhesives\* form a large and versatile product group. The reaction is increasingly being carried out in the absence of solvents.

Solvent-type polychloroprene\*-based contact adhesives are nowadays manufactured without using chlorinated hydrocarbons, aromatics or ketones\*. Efforts are being stepped up to develop solvent-free alternatives. Rubber-to-metal bonding agents are among the solvent adhesives. In this case solids are ground together with solvents and then dissolved with other additives. Here, too, alternative formulations on an aqueous basis have been developed. Construction adhesives, most of which are based on natural resins, are increasingly being replaced by aqueous dispersions.

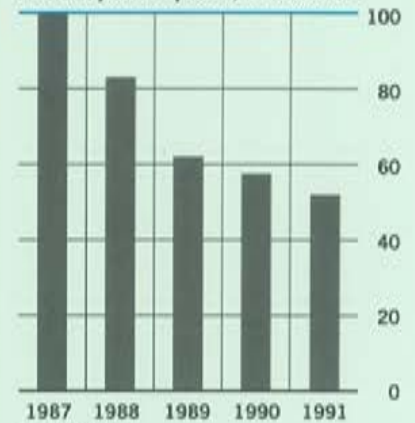
Intense development work has been carried out in the field of sealants for the automotive industry; as a result, alternative products without chlorinated hydrocarbons are now available.

### Energy production

It is the job of the power station at the parent plant in Düsseldorf to provide the production lines with energy in the form of electricity and steam. Extensive measures had to be taken to reduce emissions of nitrogen oxides and sulfur dioxide.

Because there was a lack of suitable technology, Henkel developed its own process for reducing the amount of nitrogen oxides in industrial boiler

### Wastewater contamination by dispersion adhesives in the Henkel parent plant, Düsseldorf



as percentage  
Amount of product in wastewater 1987 = 100 percent. Source: Henkel KGaA.

### Polyurethane adhesives

Adhesives based on the highly effective plastic polyurethane.

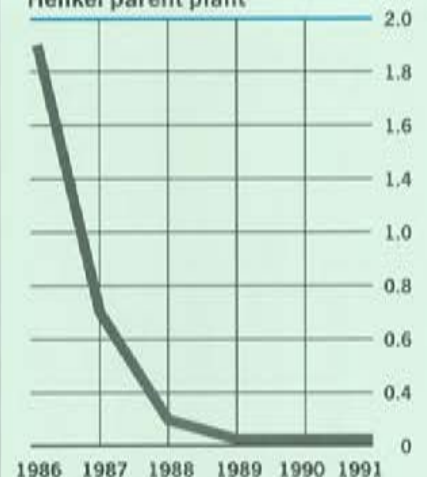
### Polychloroprene

Very hard-wearing plastic for permanent bondings and coatings.

### Ketones

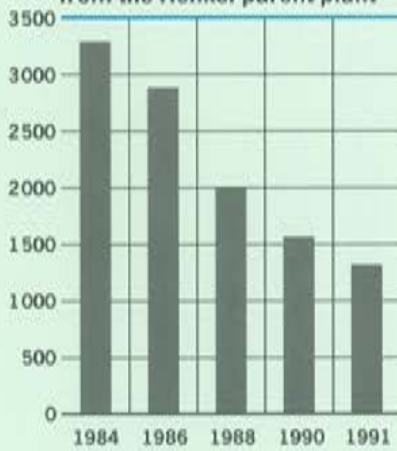
Characteristic class of organic compounds. Some ketones, such as acetone, exhibit an especially good solvent power.

### Solvents in wastewater Henkel parent plant



Expressed as milligrams solvent (trichloroethylene) per liter wastewater. Source: Henkel KGaA.

Nitrogen oxide emission from the Henkel parent plant

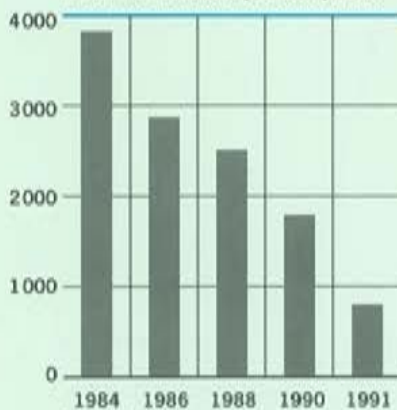


in metric tons  
Source: Henkel KGaA.

**Herenox**

Name for a process developed by Henkel for reducing the amount of nitrogen oxides (NO<sub>x</sub>) in flue gas.

Sulfur dioxide emission from the Henkel parent plant



in metric tons  
Source: Henkel KGaA.

plants. The so-called Herenox<sup>®</sup> process for cutting the amount of nitrogen oxides in gas-fired boilers was successfully implemented on an industrial scale in 1985 after a development period of almost one year; by 1988 it had also been adapted for use with coal-fired boilers.

The Herenox process is based primarily on measures affecting combustion inside the boiler and includes:

- reducing the combustion temperature;
- decreasing the excess air and improving mixing by waste gas recycling;
- eliminating temperature peaks by means of improved mixing;
- reducing the residence time of the reactants in high-temperature zones;
- accurate air allocation to the burning nozzles.

The nitrogen oxides, formed mainly as a result of thermal processes, were reduced so successfully that compliance with the legal limits of 100 and 200 milligrams per cubic meter, respectively, for gas-fired and coal-fired furnaces poses no problems.

Another focal point of the emission reduction program was lowering sulfur dioxide emissions. A first important step was to switch from heavy to light, low-sulfur fuel oil and natural gas.

A flue gas scrubbing process was developed for coal-fired combustion plants. This "caustic soda scrubbing process" removes not only sulfur dioxide from the flue gas; the plant is designed in accordance with the principle of waste avoidance. The flue gas is scrubbed with caustic soda to yielding very pure sodium sulfate that can be used for production purposes.

Because carbon dioxide is a major contributor to the greenhouse effect, special attention is given to reducing carbon dioxide emissions from fossil fuel furnaces. A package of engineering measures has enabled the Henkel power station to achieve an efficiency of 92 percent – an outstanding result compared with conventional power plants without combined



Reducing emissions by means of newly developed plant and processes: part of Henkel's power station at the Düsseldorf parent plant.

heat-and-power cogeneration". Another advantage is the relatively low level of carbon dioxide.

## Waste management

Unlike raw materials production, the manufacture of consumer goods is usually associated with only low levels of waste. This is why Henkel produces relatively little solid waste. Residual substances that cannot be exploited in the same production plant are not automatically classified as waste but are often recyclable. For instance,



Solid waste material is collected, segregated and recycled.

- residues from oil and fat processing can be used by the Holthausen power station as special fuels;
- scrap wood, from pallets for instance, is used to make chipboards;
- melting chamber granulates from the power plant are used as road construction and drainage material.

Classical recoverable materials such as scrap metal, wood, paper and plastic sheet and film are recycled. Metal and plastic drums and barrels are either reconditioned and refilled or exploited in some other way. Metals from catalysts (copper, nickel) are reworked. For some time now, building rubble has also been reprocessed. In 1991, the parent plant in Düsseldorf produced some 67,600 metric tons of residual material. 50,400 metric tons of this was reused and 17,200 metric tons was waste. Some 74.5 percent of residual materials was therefore recycled. Henkel is currently constructing a disposal center in its parent plant in Düsseldorf. In line with the latest technology, residues and waste will be stored safely before being treated and prepared for disposal. The first section of the plant has been in operation since early 1992.

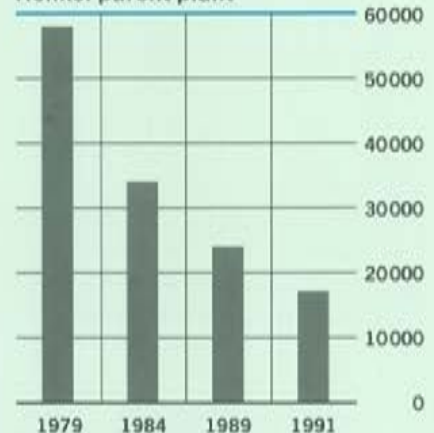
## Wastewater treatment

The parent plant in Düsseldorf produces about 20,000 cubic meters of wastewater each day – as much as a town with a population of 100,000 people.

## Combined heat-and-power cogeneration

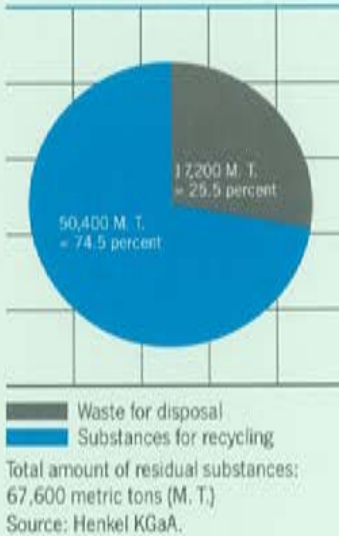
Refers to the combination of steam and electricity cogeneration. If the large amounts of heat released during electricity generation can be used as process heat in production plants, this leads to considerable savings in primary energy (fuel) and thus to an increase in efficiency.

Amount of solid waste at the Henkel parent plant

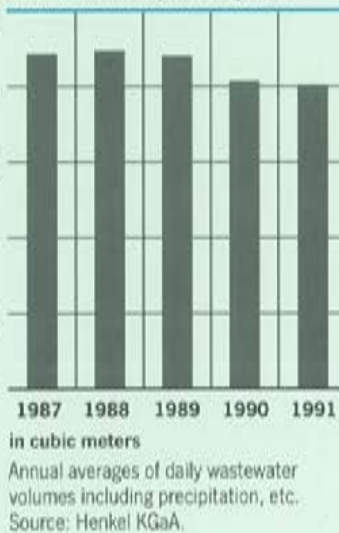


in metric tons  
Source: Henkel KGaA.

**Residual substances at the Henkel parent plant 1991**



**Daily volume of wastewater in the Henkel parent plant**



Henkel is an "indirect discharger"; this means that the wastewater is discharged into the municipal sewage treatment works in the south of Düsseldorf.

Before Henkel's wastewater leaves the parent plant it passes through a central wastewater treatment facility, where water-insoluble substances such as fats and oils are removed. In a neutralization stage the wastewater is given a preliminary treatment to ensure that the biological purification stage in the municipal sewage works is not overloaded. The individual wastewater streams flowing into the central facility are continuously monitored. For this purpose, automatically functioning control and sampling stations have been installed at five important points along the 40-kilometer drainage system in the plant. Temperature, conductivity, acidity (pH) and organic carbon content are measured at these stations, stored in a central computer system and the results displayed. Deviations from standard values are immediately detected, so that counter-measures can be taken promptly. Wastewater can be retained for specific treatment if necessary.

Water that has been contaminated as a result of fire-fighting activities can also be collected and treated in the central wastewater treatment facility.

### Environmental protection by the works fire department

Nowadays, environmental protection is an increasingly important part of the work of the fire department, alongside its traditional task of providing fire protection in preventive and defensive form. Great priority is now given to protecting air, water and soil against the hazards to which they may be exposed when products accidentally escape. Emergency plans specify all the necessary steps to be taken if an accident does occur, from sounding the alarm and taking counter-measures to eliminating the effects of the damage.

