

# Experiments with FAVOR<sup>®</sup> superabsorbents

A brochure for the scientists of tomorrow



Our FAVOR® brand superabsorbents are just one of the many innovations that have made Evonik a powerful innovative force in the field of specialty chemicals.

## Contents

What's the secret to keeping babies' bottoms dry? .....	03
The Evonik site in Krefeld .....	04
The Krefeld site within Evonik Industries AG .....	05
Superabsorbents for the hygiene industry .....	06
How superabsorbents are manufactured .....	07
The diapers of the future .....	08
The proper use of superabsorbents .....	09
Experiments with FAVOR® superabsorbents .....	10
Uncovering the secrets of how baby diapers work .....	13
Background information about the experiments .....	14
The scientists of tomorrow .....	16
FAVOR® superabsorbent polymers .....	17
Notes .....	18
Publishing details .....	20

# What's the secret to keeping babies' bottoms dry? FAVOR® brand superabsorbents!

This brochure for use in schools explains how our highly absorbent polymers work, how they are manufactured, how they are used in baby diapers, incontinence products and feminine hygiene articles – and much, much more.

## Absorbent polymers are a popular subject for scientific research.

Superabsorbents are particularly suited for use in the classroom thanks to their fascinating and easily demonstrable characteristics. They quickly absorb aqueous liquids, forming a gel that traps moisture and won't release it, even under pressure.

### Science project competition

In addition to their use in classroom lesson plans, superabsorbents are a popular topic for experiments in the German national competition for young scientists, "Jugend forscht." With the assistance (in the form of materials and know-how) of the Evonik experts, students have found new applications for the crosslinked polymers. And the two girls pictured on the cover of this brochure, students at a school in Jülich, Germany, won third place on the regional level with their

project, "Synthesis and Applications of Superabsorbents." We hope this brochure will inspire more students to take an interest in chemistry and natural science. By performing experiments on their own, the scientists and engineers of tomorrow can gain a better understanding of the relevance of chemistry for their everyday lives.

### Comprehensive information

This brochure explains how superabsorbents are used and how baby diapers are made, and outlines experiments for students to carry out. It also provides information about the Evonik site in Krefeld where superabsorbents are manufactured, and introduces the apprenticeships and training programs available for young people.

An indispensable component of modern diapers: FAVOR® superabsorbents.





In 1907, the “Crefeld Soap Factory Stockhausen & Traiser” built its second factory on what is now Bäckerpfad Street.

## The Evonik site in Krefeld

The production focus lay in the early days still on soaps which are used in the textile industry of the velvet and silk city Krefeld. The construction of the first large-scale manufacturing facility for superabsorbent polymers in 1986 was an important milestone in the company’s history.

### A factory with a distinguished heritage.

The absorbent polymers manufactured here hold a leading position in the global marketplace. They are primarily sold to companies in the hygiene industry for use in diapers and other hygiene products. FAVOR® brand superabsorbent polymers are used all over the world to help keep babies’ bottoms dry. Embedded in diapers, the granulated polymers are capable of absorbing up to 500 times their own weight in liquid. In addition to baby diapers, they are widely used in sanitary napkins and adult hygiene products. The Evonik site in Krefeld also makes STOKO® brand cleansing and protection products for occupationally stressed skin. With these products Evonik belongs to the market leaders in

Europe, serving a wide variety of customers, most notably in the automotive, steel and chemical industries.

### Environmental protection

Strict quality guidelines form the basis for innovative product development and the creation of systematic solutions. The Evonik site in Krefeld has been certified for compliance with the environmental standards DIN EN ISO9001 and DIN EN ISO 14001. Standards for safety, environmental protection and quality assurance are part of an integrated management system that guarantees high-quality, environmentally sound products and services for our customers.

# The Krefeld site within Evonik Industries AG

Evonik, the creative industrial group from Germany, is one of the world leaders in specialty chemicals. Its activities focus on the key megatrends health, nutrition, resource efficiency and globalization.

## Diversified and highly successful.

The Evonik site in Krefeld is a so-called "multi-user location," which means the infrastructure is shared by several business units. The plant employs a staff of about 1,000, manufacturing a wide variety of products, ranging from superabsorbents and skin creams to special polymers used in agriculture, the cable and packaging industries, and for fighting fires. The plant is also home to the companies Ashland Germany GmbH (chemicals for the water industry) and Bozzetto GmbH (chemical products for the textile industry).

