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f a c i l i t i e s

1997



Published by Sterling Publications Limited a subsidiary of
Sterling Publishing Group P [redacted] North Wharf Road, London W2 1XR
Tel: +44 (0) 171 915 9660 Fax: +44 (0) 171 724 2089 E-mail: 100632.1573@compuserve.com

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Printed in England by Grogher Press

Hydrogels

Hydrogels — what are they? There is no clear definition of hydrogels, but they are usually composed of water-soluble polymer or water-absorbent polymers in a liquid medium. Some solids become hydrogel when mixed with wound fluid or water.

Dr. Edward I. Stout • Southwest Technologies Incorporated

There are several types of hydrogels, including:

1. Hydrogel sheets, consisting of cross-linked water absorbent polymers that have varying amount of humectants or water, or both, absorbed into the matrix.
2. Flowable viscous liquids (amorphous gels). These products may have many different additives. One popular additive is aloe extract, another is glycerine.
3. Solid particles, which will form gels or viscous liquids when combined with water or wound exudate. These are not gels as supplied, but may be the components of the flowable gels mentioned in 2. Some of these water-absorbing solids are also the components of hydrocolloids.

History

Moist wound healing has been shown to have distinct advantages over the more traditional "dry" wound healing, such as air-exposed or gauze-covered wounds.¹⁻⁴ One of the first documented reports of the advantages of moist wound healing was published by G.D. Winter in 1962, in which he covered wounds with a clear plastic film and compared the healing rates to those wounds covered with traditional dressings.

The report of much faster healing rates under the film-covered wounds soon led to the development of what are now referred to as "thin film" dressings. These dressings are usually urethane plastic films, which have high moisture transmission rates (MTV).

The potential of increase infections in the "wet wounds" kept these dressings from being widely accepted by the professional medical care giver. This potential problem is still a real concern for many physicians. Several studies have shown that the concentration of bacteria increases under occlusive dressings, which results in a highly contaminated wound.⁵⁻⁷

However, infection rates under "occlusive" dressings are lower than under non-occlusive dressings.^{5,8} A recent study, in which the sheet

hydrogel with a high glycerine content, **Elasto-Gel™**, was used as the wound dressing, showed a large reduction in total bacteria concentration after 24 and 48 hours, even though the burn wounds on pigs were seeded with *Pseudomonas aeruginosa*⁹. Baksa has reported that in a wound which was partially covered with silver nitrate gauze and partially covered with **Elasto-Gel™**. *Pseudomonas aeruginosa* in high concentration was observed under the gauze but not under the **Elasto-Gel™**.¹⁰

One of the first "modern hydrogel" products to be introduced to the market was Debrisan®, an absorbant cross-linked dextran particle. These particles or beads are used to absorb excess exudate, which remains in the wound site until the next dressing change. Soon after came the introduction of the hydro-colloid wafer (sheet) dressings (DuoDERM®, Comfeel®, and Sween-A-Peel®), high absorbent, starch-copolymer hydrogel "paste" (Bard Absorption Dressing®), and the first hydrogel sheet dressings (Vigilon® and Geliper®). After a few years (in 1988) came the first absorbent hydrogel sheet dressing (**Elasto-Gel™**) and the first amorphous hydrogels. From 1990-1995 numerous variations of flowable gels, sheet dressings, alginates, and collagen dressings have been brought to the market.

All of these dressings have been designed either to provide a moist wound healing environment or to absorb large amounts of exudate, or both.

Hydrogel sheet dressings were introduced into the US markets in 1982 by the C.R. Bard company with their Vigilon® dressing, a cross-linked polyethylene oxide gel sheet. Soon after came the European hydrogel, Geliper®. Approximately six years after the introduction of Vigilon® (1988), the first absorbent hydrogel sheet dressing, **Elasto-Gel™**, was introduced to the US markets. During the past four years several absorbent sheet hydrogels have been brought to the market. Some of these are ClearSite®, NU-GEL™ and Aquasorb®. These

products vary widely in composition, absorbency and physical properties.

Two new hydrogel sheet dressings have just been introduced to the US market: Curagel® by Kendall, which is 98 percent water, non-adherent and similar to Vigilon®, and Acryliderm® (from Australia), which claims to be more absorbent than the hydrogels currently on the market.

In the past three years a number of composite wafer or sheet dressings have been introduced, which claim a layer of absorbent hydrogel combined with other components.

Properties of hydrogel sheet dressing

Vigilon® dressing is composed of approximately 3 percent polymer and 97 percent water. Another hydrogel sheet dressing is Geliper®, which was first introduced in Europe. It is a more complex polymer mixture, reported to contain protein, polyacrylamine and water. These two dressings are soft gels, nearly transparent, and have low water or exudate absorbent capacity. They are very inert, have essentially no adhesive properties, and produce a very cool, soothing sensation when applied to open wounds. These dressings tend to dry out, especially at the edges, if they are not completely covered with a thin film dressing or other waterproof covering. On highly exuding wounds maceration can become a problem. These dressings can give a protective gel layer but are difficult to keep in place because they are not adhesive.