As a hazard prevention measure in the event of gaseous products escaping, fixed and mobile sprayers have been installed, which can generate an extensive cloud of water droplets to blanket and smother possible emissions. Mobile and stationary covers and barriers are available to prevent any substances from entering the drainage system or contaminating the groundwater.

The range of potential incidents requiring counter-measures to avoid environmental damage stretches from a "small acid leak" to an accident involving hazardous bulk substances. Within the framework of TUIS (a transport accident information and aid system), Henkel's fire department also provides help in accidents involving hazardous substances outside of the parent plant.

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Henkel's safety principles for protecting the environment, as exemplified at the parent plant in Düsseldorf, apply analogously to all the other Group companies throughout the world.



Help in case of emergencies: the Düsseldorf works fire department is equipped to handle environmental accidents.

### **Environmental protection training for production employees**

All employees are increasingly being involved in the environmental protection efforts. In early 1990, a training and motivation program on "Environmental Protection in Production" was launched in the Düsseldorf plants. It is planned to extend this program gradually to the other Group companies, initially in Germany but later worldwide.

Skilled workers and managers from the production and pilot plants for research and testing and from the plant workshops are made more aware of environmental protection and are taught about possible measures to protect the environment and their place of work. Top priority is given to water protection, emission control, immission protection, waste disposal and accident prevention. Participation is compulsory for all employees, including plant managers. Some 2,000 employees from the chemical, engineering and technology departments attend this program annually.

## Oleochemicals

### Product groups:

Fatty acids, glycerin and fatty acid derivatives, fatty alcohols and their derivatives, soda, sodium bicarbonate, caustic soda and water glass.

## Organic Specialty Chemicals

### Product groups:

Base materials and additives for plastics, paint and coatings, products for textile, leather and paper production, specialty products for mining and oil drilling.

## Care Chemicals

### Product groups:

Specialties for the cosmetics and toiletries and pharmaceutical industry, aroma chemicals and compositions, food additives, natural-source vitamin E and sterols.

### Fatty alcohols

Long-chain alcohols, largely derived from fats and oils of animal and vegetable origin. Important intermediate products, especially for the manufacture of washing active substances (surfactants).

### Fatty acids

Long-chain organic acids; one of the two main components of all vegetable and animal fats and oils. In the oleochemical industry, starting material for numerous other products.

### Fatty acid methyl esters

Substances formed by reacting fatty acids and methanol; intermediate products of the oleochemical sector, from which other products are made, especially fatty alcohols.

## Renewable raw materials for versatile specialties

Henkel is the world's largest manufacturer of oleochemical products sourced from oils and fats based on renewable raw materials, and is the market leader in the field of native fatty alcohols\*. The Company has production facilities in Germany, France, USA and Malaysia. Renewable raw materials will continue to provide a secure basis for the manufacture of specialty chemical products. Available in adequate quantities, they can be produced to meet specific demands and specific quality requirements, and in many cases only little energy is needed to process them.



**Manufacture of oleochemicals on the basis of renewable raw materials: oil fruits are available in sufficient quantities.**

Most oils and fats are intended for human consumption, less than 15 percent of the world's oil and fat production being used for industrial purposes. So there is no danger of competition for raw materials between the oleochemicals and food industries, especially in view of the fact that the oleochemicals industry often uses fats and oils which are unsuitable for human consumption due to their composition or quality. Modern agricultural methods, improved cultivation techniques and new varieties of oil-yielding plants can all contribute toward increasing the amount of oils and fats available from renewable sources, while simultaneously promoting the growth of the economies of many underdeveloped and developing countries in terms of a world economy based on division of labor.

Henkel produces almost 1,000 different chemical products. The most important are:

- chemical raw materials such as fatty acids\*, fatty acid methyl esters\*, glycerin\*, special esters for all branches of industry;
- textile, leather and plastics auxiliaries, additives for the lubricant industry, antifoaming agents for the sugar industry;



- raw materials and specialty products for making cosmetics and pharmaceuticals;
- additives for the food industry;
- fatty alcohols, detergent raw materials, wetting agents for all kinds of chemical industries, antifoaming agents for the chemical and detergent industries, additives for the aluminum industry;
- softeners, lubricants and additives for the plastics industry, and additives for industrial paint and coatings.

When it comes to oleochemicals, the fatty alcohols form an important class of products. Their wide range of applications makes them an indispensable part of our daily lives. For example, they inhibit or stabilize foam, they prevent the growth of side shoots on tobacco plants, they make plastic products supple. Nonetheless, more than 90 percent of fatty alcohols are converted to derivatives, mainly surfactants\*, and processed to form fatty alcohol ethers\*, fatty alcohol sulfates\* and fatty alcohol ether sulfates\*. It is from these surfactants that the detergent industry manufactures detergents and cleaning agents.

## Surfactants

Surfactants – surface active agents – are indispensable components of detergents, cleaning agents and toiletries used by households, commercial and institutional clients, and industry. Surfactants have to be both effective and environmentally safe. In the late fifties, mountains of foam formed



An environmental problem at the end of the fifties: non-degradable surfactants caused mountains of foam to form on rivers.

on rivers and streams as a direct consequence of the poor degradability of the prevalent synthetic surfactants. This problem disappeared with the introduction of easily degradable surfactants in the sixties. However, another fundamental problem associated with surfactants still exists; the surface active properties of surfactants make many of them toxic toward water organisms. It is therefore essential that they undergo biodegradation before reaching any surface waters.

## Glycerin

One of the two main components of all oils and fats; serves as a solvent and as an intermediate for numerous other substances.

## Surfactants

Surface-active substances which, as a result of their special molecular structure, are able to improve the wettability and solubility of substances that are otherwise insoluble in water.

## Fatty alcohol ethers

Group of nonionic surfactants manufactured from fatty alcohols.

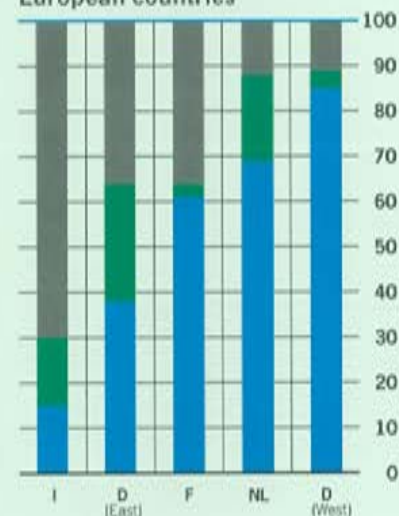
## Fatty alcohol sulfates

Anionic surfactants manufactured by reacting fatty alcohols with sulfuric acid.

## Fatty alcohol ether sulfates

Anionic surfactants manufactured by reacting fatty alcohol ethers with sulfuric acid.

## Wastewater purification in European countries



as percentage

- Mechanical/biological
- Mechanical
- Unpurified

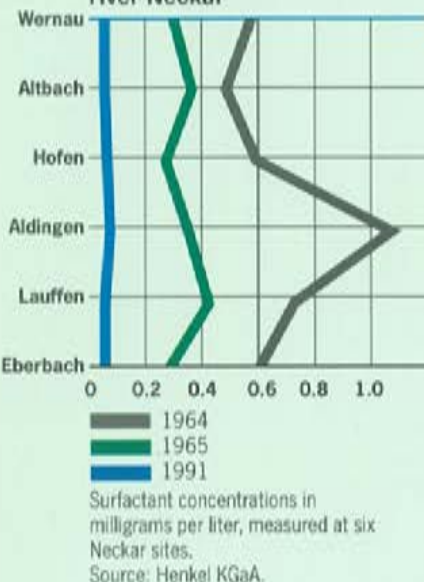
I Italy F France  
D Germany NL Netherlands

Source: Henkel KGaA.

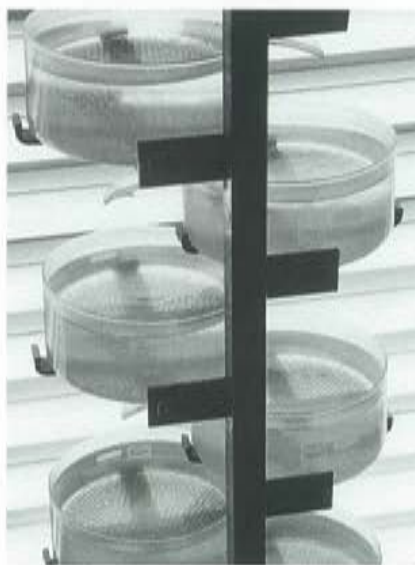
**River flow simulation in the laboratory**

To increase the relevance of laboratory studies for the real world, Henkel has developed a model that simulates the self-purification processes in a river. This so-called cascade model consists of a sequence of 25 water-filled glass basins arranged one above the other. In the course of a few weeks, biocenoses of bacteria, algae, single-cell organisms and small multicellular organisms form. In terms of the species present, the relationships are comparable to those prevailing in a real river. As in a normal environmental situation, the diluted effluent of a small sewage treatment plant is fed continuously into the upper basin. The wastewater that has been purified in the sewage plant then flows through all of the cascade basins. The situation of the biocenosis in each basin can be studied to enable questions to be answered that are fundamental to an ecological assessment, such as acute and long-term effects.

**Henkel's environmental monitoring program in the river Neckar**



According to the currently applicable laws of the European Community, anionic and nonionic surfactants must rapidly undergo more than 90 percent biodegradation under specified test conditions. The aim of Henkel's surfactant research is to achieve complete biodegradation without residues; this can be verified by more refined test methods. In order to realize this aim, surfactants may be purified even further or their chemical structures may be changed.



**Cascade model: the self-cleaning process in a river is simulated in the laboratory.**

Henkel initiated monitoring programs for the river Rhine and its major tributaries back in 1958 and has systematically continued these programs ever since; the findings show that concentrations of anionic and nonionic surfactants in these waterways have steadily decreased during the past decades. This development is attributable to two factors: the construction of biological sewage treatment plants and the use of surfactants with better degradation properties.

Henkel initiated monitoring programs for the river Rhine and its major tributaries back in 1958 and has systematically continued these programs ever since; the findings show that concentrations of anionic and nonionic surfactants in these waterways have steadily decreased during the past decades. This development is attributable to two factors: the construction of biological sewage treatment plants and the use of surfactants with better degradation properties.

**Environmentally compatible lubricants**

For more than a century, most lubricants have been manufactured from mineral oil. The total volume and the fields of application grew parallel with industrial expansion. Automobiles, ships and aircraft would not work without them; they reduce friction and wear in industrial machines and in agricultural and forestry equipment; they are used in all hydraulic systems.

However, the reconditioning and disposal of used lubricants, such as waste oil, and their poor biodegradability, are steadily growing environmental problems.

In the development of modern lubricant components, other considerations besides purely technological ones must be taken into account; these include biodegradability and toxicity toward plants and animals.