## Promoting new ideas

The key to international success is adaptability, which in turn requires encouraging new ideas by keeping the lines of dialog open between customers and employees. We at the Evonik site in Krefeld have always believed that we can best achieve our business goals by learning from one another and from our customers. That is why we equally value both economic success and ecological responsibility. This enables us to expand our existing lines of business and open up new potential at the same time.

Our specialty chemicals activities address economic megatrends and give us access to attractive future markets. We see especially promising opportunities in resource efficiency, health and nutrition and the globalization.





We conduct ongoing research to manufacture even better superabsorbents that will make it possible to create diapers that are considerably thinner than those in use today.

## Superabsorbents for the hygiene industry

More than anyone else, parents appreciate our highly effective superabsorbent polymers – every day, every night, everywhere. As a component of modern baby diapers, FAVOR® brand superabsorbents keep babies' bottoms dry.

### Superabsorbents trap and store liquids.

These granulated polymers absorb up to 500 times their own weight in liquid and form a gel that locks in fluids. The characteristic features of the polymers must be fine-tuned for the type of liquid they are intended to absorb. Even the difference between the urine of a baby and that of an adult must be taken into consideration when designing consumer products.

#### Thinner from year to year

Thanks to the use of superabsorbents, modern diapers, incontinence products and sanitary napkins are both thinner and more absorbent than they were in

the past – which means they are not only much more comfortable to wear, but also require less packaging and produce less waste. Evonik is one of the world's leading manufacturers and suppliers of superabsorbents. In addition to our plant in Krefeld, they are produced in Rheinmünster (also in Germany) as well as Greensboro, North Carolina, and Garyville, Louisiana, in the USA. The primary raw ingredient, acrylic acid, is made in Marl, Germany, and Deer Park, Texas. To ensure the long-term success of our FAVOR® brand superabsorbents on the global marketplace today and in the future, we work constantly to improve them and find new ways to use them.

# How superabsorbents are manufactured

Superabsorbents are made of inter-linked chains of hydrophilic polymer. Their primary characteristic is their ability to absorb and lock in liquids. They retain moisture and won't release it, even under pressure.



Out of the various ingredients or functional components used to manufacture superabsorbents, the primary raw material is acrylic acid.

A monomer solution is polymerized to produce polyacrylic acid/sodium polyacrylate.



The gel block is broken up into pieces.



The crushed gel is dried.



After drying, the pieces are granulated.



The granulate is sifted to produce a fine powder.



The result of this process is a white, powdery granulate with astounding capabilities.



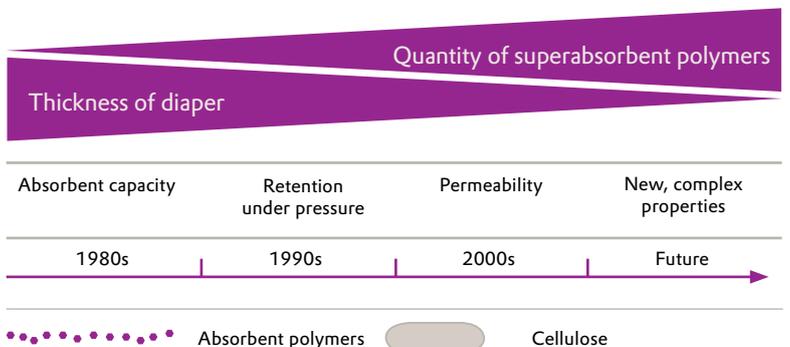
With the help of various testing procedures, laboratory employees investigate the properties of absorbent polymers and how they behave as components of various hygiene products.

## The diapers of the future

In the future, diapers will be as small and thin as panties are today. Just a few years ago, diapers were thick bundles of cellulose, but they are much smaller today – thanks to superabsorbents.

