

ENVIRONMENTAL APPLICATIONS

Solutions using Hydrogen Peroxide
and Peracetic Acid

CLARMARIN®

HYPROX®

PERACLEAN®







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OUR MISSION – FUTURIZE PEROXIDE

We are a global team of peroxide experts, driven by enthusiasm, dedicated to create resource efficient specialty oxidant solutions, ready for tomorrow. Evonik is the innovative leader in high quality hydrogen peroxide and services, offering more than a century of worldwide experience and a range of world-class products that deliver exceptional value for customers.

Our mission is to futurize peroxide and to challenge the status quo of existing applications. By understanding current and future needs we develop new solutions, set new standards, shaping megatrends of tomorrow and making the world a better place.

We live our core values of customer proximity, trust and reliability and focus on resource efficiency.

We will always go the extramile for our customers to provide hydrogen peroxide and peracetic acid with the highest quality and state-of-the-art technology.

OUR IMPACT ON THE ENVIRONMENT –

Products and solutions for safer and cleaner surroundings



Humans have been impinging on the environment for thousands of years, the industrialization of the 19th century created new challenges for the environment.

As the negative impacts of human intervention have become even more evident and could no longer be ignored, people were forced to acknowledge that damage to the environment would have a negative impact sooner or later. This has led to a reevaluation of how we think about our environment. Sustainability is now accepted as the logical path forward, many laws exist, particularly in Europe, that are intended to minimize the negative impact of our actions on the environment. These laws set limits on, for example, waste gases and waste water, which must be observed.

Hydrogen peroxide and peracetic acid are two of the most versatile, reliable and environmentally compatible oxidizers. Their relative safety and convenience as oxidizers makes them highly suitable for applications with a direct impact and beneficial effect on the environment:

- **Waste water treatment**
- **Treatment of recycled water**
- **Reduction of bacteria (e.g. legionella) in cooling water systems**
- **Soil remediation and groundwater treatment**
- **Air pollution control**

Properties of Hydrogen Peroxide and Peracetic Acid products

Hydrogen peroxide (H_2O_2) is a colorless water-soluble liquid. Pure hydrogen peroxide is primarily of interest in scientific communities. Its aqueous solutions, however, are widely used in many industrial markets and in various applications.

The molecular structure as well as oxygen's oxidation state define the chemical properties of hydrogen peroxide. The oxygen atom, being in the oxidation state I, allows hydrogen peroxide to participate in both oxidation as well as reduction reactions. Although hydrogen peroxide is well known as a strong oxidizing agent, its reduction properties play an important role in some applications. Typical chemical reactions, in which hydrogen peroxide is involved, are oxidation and reduction reactions, formation of other peroxygen or adduct compounds. Evonik supplies standard as well as high purity hydrogen peroxide depending on the quality requirements of the particular application.

Based on the high oxidation potential, hydrogen peroxide products are known to be strong oxidizing disinfectants and can be used for biocidal applications.

Similar to hydrogen peroxide the production and utilization of pure peracetic acid is not very common. For the preparation of peracetic acid Evonik uses the direct synthesis by a catalyzed, equilibrium reaction between acetic acid and hydrogen peroxide.

The equilibrium peracetic acid is produced by combining the initial components. Therefore, the resultant peracetic acid solution is a mixture of peracetic acid, hydrogen peroxide, acetic acid and water. The equilibrium concentration of peracetic acid is adjusted by the molar ratio of the starting materials.

Peracetic acid solutions are clear, colorless liquids with a specific pungent odor. They are miscible with water and organic solvents. Concentrated peracetic acid solutions boil with decomposition. Depending on the requirements of the particular application, Evonik offers various peracetic acid grades under the brand PERACLEAN®.