For many years, Henkel has been developing its lubricant components on the basis of renewable raw materials, from which environmentally compatible and highly efficient lubricants are manufactured. The main base materials are fatty acids, fatty alcohols, fatty acid methyl esters, and polyols such as glycerin. Controlled syntheses are carried out to prepare additives

that meet the specific demands of lubricant producers. Because these products are manufactured from renewable raw materials they are especially suitable for natural degradation processes. However, such degradation behavior can only be measured to a limited degree with the methods currently available, which were developed for testing readily water-soluble substances. Henkel has therefore participated in the development of new and reliable methods,



Care in the laboratory: precise measurement and analysis are indispensable to the development of environmentally compatible lubricants.

especially those for monitoring degradation in soil. The outcome of some of these efforts at developing environmentally compatible lubricants is described below.

### Chain saw oils

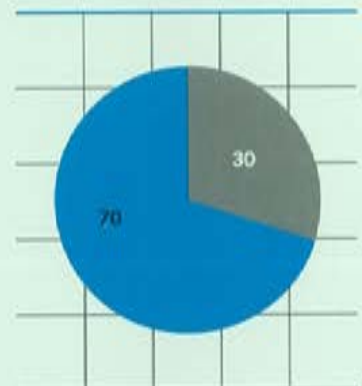
It is estimated that 30,000 metric tons of mineral-oil-based, slowly degradable lubricants for rapidly revolving chain saws employed by the timber industry, seep into the soil of the woods and forests of Western Europe each year. In Germany there has been an extensive and continued switch to readily biodegradable, rapeseed-oil-based chain lubricants since 1989. The necessary additives originated in Henkel laboratories. These additives improve the adhesion of the lubricant to the chain saw, control temperature behavior and impart oxidation resistance.

### Hydraulic oils

In Germany alone, some 160,000 metric tons of hydraulic oils are consumed each year. A large proportion goes into the hydraulic systems of vehicles and machines used in agriculture, forestry, water management, and the construction and mining industries. Because leakages are almost unavoidable in such systems, it must be ensured that the products are environmentally compatible and biodegradable.

Henkel develops basic components and additives that meet these requirements, above all esters of various viscosity\* classes, made from native fatty acids such as oleic acid, caprylic acid and capric acid.

Chain saw oils  
Market share, Germany



as percentage

- Based on mineral oil
- Based on readily degradable rapeseed oil

Data for 1990.

Source: Henkel KGaA.

### Viscosity

Measure of a substance's resistance to flow. Substances with a high viscosity flow with difficulty, whereas substances with a low viscosity flow readily.

Hydraulic oils must enable machines to operate even at low winter temperatures. For this reason it was previously impossible to use ecologically compatible rapeseed oil, because it becomes extremely viscous and loses its lubricating properties at low temperatures. This problem is now solved by the addition of oleic acid esters, developed by Henkel, so that today rapeseed oil can lubricate machinery even at low temperatures.

### **Lubricating greases**

Some 10,000 metric tons of grease are used each year in Europe to lubricate railroad switches, flanges and wire ropes. Some of it finds its way into the soil, where it is a danger to the organisms living there and, in the long term, to the groundwater. Henkel's oleochemical development laboratories have found biodegradable products for these applications, too.

### **Transmission oils**

Transmission oils are of major importance, especially in automobiles, because they extend the useful life of a vehicle and enable energy consumption to be kept to an ecologically desirable level.

Oil changes have to be carried out regularly and, especially in the case of trucks, the volume of waste oil that has to be disposed of is steadily increasing. This has become a problem. Henkel Corporation in the USA leads the field in the development of modern transmission oils for trucks. Recent developments permit trucks to be driven over much greater distances before an oil change is needed. This is a highly relevant contribution toward slowing down the rate at which waste oil is generated.

### **Drilling fluids**

Drilling fluids have a number of tasks to perform. They lubricate and cool the drill rods and simultaneously transport crushed rock and drill cuttings to the surface. As a consequence of the variety of technical demands, a whole range of differently composed drilling fluids are used. Diesel oil or other mineral oil fractions are used as the carrier liquid in mineral-oil-based products, usually mixed with 5 to 50 percent of an aqueous salt solution.

In the case of offshore drilling, the separated drill cuttings are fed back into the sea. The mineral oil that adheres to them is an inevitable source of pollution. This is why the countries bordering the North Sea have long placed considerable restrictions on the use of drilling oils based on mineral oils.

Right from the start, Henkel's development work in the field of drilling fluids has aimed at providing the drilling industry with a mineral-oil-free, aqueous-type of carrier fluid that would still have all the advantages of the

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mineral-oil products. The development of special fatty acid esters made this possible; ester-based drilling oils were formulated which are in no way inferior to their mineral-oil-based relatives, but which are ecologically and toxicologically safer.



A gentle way to obtain oil: new types of drilling auxiliaries help to make the search for mineral oil and gas less harmful to the environment.

### **Aqueous paint and coatings**

Research, Product Development and Application Technology at Henkel have been set the task of replacing chemical products containing solvents by, preferably, water-based systems. This is no easy assignment, but success is being achieved by way of numerous small steps forward.

In 1984, the German paint industry voluntarily agreed to take measures to reduce solvent emissions\* from paint and coatings – a trend-setting decision. By 1995, as a result, solvent consumption will have been reduced to less than half of the 480,000 metric tons used in 1982.

In developing its new coating resins, Henkel has concentrated on dispensing with organic solvents completely and, by developing aqueous systems, on producing emissionless coating resins.

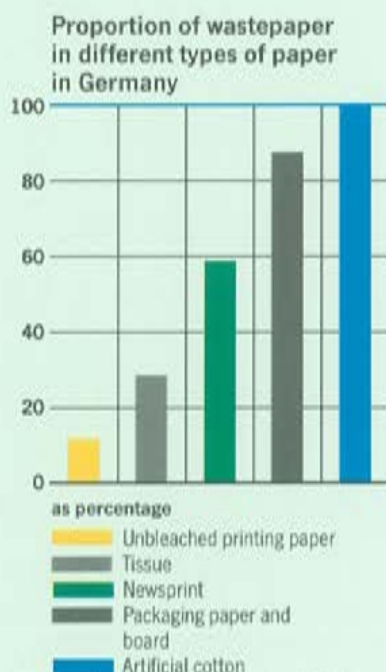
### **Light instead of solvents**

Another line of research aims at eliminating organic solvents throughout the Chemical Products sector by developing and producing innovative alternatives. Henkel researchers have developed a solvent-free method of manufacturing and processing coating resins for paper, wood, cardboard and metals. Such coatings have to be extremely thin, usually transparent, and should be applied evenly to the surface they are intended to protect. In conventional plants, the protective layer is applied with the help of solvents that are afterwards evaporated and have to be recovered by means of complicated processes.

#### **Emissions**

Solid, liquid or gaseous substances that enter the atmosphere from a plant or an industrial process.

Chemists and process engineers in the polymer pilot facility at the parent plant in Düsseldorf, together with the American subsidiary Henkel Corporation, developed an environmentally compatible and extremely eco-



Data for FRG (pre-reunification), 1988.  
 Total paper production:  
 4.97 million metric tons  
 Proportion of wastepaper:  
 46 percent

Source: Lothar Götttsching,  
 Papier in unserer Welt. Düsseldorf 1990.

#### Flotation

Process for separating fine solid particles selectively from others in liquids. Air is blown into the liquid, so that air bubbles attach themselves to the selected solids – e.g. pigments from printing inks – and carry them to the surface of the liquid, where they can be skimmed off.

Quality control in the Henkel printing shop: drying under UV light has proved its worth with protective coatings for packaging materials.



nomical production process that requires no solvents to be used. The basis of this work was the development of a new kind of coating system. Henkel researchers made ultraviolet light perform the task of the solvent in the coating process; esters of diacrylic and triacrylic acids are exposed to the ultraviolet light, which causes them to harden, forming a fine coating film. Experts speak of reactive ultraviolet light curing systems.

#### Wastepaper recycling

There is a long tradition of processing wastepaper into recycled paper and cardboard. The first Henkel patent for such a process dates from 1908.

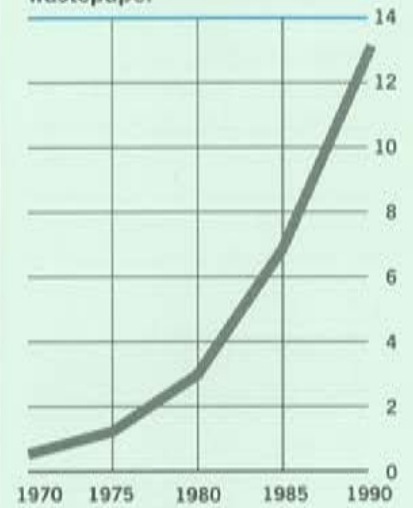
In West Germany, one quarter of all wastepaper is deinked, i.e. the printing ink is removed, and the paper is then recycled; the rest is used for packaging material. Although packaging material and some tabulation paper can now be manufactured completely from wastepaper, newsprint can only tolerate 50 to 60 percent and high-quality paper may not contain more than 5 percent. In Japan and Europe, printing inks are usually removed by means of flotation\* processes, and this type of process is steadily gaining in popularity on a global scale. Henkel has a major share of the market in flotation deinking chemicals. By developing new products and better processes for removing water-soluble flexographic printing inks, Henkel has made another important contribution to relieving the burden on the environment. These developments even enable the deinking of paper that has been printed with modern solvent-free inks and its reuse in an environmentally responsible manner.

Current development work is being carried out in close cooperation with the printing ink industry and a number of research institutes. The German Federal Research Ministry is supporting this project.



**Flotation processes in a paper mill: printing inks are removed during the recycling of wastepaper.**

### Global capacity for deinking wastepaper



in million metric tons  
Global capacity of flotation deinking plants.  
Source: Henkel KGaA.

## Institutional Hygiene

### Product groups:

Chemicals, appliances and machines for the application areas of cleaning, washing, sanitizing and disinfecting for commercial and institutional clients, the food industry and agriculture.

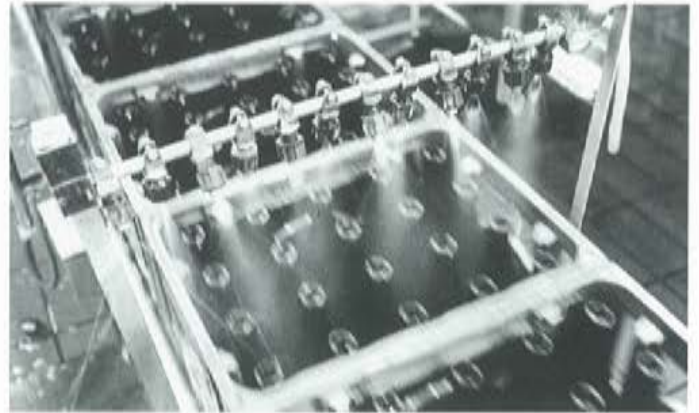
## Metal Chemicals

### Product groups:

Chemical products for the surface treatment of metal and substitutes: lubricants, cleaning products, degreasing agents, corrosion inhibitors, conversion coatings; water treatment, engineering services, recycling, waste management.

## Surface protection and care

Henkel integrated in July, 1991 its business in professional cleaning, sanitizing and maintenance for commercial and institutional clients into a joint venture with the American Ecolab Inc., headquartered in Minnesota. In this way, the strengths and the decades of experience of Henkel and Ecolab are united in a global alliance. Henkel-Ecolab has subsidiaries throughout Europe, in Germany Henkel Hygiene GmbH.