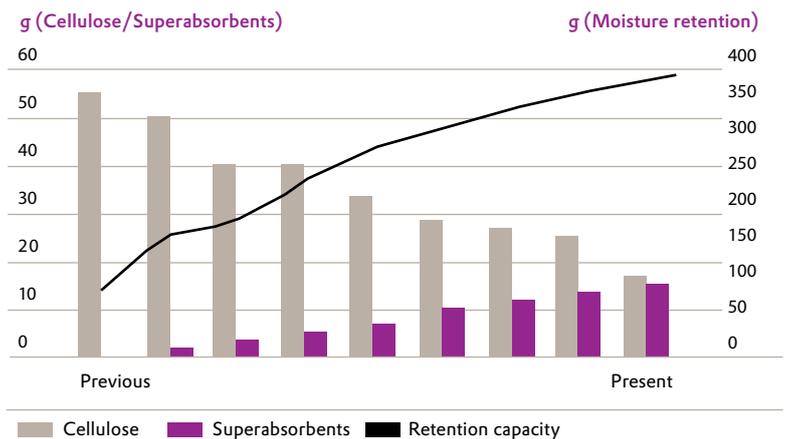
### Improvements in baby diapers since the 1980s

Schematic illustration/Cross-section of a diaper



Improvements in superabsorbent polymers were among the factors that helped make it possible to reduce the thickness and weight of baby diapers from more than 100 grams/3.5 oz in the 1980s to just 40 grams/1.4 oz today.

### Use of superabsorbents in maxi-size baby diapers



By increasing the use of superabsorbents, it was possible to considerably reduce the amount of cellulose in baby diapers and to expand the capacity to retain moisture.

# The proper use of superabsorbents

We take every precaution to ensure that our products are safe and that they are properly used once they leave our factory.

## The safety of our superabsorbent polymers is our top priority.

Numerous studies have shown that superabsorbents are non-toxic and suitable for use in personal hygiene articles. Superabsorbents are premium chemical products with a number of special properties, the foremost of which is their ability to absorb liquids. Our comprehensive safety tests assume that large quantities of superabsorbent polymers will be handled only by trained and experienced personnel, as is required for the manufacturing and marketing of hygiene articles.

products such as baby diapers. Diapers for toddlers, for example, generally contain enough granulated superabsorbent polymers for simple experiments. Young students can discover how superabsorbents are used and how they work simply by dissecting a diaper and removing the granulated polymers contained therein, which are generally sufficient for demonstrating the absorption capacity and moisture retention properties of the substance.

### Experiments for children

Children can perform experiments involving superabsorbents by extracting the granulated polymers from consumer

### Helpful tips

- When removing the granulated polymers from the diaper, care should be taken to avoid inhaling the powder, which can cause an unpleasant dryness in the mouth, nose and throat.
- If you spill any of the granulate, simply sweep it up and dispose of it with normal household waste. When it comes into contact with water, the granulate forms a gel that can be dangerously slippery. The gel itself can be disposed of with normal household waste; small quantities can be flushed down the drain with plenty of water.
- Accidentally ingesting superabsorbent polymers is harmless. Rinse your mouth and throat with plenty of water, and drink water to relieve the feeling of dryness. Do not induce vomiting.
- In case of eye contact, rinse with plenty of water.
- Once you have completed your experiment, clean the workspace and wash your hands thoroughly.
- Superabsorbents should always be stored in the bottle they were delivered in, and properly labeled.

# Experiments with FAVOR<sup>®</sup> superabsorbents

## General considerations about polymers

Superabsorbents have a number of special properties. Before investigating them more closely, we should first examine a number of general principles.

### Something to think about:

Polymers/plastics are used in many different ways. Name a few examples of polymers/plastics, and list some of their characteristics.

### Experiment #1: Gelation

This experiment examines one of the special features of these substances.

### You will need the following materials:

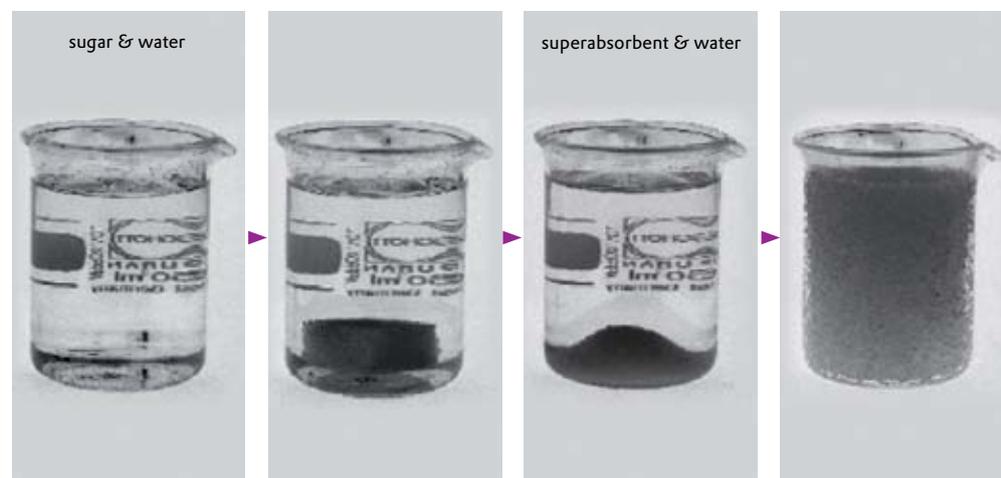
- 2 teaspoons
- 2 beakers (150 ml)
- 2 glass stir rods
- tap water
- sugar
- graduated cylinder (250 ml)
- FAVOR<sup>®</sup> superabsorbents

