The interaction of a ‘second generation’ hydrogel with the chronic wound environment

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Introduction
Hydrogel based wound dressings have found a role in chronic wound management because of their ability to absorb, retain or donate moisture to a wound. If the wound is dry then the dressing will wick the wound and enhance the environment for autolytic debridement to proceed as part of wound bed preparation for healing (Schultz et al, 2003). An additional benefit of their moisture donating property is a contribution to pain relief, which is a key area of research for dressing development.

A new type of sheet hydrogel dressing has recently been introduced. This dressing, ActiFormCool®, confers the additional benefits of continuing pain relief between dressing changes whilst providing a good wound healing environment (Hampton 2004). ActiFormCool® is a second generation hydrogel that differs chemically from traditional first generation hydrogels such as Polyethylene Glycol (PEG). The novel chemistry of ActiFormCool® contains additional properties that modify the way it interacts with the chronic wound environment. This poster describes how ActiFormCool® may contribute to pain relief and enhance healing by dynamically modulating wound moisture levels and exerting an anti-bacterial effect.

What are hydrogels?
Hydrogels are materials that absorb water and swell in aqueous solutions without dissolving. They are manufactured from polymers composed of a backbone of hydrophilic groups that are cross-linked to form a threedimensional structure that can bind up to 3 times its weight in water. Water is retained within the hydrogel structure by hydrogen bonding with a variety of hydrophilic groups that form part of the polymeric matrix.

'Second generation' hydrogels
Wound dressings can be manufactured from either neutral or ionic hydrogels. Both swell as they absorb water but ionic hydrogels can absorb more water.

In neutral hydrogels such as PEG the driving force for gel swelling arises from energy generated by thermodynamic mixing of water in solution with the hydrogel. This comes from the overall free energy of the water-matrix interaction along with a further elastic contribution from the hydrogel polymer.

Ionic hydrogels have an overall charge that gives an additional contribution to the ability of the hydrogel to swell. The ionic interaction between charged groups on the polymer backbone and the electrolyte present in solution is analogous to adjacent like signed charges (i.e. negative repelling negative) on the matrix backbone uncurls the polymer chains, permitting higher water uptake.

ActiFormCool® is a second generation hydrogel where additional pendant ionic sites have been attached to the hydrogel polymer backbone during manufacture. These groups may be carboxylic acid, sulphonic acid or amine groups and when ionsised can form a polyelectrolyte that is capable of swelling over the range of pH values likely to be encountered in the chronic wound environment.

Physiological parameters such as pH, ionic strength (as controlled by the external electrolyte concentration), temperature and pressure can all affect the equilibrium degree of swelling by several order of magnitude. The swelling properties of other hydrogel dressings manufactured from polyethylene oxide gel essentially do not adapt in the same way in response to changes in the wound environment.

Dynamic moisture handling by ActiFormCool®
When hydrogels with high water activity are placed in a dry environment they donate water and will absorb in a wet one. However, the wound environment is not necessarily static; with exudate, and hence moisture, varying in response to environmental factors such as ambient temperature (Voorden & Vosden, 2009). For a hydrogel to be able to respond with ease to a changing environment that may cycle between wet and dry relative to the hydrogel, ionic groups in the hydrogel need to be present. First generation hydrogels cannot achieve such a dynamic response to a changing environment. This can be demonstrated using a polyelectrolyte gel such as PEG based hydrogel as an example.

When the PEG hydrogel is placed in a relatively dry environment of 75%RH it loses water as expected. However, if the environmental %ERH subsequently rises to 95% it continues to lose water to the environment although at a slower rate. As the %ERH continues to cycle between low and high the PEG hydrogel hydrogel remains responsive to the changes.

In contrast, ActiFormCool®, because it is a polyelectrolyte hydrogel, demonstrates a dynamic responsiveness to changes in its environment. A low %ERH will cause water to be lost from the hydrogel but as the %ERH increases to 95% it starts to re-absorb water until the environment again decreases. This re-absorption is seen during multiple 200 minute cycles of hydrogel and lower %ERH environments.

The absorption of the final %ERH is a reflection of the considerable water loss that occurs at 40% RH.

• ActiFormCool® responds dynamically to changes in moisture
• Polyethylene Glycol hydrogels continue to donate moisture to a wet environment
• Measurement of moisture absorption

Water activity is a way of measuring the availability of water for chemical reactions and is expressed as % Equilibrium Relative Humidity (%ERH). ActiFormCool® is a hydrogel hydrogel that can be placed in an environment with a relative humidity of 60% then the hydrogel will lose water until it is in equilibrium with the external environment and the water activity is at 60%. The hydrogel will then absorb the same gibbs free energy as the environment of 60%RH then it will re-absorb water until it is in equilibrium. Water will move from high %ERH to low %ERH.

• Non-ionic first generation hydrogels cannot respond dynamically to changes in wound moisture content
• ActiFormCool® is a second generation ionic hydrogel
• Ionic hydrogels have increased water absorption properties
• ActiFormCool® can respond to changes in moisture levels by dynamically changing its water donation/donation properties
• ActiFormCool® exerts an anti-bacterial effect

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