**Smooth cleaning:** in the beverage industry, bottles and crates pass through fully automatic washing lines.

## Institutional Hygiene

Henkel-Ecolab's cleaning and sanitizing products make a significant contribution toward safeguarding and increasing the quality of life. The company markets products, application systems and services for textile, catering, building and hospital cleaning and sanitation, as well as for the



**Pilot project Ecological Building Maintenance:** cleaners being instructed in the use of environmentally compatible agents and systems.





**A minimum of wastewater contamination: in industrial cleaners, specifically applied metering and control technology reduces environmental pollution.**

Designed metering and control techniques are also making a considerable contribution toward a cleaner environment. Especially in the case of large-scale units, Henkel has developed its own automatic metering systems to reduce wastewater pollution.

Packagings and transport containers are an increasingly important aspect of environmental protection. Henkel-Ecolab aims to reduce packaging waste as far as possible by promoting a variety of systems such as bag-in-box packagings, refillable containers and super-concentrates. All containers for Henkel-Ecolab products can be recycled, and agreements to this effect have been concluded with the clients.

Henkel-Ecolab offers its customers a combination of product quality, application systems and advice to help them solve their cleaning, sanitizing and maintenance problems with a minimum of environmental impact.

### **Metal Chemicals**

Henkel offers a complete range of products for all kinds of applications involving surface cleaning and treatment, as well as the preliminary treatment of metals. This range includes lubricants for metal forming and processing, as well as water treatment products.

Chemicals are of crucial importance in many branches of industry. They play a major role in all metal processing and finishing processes. They are

agricultural, food and beverage industries. In many cases the product ingredients are already completely biodegradable, and complete biodegradability remains high on the R&D agenda.

For certain of its products, such as disinfectants, Henkel-Ecolab is the first European company to provide its customers with not only a list of ingredients but also comprehensive Ecological Certificates\* which are backed by the knowledge and research findings of the Henkel ecologists.

Chlorine bleaching components in detergents and cleaning agents are being replaced by oxygen-based alternatives. Specifically de-

#### **Ecological Certificate**

An evaluation by ecologists of the environmental impact of a product on the basis of all its ingredients.

used to degrease steel strip, clean autobodies, engine and transmission parts, as well as aluminum surfaces. Any equipment that becomes soiled during use, such as road and rail vehicles and aircraft, must also be cleaned. Large machine parts are cleaned when inspections or general overhauls are carried out.

All of the cleaning agents used for these purposes become exhausted, especially when cycled, and have to be renewed. The process wastewater containing the used cleaning agents has to undergo treatment to ensure that as little contamination as possible discharges into the sewage network. Henkel has developed sophisticated filtration for this purpose, which breaks down the used cleaning solutions into their individual components so that the active agents can be reused. This means that only the dirt in these solutions needs to be disposed of.



**Express wash:**  
rolling stock  
is quickly and  
thoroughly  
cleaned with  
Henkel products.

In certain processes, dirt can be extracted continuously during the process cycle. So, the quality of the cleaning bath can be maintained over long periods of time without infection by an accumulation of dirt. The useful life of a bath, i.e. the time between starting a new bath and discharging it, can be stretched by a factor of 6 thanks to this technology. Depending on the particular process, the life of a bath can last from several weeks up to 18 months. In this way a lot less water is used and a drastic reduction is achieved in the amounts of substances discharged into the sewage network.

#### **Substitution of chlorinated hydrocarbons**

The German Federal Environmental Agency has estimated that 180,000 metric tons of chlorinated hydrocarbons\* were used in West Germany in 1987. More than half of this amount, some 100,000 metric tons, was used for cleaning purposes. For some years now, Henkel has been successfully working to replace these solvent-based cleaners by aqueous systems. Many

#### **Chlorinated hydrocarbons (CHC)**

Organic solvents in which chlorine has been incorporated by chemical means, causing them to lose their flammability. The advantage of safe handling is offset by the disadvantage that such substances make a major contribution to the greenhouse effect.

such projects are supported by the German Federal Ministry for Research and Technology.

The cleaning mechanisms of organic solvents differ fundamentally from those of water-based cleaners. Solvents are best at removing organic impurities such as oil and grease, while aqueous formulations do a better job dissolving or removing salt residues and pigments. The use of surfactants\* enables water-based cleaners to remove organic dirt as well. In many cases it is possible to achieve at least the same level of degreasing with a suitable aqueous cleaner as can be achieved with chlorinated hydrocarbons. However, the switch from solvent-type cleaners to aqueous systems requires a change in the entire metal-degreasing process. Henkel has assisted in the development of suitable processes and facilities. Despite the necessary system switchover, Henkel's product development efforts have already borne fruit; powerful aqueous cleaning agents are increasingly replacing chlorinated hydrocarbons.

### Surface treatment

The treatment of metal surfaces before they are coated is a core business of Henkel's Metal Chemicals division. Whatever the surface to be coated, automobiles, window frames, beverage cans or steel strip, the process is always the same: cleaning, rinsing, conversion treatment\*, rinsing, passivation\*, rinsing/drying, coating.

All of Henkel's pretreatment products are used in aqueous solutions. Products and processes are refined continuously so that Henkel, as the leader in this field, can market pretreatment agents with improved environmental compatibility throughout the world. In the case of metal cleaning agents, the good biodegradability of the surfactants is a key consideration.



Rust a thing of the past: specialty products provide the metal surfaces of automobiles with long-term protection against corrosion.

### Surfactants

Surface-active substances which, as a result of their special molecular structure, are able to improve the wettability and solubility of substances that are otherwise insoluble in water.

### Conversion treatment

Application of a thin protective coating of inorganic salts or oxides to the surface of metals as protection against corrosion and to improve the adhesion of subsequent coatings.

### Passivation

Physical-chemical change to metal surfaces to improve their corrosion resistance.

Until now, nickel has already been used in the phosphating of galvanized coil. As a result, the wastewater is contaminated by nickel salts and has to undergo treatment for them to be removed. Henkel's Metal Chemicals division is working on a nickel-free zinc-phosphating process.

#### **Passivation of phosphate coatings**

Conversion coatings are formed on steel, zinc-coated steel and aluminum when these are treated with zinc phosphate solutions. Conditioners promote the deposition of dense, microcrystalline coatings. These coatings, however, are porous, i.e. up to 5 percent of the metal surface is exposed and may therefore be susceptible to later corrosive attack. A passivating rinse with a process solution containing chromic acid virtually excludes this corrosion risk. In the research laboratories of the American subsidiary Parker + Amchem in the state of Michigan a chromium-free and therefore environmentally compatible alternative has been developed and is now being used in many production plants. It is based on an organic polymer\* that reacts both with the zinc phosphate crystals and the exposed metal surface which it passivates.

#### **Architectural aluminum**

The search for a substitute for the chromic-acid compounds used in the pretreatment of aluminum parts employed in the building industry presents greater problems. Aluminum is mainly used for exterior building panels and door and window frames. Such parts are generally cleaned in a weak alkaline solution to remove oil and grease; this is followed by strongly alkaline etching during which aluminum oxide residues and stubborn dirt are dislodged from the surface. The next stage is acid pickling, which previously meant using solutions containing chromic acid. Today, these solutions have been largely replaced by chromium-free products. A similar situation applies with regard to magnesium pretreatment. The subsequent chromating\* conversion treatment has been substantially improved, for example by developing wastewater-free processes.

In the quality warranties for powder-coated aluminum siding elements, the relevant standards concerning guaranteed long-term protection stipulate that such elements must be given a preliminary treatment with products containing chromium. Henkel is supporting efforts aimed at deleting this stipulation from European standards.

#### **Polymers**

Substances made up of a large number of repeated units, for example plastics.

#### **Chromating**

Corrosion protection process by depositing a protective coating of chromium oxides.

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Henkel is pressing forward vigorously with the development of environmentally compatible processes for treating metal surfaces. A succession of small steps in this direction encourages us to hope that a chromium-free pretreatment process will be found for architectural aluminum in the foreseeable future.

## Technical Consumer Products

### Product groups:

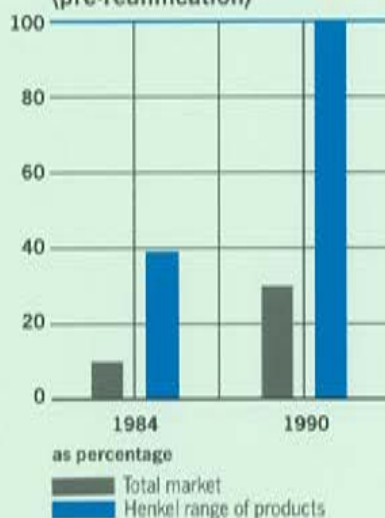
Wallpaper pastes; ceiling, wall and tile adhesives; renovating products; sealants; polyurethane foam fillers; contact adhesives; wood glues; glue sticks; super glues; PVC piping adhesives; flooring adhesives; wood preservatives; plasters; building chemicals; coatings; car care products.

## Industrial Adhesives

### Product groups:

Dispersion adhesives; starches; dextrans; caseins; hotmelts; polyurethanes; contact adhesives; polyamides; rubber-to-metal bonding agents; flocking adhesives; mold release agents, PVC plastisols, butyl sealants, PIB sealants, acrylate plastisols, waxes, epoxides.

### Solvent-free office and all-purpose adhesives FRG (pre-reunification)



Source: A.C. Nielsen.

## Researching into environmentally compatible systems

Henkel is the world's largest adhesives manufacturer. The business sector Industrial Adhesives/Technical Consumer Products produces in roughly equal amounts for industry, the professional craft trades and household use. The total range includes some 3,000 different adhesives, sealants and coating products for building construction and interior decoration, for renovation, handicraft and hobbies.

Henkel and the Henkel Group companies have production facilities in some 40 countries (the largest being the parent plant in Düsseldorf); they market their products in 120 countries. Product development and application technology are accorded high priority throughout the world. Henkel operates its own application technology laboratories at many sites and these maintain close mutual contacts to facilitate an efficient interchange of know-how and experience. In this way, knowledge gained in widely different regions regarding a variety of applications combines to stimulate and accelerate research and development. The advances thus achieved are quickly and systematically applied on an international scale.

Researchers, product developers and application technicians are continuously updating the range of industrial adhesives and technical consumer products. A not unimportant aspect is that developments and innovations often reflect improved environmental compatibility. Industrial adhesives and technical consumer products developed over the last five years now account for about 25 percent of sales. Most of the major pollution problems associated with certain product groups in years gone by (e.g. organic solvents in adhesives) have been eliminated or substantially reduced. In almost all cases where problems do still exist (e.g. contact adhesives), viable solutions are within reach.

### Brand quality harmonizing with the environment

Products must not only be highly effective and easy to use; any adverse effects on the environment must be reduced to a minimum. This combination of objectives often presents researchers and developers with difficult and time-consuming tasks.