### Instructions:

Fill each of the two beakers with 100 ml of tap water. Add a teaspoon of sugar to one of the beakers. Stir for about a minute and observe what happens. Slowly add about 1/2 teaspoon of FAVOR<sup>®</sup> superabsorbents to the water in the second beaker, and stir for about one minute with a glass stir rod. Let stand for about five minutes and observe what happens.

### Assignment:

1. Record your observations. Describe the different reactions of the two substances when added to water.
2. Compare your observations with the illustrations below.



Here, you can see what happens when sugar and superabsorbent polymer are added independently to water.

## Experiment # 2: Absorption of liquid in baby diapers

### You will need the following materials:

- 1 baby diaper (maxi size)
- distilled water
- 1 teaspoon
- 1 glass stir rod
- 1 beaker (500 ml)
- 1 graduated cylinder (250 ml)
- filter paper (blotting paper)
- FAVOR<sup>®</sup> superabsorbents
- sodium chloride (NaCl)

### Instructions:

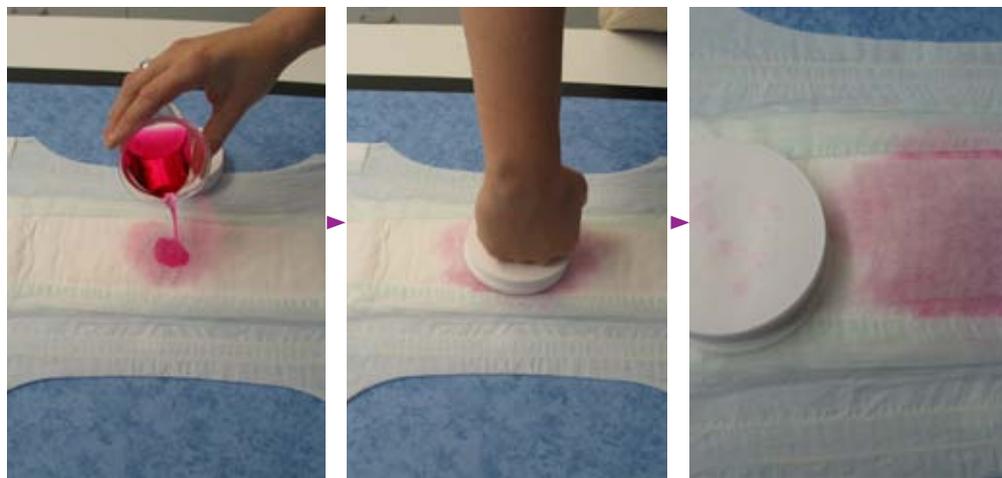
Fill the beaker with 500 ml of distilled water and add 4.5 g of sodium chloride (NaCl). Stir with a glass stir rod to make a 0.9 percent sodium chloride solution, which has an ionic concentration similar to that of human urine (for more details, see page 15). It's also a good idea to add some food coloring to make it easier to observe how the liquid is absorbed by the diaper. Using the graduated cylinder, measure out 100 ml of the 0.9 percent saline solution and pour it onto the diaper. Watch carefully and note how quickly it is absorbed as well as the way the liquid distributes itself within the diaper. Wait 15 minutes, then press some filter paper against the diaper to see how much moisture it releases under pressure. Touch the diaper to determine whether you can feel how much moisture it contains.

Wait 15 minutes; then repeat the procedure using the same diaper, pouring another 100 ml of the saline solution onto it. Observe whether the liquid is absorbed just as quickly, whether the distribution is the same as before, and whether the diaper is wetter after waiting 15 minutes. Carefully tear apart the diaper and try to recognize its various components.