Peracetic acid has outstanding disinfectant properties and acts as a potent antimicrobial agent, even at low concentration. It is effective against bacteria, yeasts, molds and viruses. The reason for the excellent and rapid antimicrobial effects of peracetic acid is the specific capability to penetrate through the cell membrane. In the cell, peracetic acid irreversibly disrupts the enzyme system, which in turn leads to destruction of the microorganism. Our products have shown superior disinfectant properties in relevant efficacy tests. Today, products based on peracetic acid are used as highly effective biocides in a wide range of applications.

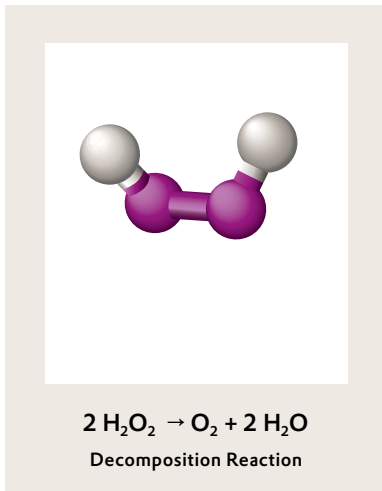
Today in Europe the biocidal applications of hydrogen peroxide and peracetic acid are highly regulated by the biocidal product registration.

ENVIRONMENTAL BENEFIT

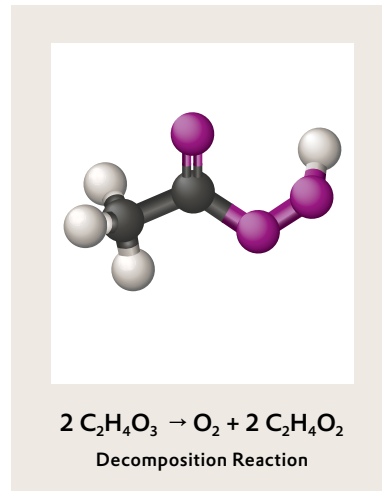
Environmental benefits of utilizing Hydrogen Peroxide and Peracetic Acid

Due to hydrogen peroxide's unique chemical properties and ecological friendliness it is a perfect candidate for extensive use in a variety of environmental applications. There are numerous examples where hydrogen peroxide helps to prevent or reduce negative impacts on the environment.

Furthermore, hydrogen peroxide is often regarded as a true "green chemical". In contrast to many other redox agents, hydrogen peroxide introduces no additional substances other than water into the reaction system and an excess can be easily decomposed into water and oxygen, thereby not interfering with subsequent reaction steps.



In the case of peracetic acid the degradation or derived product is acetic acid (AA), which is readily biodegradable in water and not bio-accumulative.



Despite its high reactivity, pure hydrogen peroxide and peracetic acid products from Evonik are stable substances and, if kept under optimal conditions, can be stored for up to a year or more. The most important factors increasing the rate of decomposition are high pH values, high temperatures, UV-irradiation, presence of transition metal salts and other kinds of impurities. Decomposition of hydrogen peroxide and peracetic acid is a complex process, which involves formation of various free radicals. In some applications (soil remediation) the induced instability is intentionally caused and used.



WATER APPLICATIONS

Waste water treatment with Hydrogen Peroxide and Peracetic Acid

Hydrogen peroxide is known to be a strong oxidizing agent, which is used in the pre-oxidation for algae control, precipitation of iron and manganese and for the oxidation of many kinds of dissolved substances, both organic and inorganic.

Furthermore, in biologically active waste water, hydrogen peroxide will readily decompose to water and oxygen. The release of oxygen can assist in biological oxygen demand (BOD) reduction by allowing the aerobic bacteria to function more

efficiently. This mechanism is especially important in cases where an oxygen deficiency exists due to high biological oxygen demand/chemical oxygen demand (COD)/total organic carbon (TOC) loadings and/or insufficient aeration.

In order to protect waters from microbiological contamination, peracetic acid can be used as a biocide (see biocidal product registration) for the reduction of germs in the purified waste water of municipal and industrial sewage plants.