This applies to the product range's most widespread and quantitatively biggest problem – organic solvents. Until some years ago, they played an important role, especially in all the adhesives. It is true that the Henkel range has always included many adhesives containing no solvents at all or only small amounts: the glue sticks, wallpaper pastes and hotmelt adhesives, the wood

glues and most industrial products. For some types of adhesives, however, highly volatile solvents were long regarded as indispensable formulation components; among other reasons, this was because they ensured the solubility of the adhesive resins, the essential low viscosity, good wetting and rapid setting properties of the products.



**Trend to water-based film and foil laminating adhesives: production of composite film with solvent-free film adhesives.**

### **Reducing solvent input**

Today, these properties can often be imparted in other ways. With the help of new or improved raw materials, formulations and manufacturing processes, natural and synthetic polymers are increasingly being used in aqueous suspensions\* and as melts. Solvents have now become superfluous for most adhesives.

Among the industrial adhesives, solvents are of special importance in film and foil lamination\*. Until a few years ago, considerable amounts of solvents used to be present in these laminating adhesives. During processing, the solvents had to be collected by complex absorption equipment. As the market leader in this special field, Henkel was the first to launch fully equivalent solvent-free alternatives on to the market – the result of more than ten years of development work.

In the mid-seventies, the Group introduced the first generation of solvent-free laminating adhesives, which were initially only suitable for fairly simple applications. In the early eighties, they were succeeded by a second generation comprising solvent-free two-component products, which could be used for more sophisticated applications. The third generation of these products has now been available for a few years, in the form of universal, reactive adhesive systems\*. Tests are also being carried out with aqueous polyurethane adhesives\* usable on conventional laminating machines without any prior engineering changes having to be made. It is true that water-based adhesives cannot yet cover the whole spectrum of applications, nevertheless they are already being used increasingly for high-gloss film laminating.

#### **Suspension**

A dispersion of nonsedimenting and solid particles in a liquid.

#### **Lamination**

Bonding the surfaces of two materials together.

#### **Reactive adhesive systems**

Systems in which adhesive strength is achieved by a chemical reaction.

#### **Polyurethane adhesives**

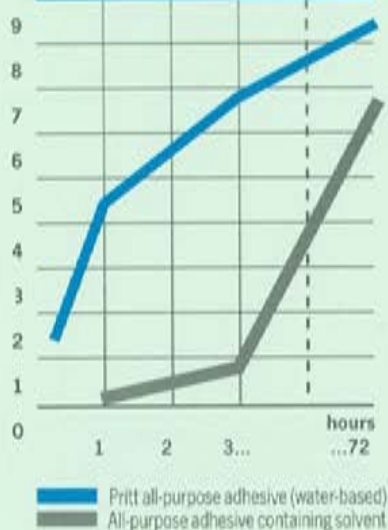
Adhesives based on the highly effective plastic polyurethane.

**Dispersion**

System comprising two or more phases, in which one substance is finely dispersed in another.

Example: suspension.

**Adhesive strength as a function of time (adhesion to wood)**



Adhesive strength measured in Newton per square millimeter of glued wood surface.

Source: Henkel KGaA.

**Making the professional's job easier**

Considerable amounts of solvents used to enter the environment, especially from primers alone or in combination with flooring adhesives. Quite apart from pollution problems, the explosion risk represented an additional danger for the user. In 1984, Henkel was the first manufacturer to withdraw a solvent-based primer, in this case from its Thomsit range of products, and replace it with a dispersion\* – despite strong initial market resistance. In a parallel development, the Group promoted the development of dispersion-based wall and tile adhesives to replace solvent-based products. The products of the new generation, which are at least as good as their predecessors for almost all applications, required users to change long-ingrained habits, and for this reason provoked considerable initial customer scepticism. Henkel supported the more environmentally compatible product line with intense training and Public Relations efforts. Today, these products are regarded as representing the state of the art. Ten years ago only 30 percent of Henkel's flooring adhesives were solvent-free, today the proportion is more than 70 percent.

**Breakthrough for all-purpose adhesives**

In 1988, Henkel laboratories achieved a decisive scientific breakthrough affecting all-purpose adhesives, the most widespread category of household adhesives, which contained some 70 percent solvent and were therefore seen as presenting a serious challenge in terms of pioneering reformulations. In the spring of 1989, Henkel introduced a solvent-free all-purpose adhesive under the Pritt umbrella brand. This product not only matched its solvent-based predecessors in all essential performance characteristics but even excelled them. The innovation was made possible by the development of a completely new type of formulation, based on special polyurethanes, and a new type of manufacturing process. Under the Pritt brand name, Henkel now provides a complete range of extremely efficient adhesives for households, schools, kindergartens and offices, and what's more, none of these products contains any solvent whatsoever.

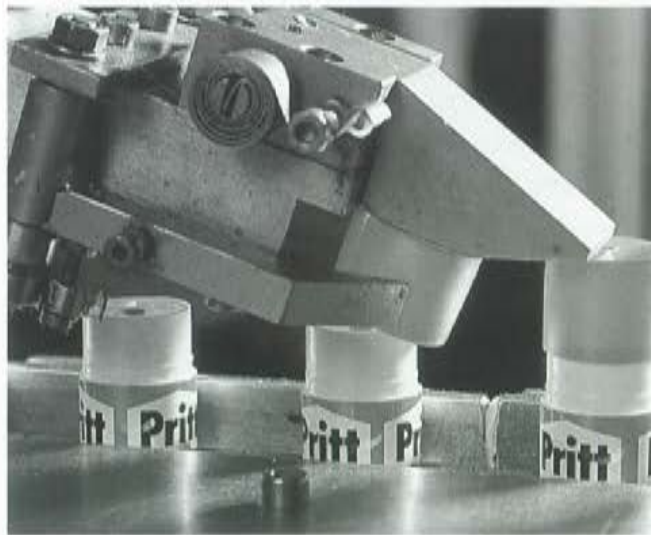


**State of the art: Henkel has supplied dispersion-based flooring undercoats and adhesives since 1984.**



There are still a number of adhesives, in particular the contact, piping and some industrial adhesives, whose specific properties cannot be reproduced without solvents. It continues to be Henkel's aim to dispense completely with solvents in all adhesives while retaining full product performance, and intense research is persisting toward this end.

Today, the majority of Henkel adhesives are based on aqueous dispersions of synthetic resins. These are followed by a growing proportion of



Solvent-free from the very beginning: more than one billion Pritt glue sticks have been produced worldwide since 1969.

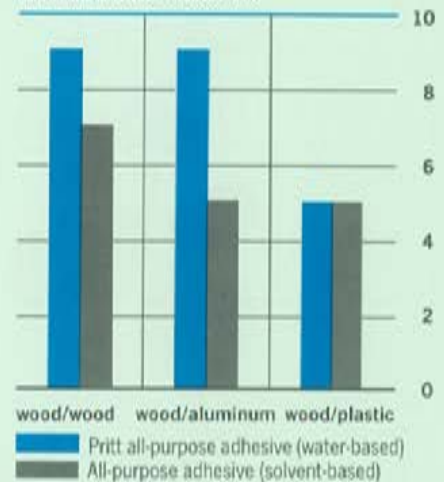
hotmelt adhesives, especially for industrial applications. Just like sealing wax, hotmelts set on cooling. There is also a considerable number of adhesives based on natural raw materials such as resins, cellulose, casein\*, dextrans\* and starch. The adhesives and sealants used in the automotive industry are also solvent-free; they cure during the baking process without losing any of their components by distortion.

### Processing and recycling – reconcilable

Some of the earlier environmental demands made on adhesives have been outdated by recent developments. One such was for recyclable book binding adhesives, for instance as used in telephone directories. However, it has meanwhile proved more sensible to filter off adhesive residues when wastepaper is processed than to use products that form aqueous dispersions or dissolve in water and eventually accumulate in circulating water.

In the case of renovation products, for many years paint strippers posed the greatest problems because they release chlorinated\* and aromatic\* hydrocarbons. New products developed by Henkel make no use of these substances. In Germany, the new formulations are now the accepted standard.

Strength of all-purpose adhesives with various materials



Adhesive strength measured in Newton per square millimeter of glued surface.  
Source: Henkel KGaA.

#### Casein

Protein component of milk.

#### Dextrans

Degradation products of starch; can be used as an adhesive.

#### Chlorinated hydrocarbons

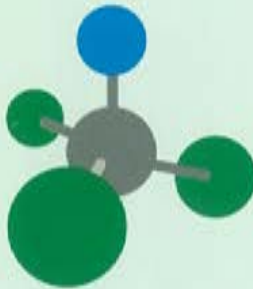
Certain organic solvents in which chlorine has been incorporated by chemical means, causing them to lose their flammability. The advantage of safe handling is offset by the disadvantage that such substances make a major contribution to destroying the ozone layer.

#### Aromatics

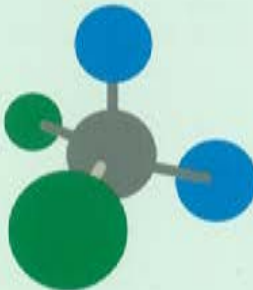
Class of organic compounds derived from benzene.

**Chlorofluorocarbons**  
Organic solvents used  
as propellants and refrigerants.

CFC 11



CFC 12



CFC 22



■ Fluorine  
■ Chlorine  
■ Hydrogen  
■ Carbon

**Fungicide**

Substance that kills fungi or prevents fungal growth.

**Biocide**

Substance that kills micro-organisms.

The amount of noncombustible chlorinated hydrocarbons used by industry is also decreasing steadily. At the moment, the only alternatives are combustible solvents, which can, however, be recovered and fed into the production cycle again without hurting the environment.

The foaming agents currently used in polyurethane assembly foams (PU foams) represent a transitional solution. Henkel was one of the first manufacturers to stop using chlorofluorocarbons CFC 11\* and CFC 12\*, which are now known to damage the ozone layer, switching initially to the partly halogenated CFC 22. This propellant also harms the ozone layer but its damage potential is only 5 percent of its predecessors'. In this way a quickly implementable, albeit only partial, solution was found. The formulations of Henkel assembly foams will again be changed as soon as suitable alternatives are available. By late 1990 potential solutions were in sight, and since October 1991 Henkel has been marketing Assil Multi 134 PU-Foam, the first such product worldwide that represents no danger to the ozone layer.

As a supplier of wood treatment products, Henkel aims to dispense with biocides\* as far as possible and to market its products in forms that restrict careless application. As ever, therefore, wood treatment products marketed under the Gori brand still do not contain combined products that integrate protection against wood decay into a decorative coating. Apart from the unavoidable so-called pot and film preservation, all stains are free of fungicides\* and biocides. The range is supplemented by pretreatment primers containing active agents for special applications where they are genuinely needed. Harmful substances such as pentachlorophenol (PCP) have not been used in these products for decades.

One of the focal points of environmentally-related development work is the use of renewable raw materials on a much broader scale. Above all, starch has been rediscovered; this is obtained from potatoes, wheat, rice or maize, depending on the region, and has been used for the production of adhesives since time immemorial. The potential uses of renewable raw materials for wall, paper and packaging adhesives were undoubtedly underestimated for many years. Hotmelts, too, consist of fatty acids based on renewable raw materials. Casein adhesives from this product group have been marketed as bottle label adhesives for decades.