### Assignment:

1. Record your observations of what happened when you added the sodium chloride solution. Describe the distribution pattern and how quickly the liquid was absorbed.
2. Characterize the way the liquid distributed itself within the diaper.
3. Record your observations of how much moisture the diaper released after waiting 15 minutes, and describe the way the diaper felt to the touch.
4. Repeat the experiment and record the differences (speed of absorption, distribution of liquid, moisture retention) as compared to the first time.
5. Sketch the composition of the diaper and describe where the superabsorbent polymers are located within the diaper. Discuss the structure and makeup of the diaper with your teacher and the rest of the class.

How much liquid can a diaper absorb? A simple experiment provides a quick answer to this question.



### Experiment # 3: The effect of the salinity of a liquid on absorption and gelation

#### You will need the following materials:

- 2 beakers (250 ml)
- 1 glass stir rod
- 1 teaspoon
- distilled water
- FAVOR®superabsorbents
- sodium chloride (NaCl)

#### Instructions:

Fill a beaker with 200 ml of distilled water and stir in 1.8 g of sodium chloride to produce a 0.9 percent sodium chloride solution with an ionic concentration similar to that of human urine. Fill the second beaker with 200 ml of distilled water. Add a teaspoon of FAVOR® absorbent polymers to each of the beakers, first the one with 200 ml of distilled water, then the

one with 200 ml of the saline solution. Stir each briefly using a glass stir rod, then let stand for five minutes and observe what happens.

#### Assignment:

1. Record your observations and describe the differences between the two liquids in terms of absorption and the gelation process.
2. Postulate a reason for the differences in behavior between the two liquids, and speculate what kinds of tests must be performed in the Evonik laboratories to determine the characteristics of superabsorbent polymers.
3. Do you think the results of such tests might influence the way liquid is absorbed by baby diapers (as observed in experiment # 2)? If so, in what way? And why?

Just a few grams of superabsorbent polymer are sufficient to turn a liquid into a gel.



# Uncovering the secrets of how baby diapers work

These two simple experiments demonstrate for young children how baby diapers work.

## Experiment # 1: The secret ingredient in baby diapers - superabsorbents

You will need the following materials:

- diapers
- a bowl

### Instructions:

Tear open a diaper to find the granulated superabsorbents inside. Collect the granules in a bowl.

## Experiment # 2: Superabsorbent gelation

You will need the following materials:

- a beaker
- a spoon
- tap water
- superabsorbent polymer granules (removed from a diaper)

### Instructions:

Add a few grams of granulated superabsorbent polymer to a beaker of water. Stir and watch what happens.

Diapers – and the superabsorbents they contain – awaken the curiosity of the scientists of tomorrow.



# Background information about the experiments

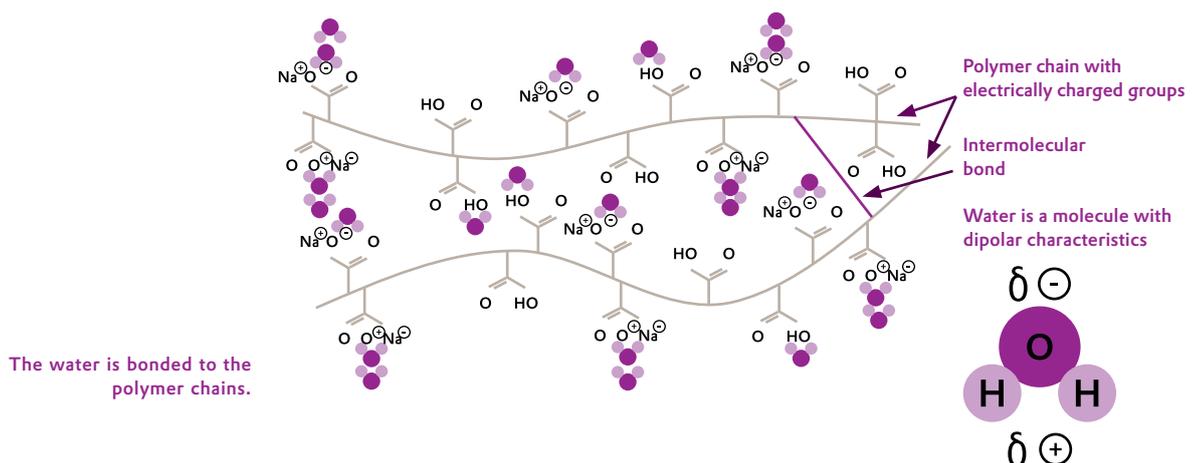
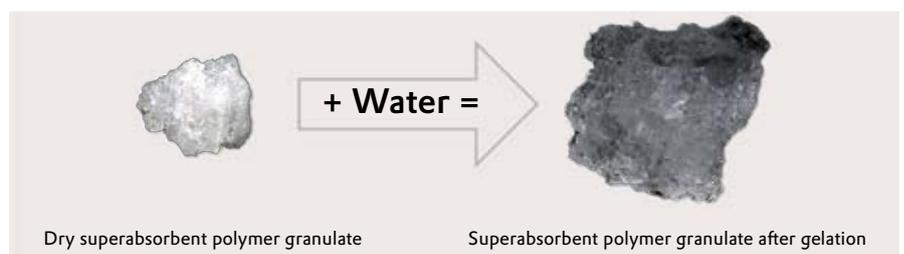
## How absorbent polymers work