Waste water treatment with AOP

In the Advanced Oxidation Process (AOP) hydrogen peroxide is activated by additional components, such as iron salts (Fenton's reagent), ozone or ultraviolet light. The AOP technology is one of the most commonly applied approaches for waste water treatment. It is successfully used for the degradation of recalcitrant

pollutants in various refinery effluents and waste water especially from chemical or pharmaceutical facilities.

The high efficiency of this process is based on the oxidation power of highly reactive hydroxyl radicals, which are formed by the activation of hydrogen peroxide.

Treatment of recycled water

Recycling water is one of the most suitable methods for saving water and reducing waste water. In many applications, it is possible to recycle process or rinsing water instead of disposing. Therefore, this approach has an enormous beneficial impact on the environment.

On the other hand, the increasing amount of pollutants in recycled water can be a big drawback for users. The presence of biodegradable organic compounds, especially, can result in the formation and proliferation of microorganisms significantly reducing water quality. This can be observed in the lack of clarity and strong odor of the water.

Good examples of this are car wash facilities in which the majority of the washing water is recycled.

Unpleasant odors resulting from the metabolic processes of microorganisms can be avoided by continuously dosing small amounts of germ reducing disinfectants e.g. peracetic acid into the recycled water.

In case of an acute smell occurrence, it is also possible to carry out a shock dosage using peracetic acid. Thus, the application of peracetic acid helps to offset the drawback of using recycled water and results in direct benefits for the environment.





Reduction of bacteria (e.g. legionella) in cooling water

Cooling water is essential in a wide range of systems across various industries and power plants. But in many cases the cooling water offers ideal conditions for the undesired growth of microorganisms and biofilms.

This biological growth in the cooling circuits leads to corrosion damage and reduction in heat transfer, and thus to reduced efficiency in heat exchangers.

Uncontrolled multiplication of bacteria in cooling water can also endanger people and the environment. Particularly in the case of evaporative coolers, cooling water aerosols are formed that spread out over long stretches. Bacteria present in cooling water can also be distributed in this way. This is why,

in the 42nd German Federal Emission Control Act (BImSchV), monitoring of legionella counts is required in such plants; uptake of these bacteria via the respiratory tract leads to dangerous diseases. Efficient disinfectants are needed to combat germs. Peracetic acid products are particularly suitable for this application due to their high efficacy and environmentally safe degradation products.

Combating bacteria in cooling water systems is a biocide application that is regulated by ECHA (the European Chemicals Agency) within the frame of the Biocidal Products Regulation (BPR).



SOIL REMEDIATION

Soils are the object of several pollution sources, which were underestimated for a long time due to their physical and chemical degradation. This was related to conjugated effects from various factors such as: atmospheric, agricultural, urban and industrial effects.

In the treatment of soils, hydrogen peroxide can be used in two ways:

One approach is similar to the AOP process used in waste water treatment. The combination of hydrogen peroxide and catalytically amounts of iron salts results in the formation of highly reactive hydroxyl radicals which degrade even very stable organic compounds (Fenton's reaction).

Oxidizing treatments with systems using O_3/H_2O_2 or H_2O_2/UV are well adapted for the elimination of organic pollutants present in groundwater (aromatic compounds, chlorinated organics).

Furthermore, hydrogen peroxide can be used as a source of oxygen for in-situ bioremediation of the soil, in particular for the elimination of hydrocarbons.

AIR POLLUTION



Hydrogen peroxide is widely used in various technological processes to reduce the environmental impact of exhaust gases.

Thus, nitrogen dioxide and nitrous oxide emissions from the steel industry, which uses nitric acid in a pickling process, can be strongly reduced.

At the end of the last century, acid rain was a huge environmental problem for developed countries. One of the main reasons was the emission of SO_2 in exhaust gases. Mercaptans, H_2S and SO_2 removal from effluents or off-gases is achieved by utilization of a wet scrubber with hydrogen peroxide.

It is also used to reduce toxicity and odors at paper mills, rendering plants, metal smelters, pharmaceuticals, pesticides, chemical manufacturing or petrochemical facilities.