**Packaging – important for adhesives, too**

The packaging of many technical consumer products sold in plastic containers has been converted to 100-percent recycled plastic since 1991. The easily recycled buckets, cans and cartridges can be reused up to five times and then processed into lower quality products, for example granulates for road

surfaces. In this way, the advantages of plastic packagings as transport and application containers are retained, yet resources are husbanded and needless waste is avoided. Each year, in Germany alone, Henkel uses some 2 million buckets, 3.5 million cans and 9 million cartridges made of recycled polyethylene for its products destined for professional craftsmen and the D.I.Y. market. The basic color of the reclaim containers changes inevitably from white to gray, but Henkel relies on the acceptance and support of retailers and users and carries out extensive informative activities.

As part of its efforts to provide an environmentally compatible range of products, Henkel has critically reviewed all other types of packaging. Even the so-called blister packs\* have undergone careful scrutiny. New solutions

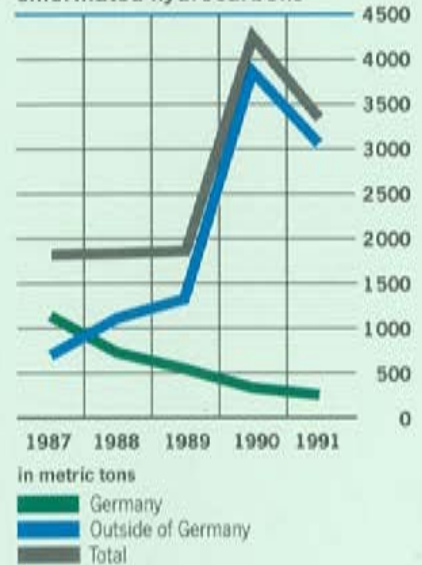


**Gray instead of white containers: buckets, cans and cartridges made from 100-percent recycled plastic, for technical consumer products.**

were developed, which Henkel also began to put into practice in 1991. Ideas that allow a minimum of packaging to be used have been tested in Germany and will be introduced internationally in the near future.

In a parallel development, work is being carried out in the industrial sector with the aim of allowing empty containers to be reused. For some years, the trend has been toward returnable containers. Problems have been encountered above all in cleaning unavoidable adhesive residues from emptied containers in an environmentally compatible manner. This is a field in which Henkel is developing new proposals designed to meet the specific needs of customers in the various branches of industry.

**Henkel's consumption of chlorinated hydrocarbons**



Increase in rest of world attributable to company acquisitions; such as purchase in 1990 of the largest British manufacturer of paint strippers (until then containing chlorinated hydrocarbons).

Source: Henkel KGaA.

#### Blister pack

Transparent plastic film into which the product to be packaged is welded.

## Cosmetics/ Toiletries

### Product groups:

Toilet soaps, bath and shower products, deodorants, skin creams, skin care products, dental care products, hair shampoos and conditioners, hair colorants, hair styling and permanent wave products, perfumes and fragrances.

### Surfactants

Surface-active substances which, as a result of their special molecular structure, are able to improve the wettability and solubility of substances that are otherwise insoluble in water.

### Fatty alcohol ether sulfates

Anionic surfactants manufactured from fatty alcohol ethers by adding sulfuric acid.

### Betaines

Group of especially mild surfactants.

### Fatty acids

Long-chain organic acids; one of the two main components of all vegetable and animal fats and oils. In the oleochemical sector, starting materials for numerous other products.

### Fatty alcohol ethoxylates

Group of nonionic surfactants manufactured on the basis of fatty alcohols.

## Optimum formulations, modern packaging

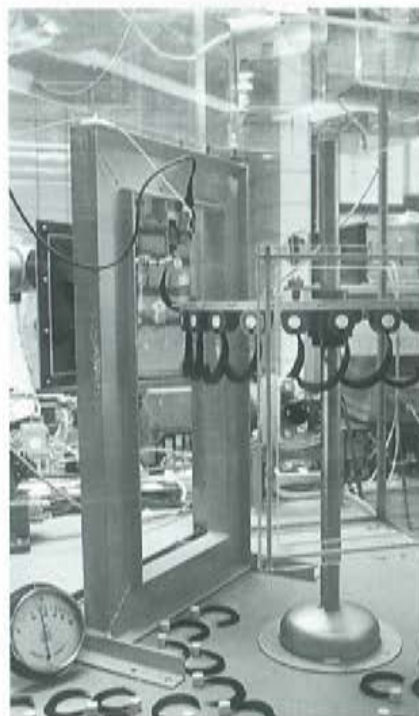
The most important market for Henkel's cosmetics and toiletry products is Europe. Henkel cosmetics are available principally in Germany, the Netherlands, Belgium, France, Greece, Austria and Spain, but also in central and eastern European countries such as Hungary and Poland. The most important items are toiletry, personal hygiene, hair treatment and scented products. Primarily of ecological interest are the surfactant-type toiletries and products containing aerosols.

### Toiletries

The processes used by Henkel in the production of cosmetics are designed to make the most efficient use of energy and raw materials. Cleaning products such as shampoos, shower gels and foam baths, toothpastes and hand-cleaning agents contain surfactants\* as the most important of their components.

In Europe, these surfactants must meet the degradability requirements applicable to detergents. For many years, Henkel Cosmetics has placed great emphasis on the use of renewable raw materials, including fatty alcohol ether sulfates\*, betaines\*, fatty acid\* derivatives and fatty alcohol ethoxylates\*. They feature good applicational properties as well as excellent degradability. In fact, the environmental compatibility of the surfactants has been exhaustively studied and confirmed in Henkel's ecological laboratories.

In recent years, the selection of starting materials has been improved. By skilfully combining certain surfactants, Henkel researchers have succeeded in reducing the overall amounts of washing active substances needed. This again is an active contribution to environmental protection.



Meticulous research into safe and environmentally compatible hair care products: this equipment measures the resilience of curls.

## Aerosol products

Aerosol products at Henkel Cosmetics include deo-sprays, hair sprays and a variety of foam products for hair styling. Aerosol sprays have the following advantages for the user:

- easy to use;
- easy dosage of product;
- ideally suited for specific purposes.

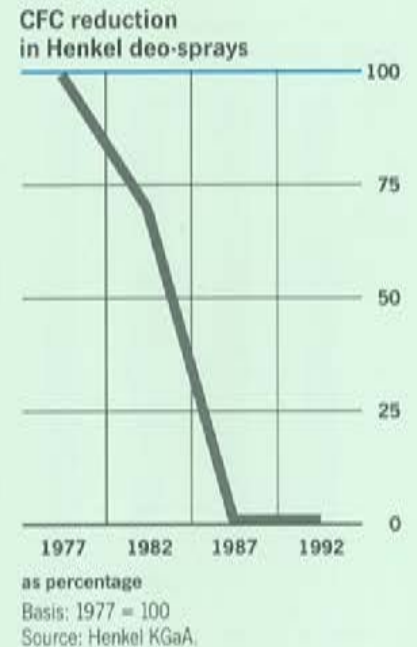


Consumer acceptance: pump sprays only established themselves as an alternative to aerosols at the second attempt.

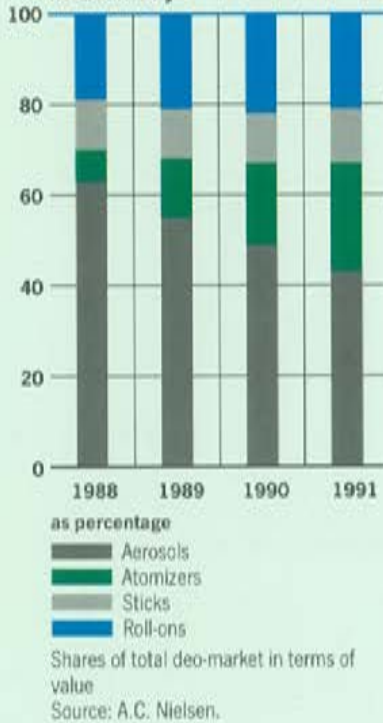
Only a few years ago chlorofluorocarbons (CFCs) were the preferred propellant. They were thought to be particularly suitable on account of their extraordinary chemical stability, their excellent compatibility with the other ingredients, their neutral odor, and the fact that they could be used as both solvents and propellants. It is now known that CFCs destroy the earth's ozone layer. Since as far back as 1987, Henkel Cosmetics has succeeded in manufacturing all of its aerosol products without resorting to CFCs. The use of CFCs had already been gradually downscaled in the years preceding 1987.

Although it has always been possible to manufacture foam aerosol products with water and hydrocarbons instead of CFCs, suitable alternatives that were compatible with the other product components had to be found for some of the atomized sprays. Sprays now contain a variety of hydrocarbons, sometimes with ultrapure dimethyl ether as a propellant. They therefore meet modern, globally accepted product standards for cosmetic aerosols.

From an ecological point of view the substitution of CFCs by other volatile organic components can only be seen as a transitional measure. Work is being carried out with the aim of replacing the currently used propellants – hydrocarbons and dimethyl ether – by more ecologically acceptable components. Gases such as carbon dioxide and nitrogen, which occur naturally in the atmosphere, are of relevance in this context. However, such systems have not yet matured to marketability.



Market changes in the forms in which deodorants are sold in Germany



#### Tray

Support, usually made of cardboard, for the accommodation and presentation of several individual sales packagings.

The use of volatile organic components has been successfully reduced not only in the field of propellants but also with regard to solvents (which include alcohol, for instance). In recent years, the proportion of alcohol in deo-sprays has been reduced in favor of the most environmentally compatible of all solvents, water. Technically, this substitution is not simple, because a deodorant should be neither "wet" nor "sticky".

Other approaches involve alternatives to aerosols. Henkel has marketed cosmetic systems that operate without propellants since 1979. The hair styling range of products, for instance, contains no fewer than 7 different pump sprays. Furthermore, for all deo-sprays in the Fa range Henkel supplies alternative roll-ons and sticks as well as the pump sprays.

Such alternatives can only be successful if consumers are ready to accept them. In 1985, for instance, Henkel had to withdraw a longstanding Fa deodorant pump spray from the market because sales were too low. Shoppers only began to show interest in this type of product in the wake of growing ecological awareness by the public at large. The Fa deodorant pump spray was reintroduced on to the market in 1989 and is now accepted.

#### Packagings – toothpastes, for instance

Two toothpaste brands, Thera-med and Denta-Clin, illustrate how an appreciable contribution can be made toward reducing the amount of packaging materials. Until the end of 1990, all the toothpaste dispensers and tubes had been sold in folding boxes to protect them from soiling. Since that time this form of outer packaging has been dropped without substitute. This represents an annual saving of 200 metric tons of cardboard.

The amount of packaging material has also been reduced by improving the transport packaging in which the product is conveyed from manufacturer to retailer. Since 1991 the Thera-med dispenser has only been supplied in a contact adhesive tray\*. The dispensers are held firmly by a layer

Forget the folding boxes: in the case of Henkel toothpastes alone, some 200 metric tons less cardboard is used each year as packaging material.



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of contact adhesive on the bottom of the tray and can thus be positioned securely on the sales shelf. These trays no longer need high side walls.