The explanation for the effectiveness of superabsorbents lies in the polar characteristics of water molecules and the absorbent polymers.

### A product with very special properties.

When superabsorbents come into contact with water, the polymer molecules are initially inclined to dissolve themselves in the liquid. At the same time, however, the more negatively charged portion of the water molecule, namely the oxygen atom, binds with sodium ions contained in the superabsorbent polymer (hydration). These sodium ions in the solid polymer shield the many negatively charged carboxylate groups in the polymer chain, whereby the shielding effect decreases as water molecules bind with the sodium ions and cause the negatively charged particles to repel one another. The individual strands of the macromolecular structure distance themselves as far as possible from one another, thereby making room for more water, which is in turn absorbed into the molecular structure.

However, the polymers do not dissolve entirely because of the inter-molecular bond that link the strands together in a network and prevents the individual polymer molecules from putting too much distance between one another. Because the absorption process is partially supported by hydrogen bonds (in addition to the aforementioned mechanisms, the difference in osmotic pressure between the superabsorbents and the water they absorb also plays a decisive role), the water molecules remain trapped in the polymer network and are not released, even under mechanical pressure. This is the primary difference between polymer absorption and the absorption properties of sponges or cotton, which release most of the liquid they have absorbed when even the slightest mechanical pressure is applied.



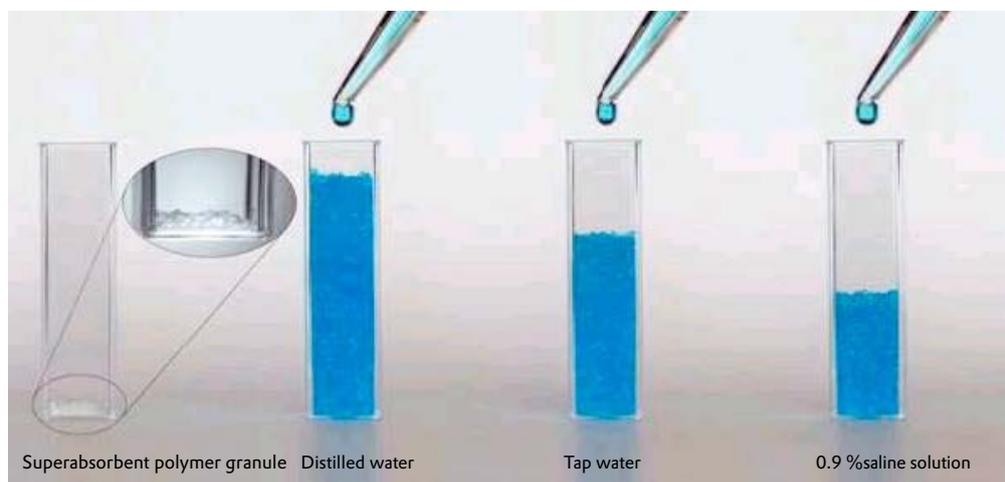
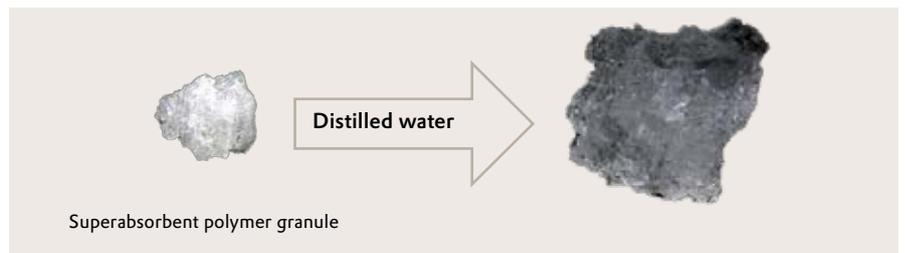
## A highly absorbent product

Absorbent polymers can absorb up to 500 times their own weight in de-ionized water. However, if an electrolyte such as table salt is dissolved in the water, the absorption capacity is reduced considerably.