GRADES – Our product portfolio for environmentally benign applications

Evonik offers CLARMARIN®, HYPROX® and PERACLEAN®, for use in environmental applications. Products are available in several concentrations starting from 35% and up to 70% hydrogen peroxide and 2% to 15% peracetic acid.

Product	Application	Process	Concentration
CLARMARIN® HYPROX®	Hydrogen Peroxide	Advanced oxidation process in water treatment Advanced oxidation process in soil remediation Industrial off-gas treatment, Nox, SO ₂ oxidation Odor control in evaporation pond treatment	Chemical Oxidation H ₂ O ₂ : 35% - 70%
PERACLEAN®	Peracetic Acid	Water treatment Effluent treatment from sewage treatment plants Treatment of recycling water Biofilm control in cooling water treatment	Disinfection PAA: 2% - 15%

* CLARMARIN® fulfills DIN EN 902

Specialty grades are available on request.

Please contact us for a recommendation regarding the most suitable grade for your application.

CLARMARIN®

HYPROX®

PERACLEAN®





REGULATORY EXCELLENCE – BPR Biocidal Product Regulation

The aim of the BPR is to harmonize the European rules for biocidal products and their active substances.

Through risk assessment, it intends to provide a high level of protection for people, animals and the environment and to ensure that products are sufficiently effective against the target species. The BPR stipulates a two-step process, in which the active substance evaluation is followed by a product authorization of individual biocidal products.

Biocidal products from Evonik containing peracetic acid and/or hydrogen peroxide fulfil the obligations of the European Biocidal Products Regulation (BPR) (EU) No. 528/2012 and are therefore actively supported in the product registration under the BPR. In the transitional period the existing biocidal products are marketed with existing national biocidal registrations.

In accordance with BPR, effluent disinfection represents a biocidal application, which belongs to **“Main Group1: Disinfectants, Product type 2”**.

Cooling water treatment is defined to be in **“Main Group 2: Preservatives, Product type 11.”**

Evonik applies for authorization under the BPR, including product type 2 and 11.

Please contact us if you have any questions.

PACKAGING

Depending on the customer, grade, region and additional requirements, the shipment of hydrogen peroxide and peracetic acid is made in small to large containers. For consumers of large quantities,

the installation of a storage tank is recommended. Common forms of packaging for hydrogen peroxide and peracetic acid are shown in the overview below.

	Cans	Drums	IBC	Bulk Container
H ₂ O ₂	30 kg, 60 kg		1100 kg	✓
PAA	20 kg, 30 kg, 60 kg	220 kg	1100 kg	✓

Please contact us regarding the availability of desired packaging systems.



LABELING & STORAGE

Hydrogen peroxide solutions with concentration higher than 8% by weight as well as aqueous solutions of peracetic acid are dangerous substances, e.g. according to Global Harmonized System (GHS) and the European Regulation No. 1272/2008.

They must be labeled and handled correspondingly. The exact classification of the particular product depends on the concentration of hydrogen peroxide and peracetic acid. Please contact our Applied Technology to obtain our Material Safety Data Sheets with more information about the product.

Hydrogen peroxide or peracetic acid containing containers should be stored in roofed, fireproof rooms in order to keep them cool and protected from sunlight.

It is important that the hydrogen peroxide or peracetic acid is protected against all types of contamination. Therefore, the containers should be stored unopened and in an upright position without blocking the breather vents. With proper storage in the original containers or in tank installations, the product can be stored safely for a long period of time without noticeable losses in concentration (typical shelf life of one year).

When handling large volumes of hydrogen peroxide or peracetic acid it could be reasonable to store the products in a tank installation. Due to the properties of the products a range of safety aspects have to be observed when constructing a bulk storage plant and dosage units.

Our engineering service team can assist you in various aspects of bulk storage, including: Planning and engineering of a tank construction, manufacturing and mounting, start-up of the installation, safety training of the operators.



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