Station for testing the seal on toothpaste tubes and the cardboard supports. Inside the retail outlet, the tubes must be tamper proof.

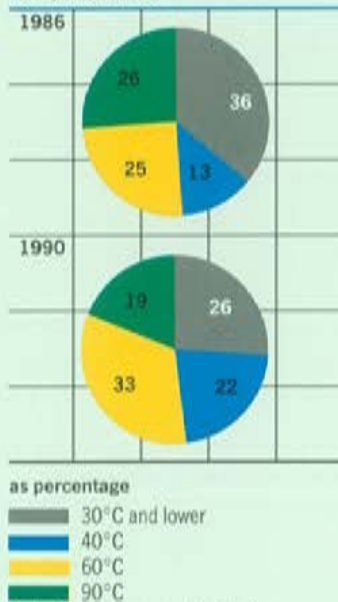
All the packagings used for Henkel cosmetics are made of largely recyclable materials. Nevertheless, the cosmetic and packaging development specialists are still working intensely on innovations that will improve packaging systems – sometimes only in very modest steps – and thus contribute even further toward protecting the environment.

## Detergents/ Household Cleansers

### Product groups:

Heavy-duty detergents, specialty detergents, fabric softeners, dishwashing products, household cleansers, scouring agents, floor and carpet care products, bath and toilet cleansers, glass cleaners, eyeglass wipes, furniture and kitchen care products, shoe and laundry conditioning products, insecticides, plant protection and plant care products.

### Selected washing machine temperatures



Data for FRG (pre-reunification)  
Source: Henkel KGaA.

### Bacterial biomass

Organic material used by the bacteria present in wastewater for their cell growth.

## Intense product development for less impact on the environment

For more than one hundred years Henkel has grown and made a name as a manufacturer of detergents. Today, detergents and cleaning agents account for one-third of Group sales.

### Phosphate-free powdered detergents

Some 3.7 million metric tons of detergents are produced annually in Europe. Each European uses an average of ten kilograms of detergent a year. Henkel has its own detergent manufacturing facilities in most European countries. Because detergents are discharged with wastewater after use, Henkel is committed to closely analyzing their path in, and their effects on, the environment.

In the course of the years it has proved possible to gain improved insight into the ultimate destination and ecological impact of the various detergent components. The composition of a powdered detergent is extremely complex; a typical formulation may contain up to 25 ingredients.

The most important of these are surfactants, the bleaching system and the builders. Anionic and nonionic surfactants are used as washing active substances and are largely responsible for removing soils and stains from the textile fibers. Extensive test methods had to be developed to assess the biodegradability of detergent components, and Henkel has made a major contribution. Modern surfactants ultimately degrade into water, carbon dioxide and sulfate, as well as bacterial biomass\*.

Nowadays tetraacetylenediamine (TAED) is used as a bleach activator in detergents. Combined with perborate, an oxygen releasing form of borate, this material yields sufficient amounts of bleaching oxygen, especially at low washing temperatures. TAED therefore makes a considerable contribution to energy saving during the washing process. All bleaching, hygienic and odor-



Modern since 1907: Persil, at that time the world's first self-acting detergent.



removing requirements are fulfilled. TAED biodegrades fast and completely and is therefore ecotoxicologically harmless.

Borate is formed as an end product after bleaching and enters wastewater together with the lye. It is not eliminated to any significant degree in sewage treatment plants, so that practically all borate formed from detergents finds its way into surface waters. The amount of borate used in detergents has decreased as a result of the increasing use of bleach activators. This downward trend is confirmed by annual measurements made by Henkel of concentrations in a number of rivers. The levels of boron detected include a not insignificant contribution from naturally occurring boron in waters, and are such that harmful effects on vegetable and animal life in the aquatic environment can be ruled out.



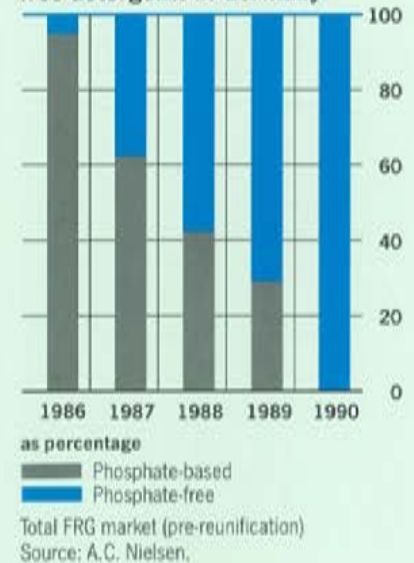
Excessive plant growth in surface waters: previously also caused by phosphates in detergents.

Up into the eighties, sodium triphosphate was regarded as an indispensable builder component of all powdered detergents. This meant that detergents ranked equally with faeces and fertilizers as a major source of phosphate in the environment.

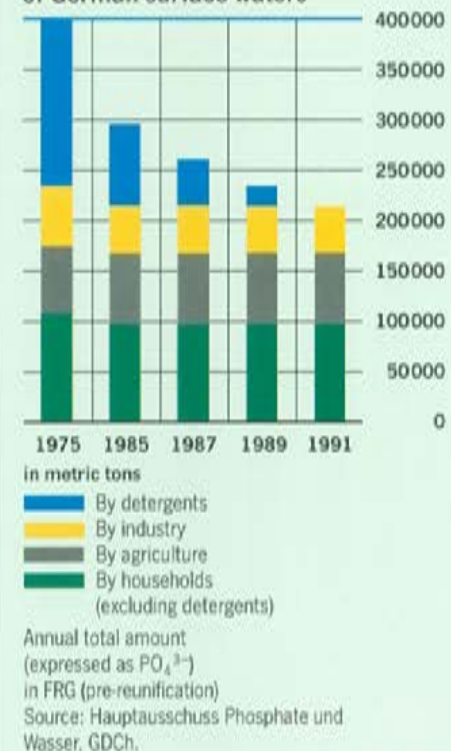
Phosphates are nutrients. Excess amounts can promote strong plant growth in slowly flowing or stagnant waters (eutrophication). Henkel addressed this problem back in the mid-seventies and developed zeolite A as a response. Its brand name at Henkel is Sasil. It is a water-insoluble ion exchanger, which is able to combine with hardness elements that interfere with the washing process (calcium and magnesium ions), removing them from the water.

Zeolite A has been subjected to comprehensive ecological and toxicological studies. Such safety studies were carried out in the seventies as part of a concerted program involving the Federal German Government, water

Market share of phosphate-free detergents in Germany



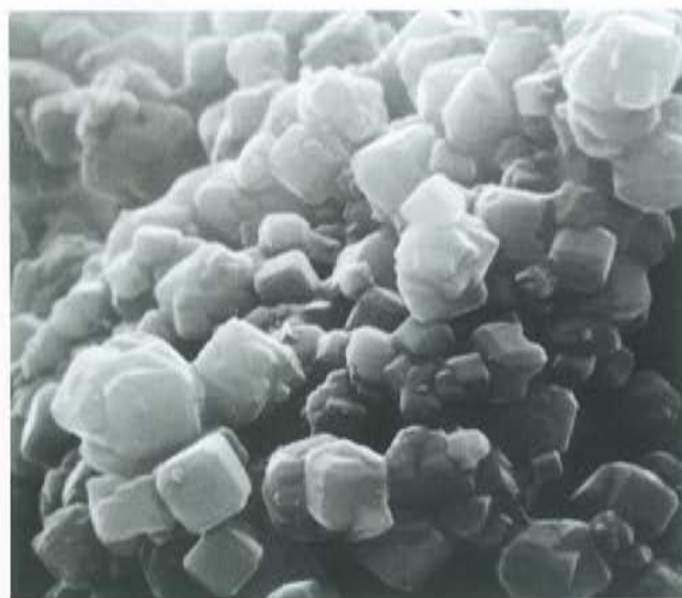
Phosphate contamination of German surface waters



**Market share of phosphate-free detergents in Western Europe**

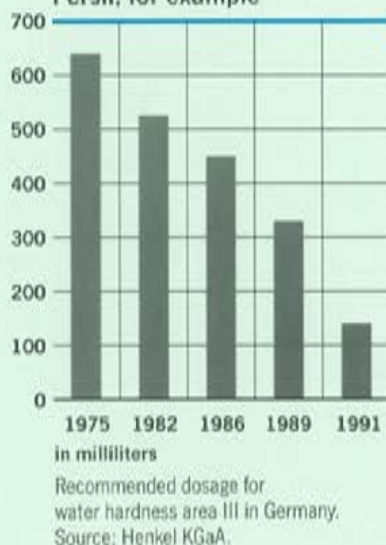


authorities and independent research institutes. The findings were published by the Umweltbundesamt (German Federal Environmental Agency) and show conclusively that zeolite A, even when present in the environment in amounts that far exceed those that can be expected under realistic conditions, exerts no negative ecotoxicological influence on the organisms in water and soil and, particularly, does not promote the growth of algae. This means that even in countries where wastewater treatment systems are still less than satisfactory, the use of zeolite in detergents can have no negative effects on surface and waters.



View through a scanning electron microscope: Sasil crystals magnified many times over.

**Detergent dosages Persil, for example**



In all, Henkel has spent some DM 140 million on research aimed at finding a phosphate substitute of its own; of this, DM 40 million have been devoted to ensuring that zeolite A is ecologically and toxicologically harmless as well as safe to use and produce.

The development of zeolite A has radically changed the world's detergent market. In many industrialized countries (Western Europe, USA, Japan), detergents containing phosphates have been largely or completely replaced by those with zeolite. In 1991, some 730,000 metric tons of zeolite A were used worldwide to produce detergents.

Polycarboxylates are another important component of modern phosphate-free detergents. As cobuilders they delay the crystallization of lime during the washing process and prevent it depositing on textiles and washing-machine parts. In addition, they inhibit textile graying. More than 90 percent of polycarboxylates are removed in sewage treatment plants.

The ecotoxicity\* of these compounds and their possible effects on wastewater purification and the balance of heavy metals in sewage plants and surface waters have been extensively studied. None of the findings concerning their behavior in the environment yet reveal any ecologically harmful effects. Nevertheless, intense research aimed at finding cobuilders featuring better biodegradability is continuing.

As a cobuilder in detergents, sodium carbonate (soda ash) fulfills several functions simultaneously. Not only does it soften water but, as an alkali, it enhances detergency performance. The amount of soda ash now used in detergents is so small that it cannot be expected to have any consequences for the ecosystem.

Other components of modern detergents, such as silicates, enzymes\*, optical brighteners, foam inhibitors and fragrances are not known to have any ecological disadvantages.

Without the new Sasil and polycarboxylate builder systems developed by Henkel, present-day low recommended dosages of powdered detergents would not be possible. Whereas more than 600 milliliters of powdered detergent used to be recommended for one washing machine load, today's recommended dosages average under 140 milliliters. This saving represents – together with the phosphate substitute – a considerable contribution toward lessening any adverse impact on our environment.