### Absorption capacity for saline solutions of various concentrations.

The reason for this is the increase in the number of positively charged ions. As their concentration increases, they surround more and more of the anionic groups within the polymer structure. This weakens the electrostatic repulsion between the polymer chains, which in turn reduces the readiness of the gel to absorb more liquid. For this reason, superabsorbent polymers are only able to

absorb up to 100 times their own weight of a 0.9 percent saline (NaCl) solution, which has a concentration of dissolved ions roughly similar to that of human urine. Even though superabsorbents cannot absorb as much urine as they can water, their absorption capacity is still far superior to that of materials such as cellulose, cotton or sponges.



The absorption capacity of superabsorbent polymers varies depending on the type of liquid.



We also support "Girl's Day," a program created to interest young women in pursuing careers in science.

## The scientists of tomorrow

At our Krefeld site we have a long tradition of preparing young people for the future. We offer apprenticeship training positions in commercial and chemical-technical professions each year.

### Young people are the future.

#### Factory tours and school training programs

Tours of the Evonik site in Krefeld, including visits to the superabsorbent production facility and testing laboratories, can be arranged for school classes. A limited number of student internships are also available.

#### Apprenticeships and training positions – An investment in the future

Have you already decided on a profession? The Evonik site in Krefeld offers a wide variety of entry-level positions – maybe one of them is right for you! If you would like to start a career as soon as you finish school, you can do so here. We offer a broad range of interesting training programs for prestigious occupations.

If you had good grades in school, are a team worker, are highly motivated and have good computer and language skills, we encourage you to take advantage of the opportunity. As a trainee at the Evonik plant in Krefeld you will receive optimal training for a highly skilled job. We offer positions on the production line, in the laboratory, in customer service, and in sales and marketing. We make it easy for you to get started by keeping our training groups small, and we have our own training institutes and courses, including a comprehensive introductory seminar.

#### Our training programs cover the following professions:

- Chemist
- Chemical lab technician
- Chemical administrator
- Industrial administrator
- IT administrator
- Warehouse logistics administrator
- Industrial technician
- Electronics engineer / Automation engineer

For more information about the training opportunities at the Evonik site in Krefeld, please contact our human resources department:

PHONE +49 2151 38-1218 or -1610

#### Positions for graduates, interns:

For more information about positions and internships for students and recent graduates, please contact our human resources department:

PHONE +49 2151 38-1218 or -1610

Only a limited number of positions are available.

# FAVOR® superabsorbents

## Global market leader

We have been successfully manufacturing and marketing superabsorbent polymers for more than twenty years. The fact that diapers have become smaller and thinner – from more than 100 grams/3.5 oz in the 1980s to just 40 grams/1.4 oz today – is an achievement that demonstrates the progress we have made in developing new superabsorbent polymers. Just a few grams of superabsorbents are sufficient to absorb and “lock in” a baby’s urine. Superabsorbent polymers can absorb up to 500 times their own weight in liquid, turning it into a gel that locks in and retains moisture. Our highly absorbent granulates are also used in incontinence and feminine hygiene products.

Krefeld is home to our primary production facility for superabsorbent polymers in Europe. Additional manufacturing facilities in Germany can be found in

Rheinmünster (superabsorbents) and Marl (acrylic acid). We also maintain several plants in the USA, namely Greensboro, North Carolina, and Garyville, Louisiana (superabsorbents), and Deer Park, Texas (acrylic acid). Laboratories for research & development and application technology are located in Krefeld and Greensboro (USA).

## Close cooperation with our customers

The safety of our absorbent polymers is our top priority. All of our raw materials and products are subject to comprehensive tests and comply with our strict safety criteria. We also work closely with our global and regional customers to develop new technologies that enable us to offer unique solutions for our customers’ individual needs.



FAVOR® - high-quality products for the hygiene industry.





**Publishing details**

Published by:  
Evonik Industries AG  
Baby Care  
Bäckerpfad 25  
47805 Krefeld

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