Superabsorbent; Investigation of water absorption capacity

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Abstract

Superabsorbent (Superabsorbent Polymers, SAP) are called plastics which are able to absorb a multiplicity of their own weight - up to 1000 times - in liquids (usually water or distilled water). With the help of the experiments described, the properties and the water absorption capacity of a superabsorbent are investigated under different conditions.

Introduction

Superabsorbers are used as white, coarse-grained powder with particle sizes of 100-1,000 µm (= 0.1 - 1.0 mm). It is mainly used in baby diapers, but also in products for women's hygiene, incontinence care and in small quantities also in cable jackets for deep sea lines. However, it is also gradually becoming more and more application-oriented, for example, For example superabsorbents as an aid to combating fires or as an additive for plant soil in order to permanently store water.

Chemically, the superabsorbent is a copolymer of acrylic acid (propene acid, H2C = CH-COOH) and sodium acrylate (sodium salt of acrylic acid, H2C = CH-COONa), where the ratio of the two monomers can vary. In addition, a so-called core crosslinker (core-cross-linker, CXL) is added to the monomer solution, which connects the formed long-chain polymer molecules in situ by chemical bridges (Fig. 1). Through these bridges, the polymer becomes insoluble in water. When superabsorbers come into contact with water, the (polymer) molecules tend to spread in the solvent. At the same time, the more negative part of the water molecule, ie the oxygen atom, is deposited on sodium ions (hydration), which are contained in the superabsorber [3].

In the solid polymer, the many negatively charged carboxylate groups in the polymer chain are screened by these sodium ions. This shielding decreases by the addition of the water molecules to the sodium ions, so that the negative charges are increasingly displaced from each other. The individual strands of the macromolecular framework are removed as far apart as possible, thus creating space for additional water that can be absorbed. However, the intermolecular linkage, a net-like linkage of the strands to one another, prevents the individual polymer molecules from being removed as widely as possible from each other and the polymers can dissolve.

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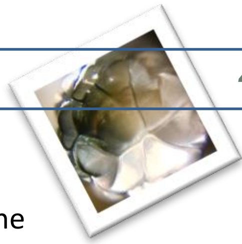

Since the absorption takes place, inter alia, via hydrogen bonds, the water bound by the superabsorbent is not released again under pressure. This is also the difference to the absorption, as in the case of sponges or a cotton ball. With these, a relatively low pressure is sufficient to return the largest proportion of the absorbed liquid [1].

When water or aqueous salt solutions penetrate the polymer particles, it swells and, on the molecular level, tightens this network - a hydrogel is formed. A hydrogel is a water-retaining but water-insoluble polymer whose molecules are chemically, For example by covalent or ionic bonds, or physically, For example, by looping the polymer chains into a three-dimensional network. Hydrogels are gaining importance in the biomedical field due to their biocompatibility and tissue-like mechanical properties. Known examples are soft contact lenses (invented by the Czech chemist Otto Wichterle), intraocular lenses as well as plastic implants [4].

The absorbency of the superabsorbent decreases when water is added with dissolved electrolytes (e.g., sodium chloride). The reason for this is the increased input of positive ions, which increasingly shield the anionic groups of the polymer framework with increasing concentration. The electrostatic repulsion of the polymer chains among each other becomes less and thus also the tendency of the gel to absorb further liquid. Therefore, superabsorbents bind only 100 times their own weight of a saline solution (0.9% NaCl), the concentration of which is approximately equal to that of human urine [1].

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Experiment 1: Extraction of the superabsorbent from a diaper

Material:

diaper
scissors
beaker

Execution:

The diaper is cut out with the scissors in the center and the cotton is separated from the adhering white solid (Fig. 2).

Figure 2: Cut-up diapers and superabsorbents.

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Experiment 2: Determination of the water absorption capacity of the superabsorbent

Material:

superabsorbent
scale
water
measuring cylinders
paper
beaker

Execution:

The superabsorbent is weighed exactly 1 gram. The superabsorber is placed in the glass. Water is gradually added to the superabsorber. At the same time, a check is made to check whether the water can still be absorbed completely by the superabsorber (Fig. 3)

Figure 3: Water absorption by the superabsorber

Results:

The superabsorber is able to absorb up to 500 mL of water and thus 500 times its own weight.

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Experiment 3: Dependency of the water absorption capacity of the superabsorbent on the salt content

Material:

superabsorbent
water
sodium chloride
beaker

Execution:

From the superabsorber, 0.5 gram each is added in salt solutions of different concentrations. The respective water intake is measured. In a diagram, the absorbed liquid quantity per gram of superabsorbers can then be plotted as a function of the salt concentration.

Results:

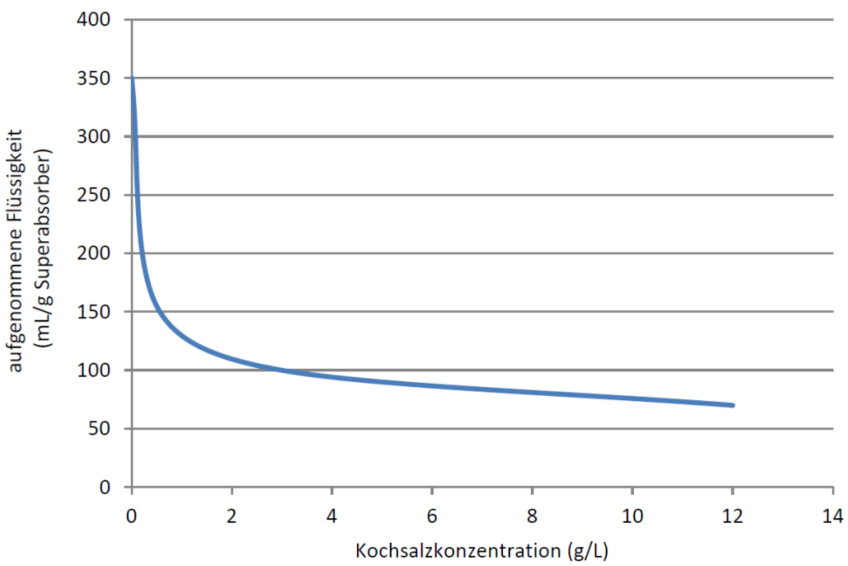

Figure 4: Liquid absorption of a superabsorbent as a function of salt concentration [2]

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Sources/Literature

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