### Definite drop in surfactant consumption

After many years of development work, Henkel has succeeded



Completely degradable: new surfactant combinations in liquid detergents.

in taking a major innovative step in the field of liquid heavy-duty detergents. Since May 1990, a new liquid detergent has been on the market. A combination of surfactants (coco alcohol sulfate, coco alcohol ethoxylate, soaps from coconut fatty acids and palm kernel fatty acids, alkyl polyglycosides), it provides better washing performance while requiring markedly lower amounts of surfactant than previous products. All of the surfactants biodegrade rapidly and readily. Furthermore, the metabolite test\* developed by Henkel has revealed that no stable intermediate products are formed during the biodegradation of these surfactants.

#### Ecotoxicity

Toxicity of a substance toward various organisms in the environment.

#### Enzymes

Biological active substances. Used in detergents to remove stubborn stains.

#### Metabolite test

The Organization for Economic Cooperation and Development (OECD) has recommended the use of exactly defined test methods for determining the biodegradability of chemicals. These methods measure the speed of biodegradation but not the extent of ultimate degradation. For this reason, Henkel has developed the so-called metabolite test. A model sewage plant is operated in the laboratory. The outflow is connected to the inflow. Simultaneously, new test substance is fed in. After some 100 test cycles it can be determined whether fragments of the test substance, i.e. intermediate degradation products (metabolites), have accumulated. On this basis it can be concluded whether a test substance is completely biodegradable.

### **Fabric softeners with improved environmental compatibility**

Fabric softeners have been used for more than 30 years as one of the products that provide washed textiles with their "final finish." They restore the properties that the textiles lose during the washing process; for example their softness and their pleasant "feel" next to the skin.

In addition, fabric softeners impart antistatic properties to textiles made from synthetic fibers. They also reduce the amount of water retained in tumble-dried items. The laundry therefore dries more quickly and the tumbler uses less energy. Fabric softeners also reduce the wrinkle propensity of the laundry, so that ironing is easier or even unnecessary. In addition, fabric softeners lessen the stress on the fibers and thus extend the useful life of the textiles.

All these effects are achieved with cationic surfactants. Until the early nineties, ditallowalkyl dimethyl ammonium or imidazolinium salts were used almost exclusively in the manufacture of fabric softeners. In particular, ditallow dimethyl ammonium chloride (DTDMAC for short) was predominant. However, this active substance is not adequately degraded in sewage treatment plants and so Henkel researchers sought ecologically better but equally effective DTDMAC substitutes and were rewarded by finding a group of such substitutes, the esterquats.

Esterquats exhibit much superior ecological properties. As sewage treatment plant simulation tests\* demonstrate, they biodegrade readily and rapidly. The intermediate products formed during degradation also undergo biodegradation. Only very low amounts of esterquats accumulate in sewage sludge. Studies have shown that these residues are readily degradable under conditions of sludge digestion, so that no accumulation in the soil can be expected through agricultural exploitation of sewage sludge.

### **Dishwashing and cleaning agents**

Dishwashing and cleaning agents are an indispensable part of a hygienic household. After use, these products, together with the removed deposits, pass into the wastewater. Efforts to ensure that the components of dishwashing and household cleaning agents pollute the environment as little as possible have recently made considerable progress.

Manual dishwashing detergents rely exclusively on surfactants as cleaning substances. These surfactants reduce interfacial tension between the food deposits, the water and the surface of the dishes. Relatively minor amounts of detergent produce a good cleaning effect. A more recent development and vegetable-based surfactant, alkyl polyglycoside (APG) is increasingly being used

#### **Sewage treatment plant simulation test**

Ecological test procedure for determining the biodegradability of substances. The test substance is fed into a model sewage treatment plant together with standardized wastewater. The fundamental design, the concentration of bacteria and the aeration of this plant are such that conditions correspond to those in municipal sewage treatment plants. The degradation performances of both types of plant are therefore directly comparable. Hence, the biodegradability of a substance can be determined under realistic conditions. A surfactant manufactured by Henkel is only marketed when the simulation test has shown that it will be removed from wastewater when it passes through a municipal sewage treatment plant. In the European Community, the sewage treatment plant simulation test is a legally recognized procedure for evaluating the biodegradability of chemicals.

in dishwashing agents. Its Henkel brand name is Plantaren. APG reinforces the dishwashing efficiency of other surfactants, so that all in all the desired product performance is achieved despite lower consumption of surfactants. This means less work for the sewage treatment plants as they take in less material.

All surfactants used in manual dishwashing products are based on renewable raw materials and are readily and completely biodegradable. The metabolite test has demonstrated that they form no stable intermediate products. This also applies to the surfactants in general household cleaning products, all-purpose cleaners and scouring agents. The wide variety of surfaces that need to be cleaned in the household and the many types of dirt together mean that an effective cleaning agent must contain additional active agents. Until a few years ago, phosphate was used as a builder. As in the case of detergents, here, too, it has been replaced.

### Dishwasher detergents

In recent years, manufacturers of both dishwashers and detergents have become increasingly concerned with the environmental impact of their products. The outcome of these reflections is that the dishwasher market now offers appliances that use less water and less energy. The conventional programs that operate at 55 and 65 degrees Celsius have been supplemented by economy programs, short programs and eco-programs for lightly soiled

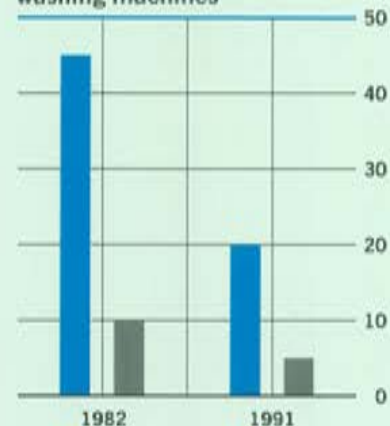


Formulation with improved environmental compatibility: the dishwasher detergent Somat 2000.

dishes. The volume of water needed for one washing cycle has been reduced from 45 liters in 1982 to 20 liters in 1991. The volume used in the actual cleaning cycle has been lowered from ten liters to only four or five. The amount of dishes cleaned in one cycle has remained unchanged, as has the amount of dirt. The most important demands on dishwasher detergents are:

- dirt and food deposits must be removed from the dishes;
- the removed deposits must be kept in the dishwashing liquor;
- the water must be softened to prevent deposits forming on dishes and machine parts.

Water consumption of dishwashing machines

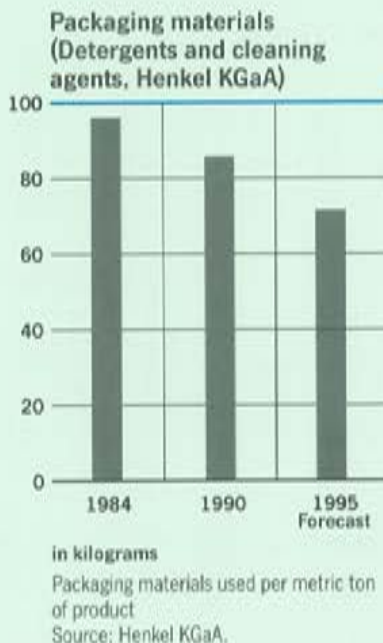


in liters  
 Total volume  
 Per cleaning cycle  
 Consumption per washing cycle in Germany  
 Source: ZVEI.

In conventional cleaning agents, these functions were carried out by phosphates (water softening), metal silicates (deposit removal) and bleaching agents on the basis of active chlorine. Since April 1991, a new type of cleaning agent has been on the market: Somat 2000. Instead of phosphate, this low-alkaline product contains citrate and polycarboxylates. Citrates, salts of citric acid, dissolve the hardness elements from the food residues. Polycarboxylates support the bonding of hardness elements and contribute toward ensuring that dirt particles and salts such as lime, that are not readily soluble, are finely distributed. The new formulation uses perborate as a bleaching agent. This compound contains active oxygen, which oxidizes residues of tea and coffee, color stains from fruit and vegetables, and even lipstick residues. Nonionic surfactants ensure that the dishes are wetted thoroughly and help dissolve food residues containing fat. The surfactants used are readily biodegradable.

### Packaging progress accelerating

By steadily reducing the amount of packaging material it uses, Henkel has for years been making a considerable contribution toward reducing waste without compromising in terms of quality and functionality. The possibilities of reducing the amount of packaging materials used are extended



Ecologically formulated cleaning agents in environmentally compatible packaging materials: Atlas products in Italy.



and improved by the development of concentrates and higher-yield products. Useful innovations in this trend are refill pouches, bag-in-box packings, liquid packs and cardboard-reinforced lightweight bottles. All these systems require much less plastic than conventional forms of packaging. Transport and handling requirements are met by the use of cardboard. During development work, priority was given to ensuring that the different packaging materials separate easily and that the packaging readily reduces in volume after use. In this way, it proved possible to use 400 metric tons less plastic in packaging in 1989 and

700 metric tons less in 1990. The introduction of powdered concentrates reduced carton demand by some 40 percent. As a result of the various measures taken, between 1984 and 1990 there was a drop of 10 percent in the amount of packaging materials used. By 1995 a further decrease of 15 percent should be achieved.

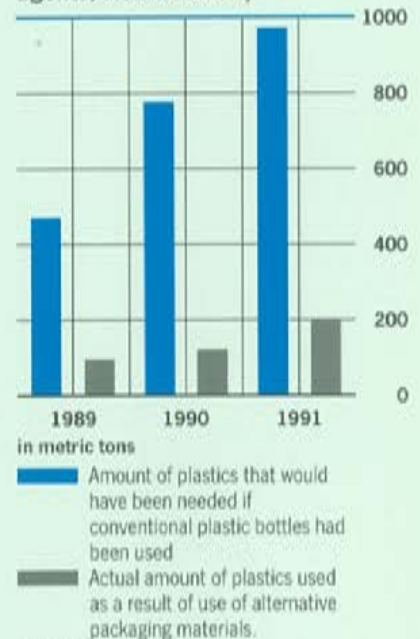
The choice of packaging materials used to develop new packaging systems to meet the requirements of today needs to be made on an objective and ecologically defensible basis. This can be done with the help of an ecological balance\*, which takes into account the complete life cycle of the packaging. The currently available balance systems represent only a first step and will need further development. Nevertheless, they are already an indispensable aid to packaging developers as a means of allowing them to take environmentally relevant criteria into consideration. Only when a general consensus has been reached on the different expert systems will ecological balances be suitable tools for guaranteeing an objective assessment.



**A packaging premiere:**  
a layer of recycled plastic sandwiched  
in the Pril bottle.

Alongside the ecologically acceptable choice of packaging materials, priority is now being given to designing packaging in such a way that it is suitable for recycling. It is not enough to select an environmentally compatible packaging material. The design of the packaging should be such that the material can be easily reused. A case in point is the bottle containing Pril, the manual dishwashing detergent. Here, packaging developers have succeeded in sandwiching a middle layer of recycled plastic between two outer layers.

**Plastics savings in packaging materials  
(Detergents and cleaning agents, Henkel KGaA)**



Source: Henkel KGaA.

#### Ecological balance

A methodical approach intended to take account of all energy- and substance-related environmental consequences of a product during its whole life cycle, from the manufacture or extraction of the required starting substances through the manufacture of the product itself, its sale and use, to ultimate disposal.

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