Elasto-Gel™ dressing is considerably different from Vigilon® or Geliper®, in that it is composed of 65 percent glycerine, is mildly adhesive, and is absorbent (approximately 3-4 times its own weight). This dressing is reported not to dry out nor to allow the exudate to dry out. This keeps the dressing from becoming bonded to the wound or to the surrounding tissue. It is also reported to be bacteriostatic and fungistatic.¹¹ This dressing has excellent padding and cushioning properties and is used for the prevention of pressure sores on heels, elbows, head and sacral areas. It is

used as padding for casts, splints and braces. It is also used extensively for the treatment of hypertrophic scars.^{11,12} Because of the high glycerine content, this dressing has less chance of causing maceration when used for this purpose. This dressing is covered with a 4-way stretch cloth backing, which allows for a very conforming, comfortable bandage or padding. It is also a breathable bandage (high MVT) because there is no film barrier to the moisture-vapour transmission. When treating highly exudating wounds, additional absorbents may be desired to absorb excess exudate to prevent maceration.

ClearSite[®] is a nearly transparent soft gel covered with a urethane film with a grid pattern. It has an absorption capacity of about four times its own weight and is available with or without an adhesive border. The product without a border contains a scrim for additional support for the gels. However, this reduces the transparency. This product contains a high percentage of water, propylene glycol, and a cross-linked polymer. The gel is mildly adhesive and also gives a cool soothing feeling when applied. The wound may be viewed through the dressing, although somewhat distorted. NU-GEL[™] is a more firm gel structure than any of the above gel sheets and contains a scrim and a thin film backing. It is mildly adhesive, is absorbent and is thinner than either ClearSite[®] or **Elasto-Gel[™]**. Aquasorb[®] is a translucent, firm gel, also with a poly-urethane backing and mildly adhesive and absorbent. It is very similar to NU-GEL[™]. All hydrogel sheet dressings have limited absorption capacity and additional absorbent materials may be needed to contain large amounts of exudates.

It is a common practice to fill the wound cavity and "tunnels" with a "packing agent or wound filler" of some kind. It is believed by many practitioners that applying a slight pressure against the wound bed will stimulate the healing process. The explanation for this observation is unclear. It may be that most of the packaging materials are absorbent and will absorb excess exudate. This will reduce the "free" water in the wound site, and absorption, coupled with frequent dressing changes, will reduce the level of bacteria in the wound site, thus allowing a faster healing rate.

In a number of publications by Teplitz and co-workers has shown that when the concentrations of *Pseudomonas aeruginosa* exceeded 105 per gram wound closure did not occur.^{13,14} Robson, et al, have further examined the role of bacteria on wound healing and have reported that wound closure did not occur when total bacterial contamination was more than 105 micro-organisms per gram.¹⁵⁻¹⁸

However, it has been reported that healing does occur in leg ulcers, even at high levels of bacterial contamination.^{19,21}

Some of the first products to be used as wound fillers include gauze, saline gauze, sugar, honey, and many other materials. One of the first absorbent polymer wound fillers, other than gauze, was the Debrisan beads, which would absorb up to four times their weight in fluid. This product was available in the 1970s and was followed in the early 1980s by the starch graft polymer super absorbents, which were made into a moist cake or paste to prevent over-drying the wound, along with the DuoDERM[®] granules and a number of other dry powders and granules.

Shortly after, a number of viscous gel preparations were introduced to the markets and now many gels with different formulations are available. These include Carrington[™] wound gel, MPM Wound gel, Elta-Dermal Wound Gel, Hollister Restore[™] Hydrogel, and Sween Woun'Dres[®], to name just a few of the many products available. The first three products listed contain both aloe vera extract and glycerine, where as Woun'Dres[®] contains collagen. In addition, there are many gauze pads which are impregnated with water-based viscous gel liquids and are sometimes referred to as hydrogel dressings. Most of these hydrogels are designed to provide a moist wound healing environment, but require a cover dressing to retain the moisture level.

Hydrogels have proved to be useful and desirable wound dressings, wound fillers or packings, and absorbent dressings. Some of the sheet hydrogels are exceptional cushioning agents and protective padding. These products are effective for protection against sheer, friction, and pressure. All of the moist dressings give a cool, soothing, pain-relieving effect when applied. Those sheet dressings, which are mildly adhesive and very soft, have proved to be exceptional pain-relieving agents. The moist healing environment has been proven to reduce scarring. **Elasto-Gel[™]** has been proven to reverse hypertrophic and keloid scarring. Hydrogel dressings provide the ideal healing environment for many wounds. ■

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Biography

Dr. Edward I. Stout is a chemist and is President of Southwest Technologies Incorporated.