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# EFFECTS OF WOUND DRESSINGS ON SKIN PROPERTIES

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The hydration and occlusiveness effects on intact human skin of three different wound dressings (Silgel, Mepiform and Opsite Flexigrid) were compared. The results showed that Silgel is more occlusive than Mepiform and Opsite Flexigrid. Thus, if hydration aids wound healing, then Silgel may be more effective than the other two.

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## 1. Introduction

The treatment of chronic wounds, burns and scars is not easy to solve, because the most suitable dressing for wound care depends not only on the type of wound but also on the stage of the healing process. Wound dressing have been employed to speed up the healing process in acute and chronic wounds by keeping healing tissues moist and increasing superficial wound epithelialization [1,2]. Apart of the chronic wounds and burns, the treatment of keloids and hypertrophic scars has also been a concern for dermatologist and plastic surgeons because of the lack of effective methods. Recently, it has been reported that topical silicone gel sheet treatment for such types of scars can be effective. However, the mechanisms underlying its therapeutic effect still remain unclear [3]. With chronic wounds and burns or scars, it has been sugested that the mechanism underlying the therapeutic effectiveness of the dressings is the hydrating effect on the skin.

In the present paper, the occlusiveness of three different wound dressings were studied on intact volar forearm skin using OTTER (Opto-thermal Transient Emission Radiometry) technique and TEWL measurements using the AquaFlux device [4,5].

## 2. Materials and experimental set-up

The dressings investigated were: Silgel (Nagor), Mepiform (Safetec Technology) and Opsite Flexigrid (Smith and Nephew). The first two are silicone-based dressings Opsite being a wound dressing consisting of a thin polyurethane membrane coated with a layer of acrylic adhesive. The features studied are i) the permeability to water vapour (measured with AquaFlux) and ii) the hydration of the skin (OTTER technique). *In vivo* measurements were performed on both left and right volar forearm for 24 hours on six different sites positioned from wrist to elbow, as follows: hydration was measuremed on left volar foream (Sites 1-3) and TEWL (Transepidermal Water Loss) wes measured on right volar forearm (Sites 4-6) immediately after removal of the dressings and subsequently at different intervals of time, at room temperature $\theta=20°\pm1°C$ and RH=40% ±1 %.
TEWL measurements were performed with the AquaFlux, an apparatus which schematic diagram is shown in Fig. 1.

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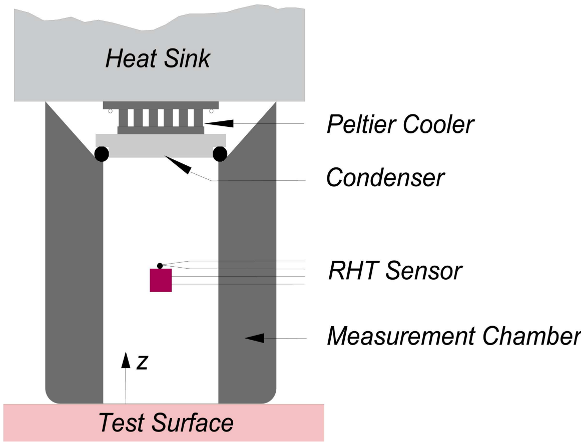


Fig. 1 Experimental apparatus for transpiration measurements.

The AquaFlux uses a cylindrical measurement chamber closed at one end, equipped with an electronically cooled condensig surface where water vapour is removed from the adjancent air by condensing it to ice. The migration of water molecules in the chamber (water vapor flux density or TEWL) can be calculated from Fick's first law of diffusion using the readings from the RHT (Relative humidity – Temperature) sensor.

Hydration measurements have been performed with the OTTER technique, which schematic diagram is shown in Fig. 2.

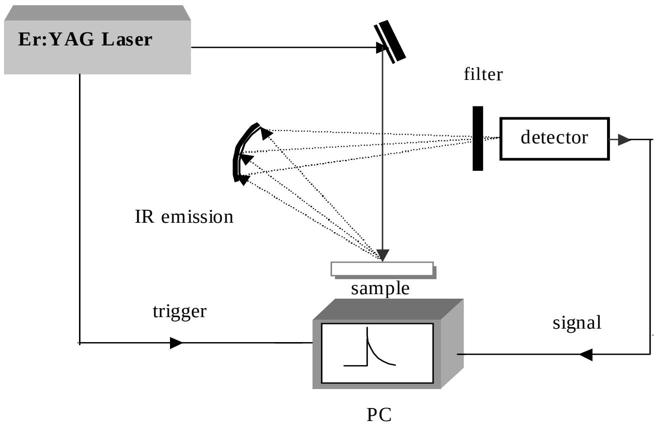


Fig. 2. Schematic diagram of OTTER.

For skin hydration measurements, this technique uses a Q-switched Er-YAG laser, its output at 2.94 μm wavelength being close to the main absorption peak of water, where its 1/e penetration distance is as small as ~ 800nm. This strong absorption in water causes its heating action to be confined to the near-surface of the SC (stratum corneum).

## 3. Results and discussions

Before any *in vivo* measurements, the permeability and the capacity of the dressings to take up water vapour were investigated using the AquaFlux. The results showed that Opsite is the most permeable dressing to water vapour, followed by Mepiform and Silgel. It was noticed that Scotch tape usage over the Silgel reduces the flux density almost to zero. The reason this measurement was taken is that Silgel is not self-adherent, so for *in vivo* measurements it has to be fixed with an adhesive band. The total amount of water desorbed by the samples, showed that Silgel absorbes more water than Mepiform and Opsite. The lower permeance to water vapour of the Silgel and its highest capacity of absorbing water molecules could be due to 1) the large thickness (2.04mm in comparison with 0.25mm for Silgel and 0.06 mm for Opsite) and 2) the white paper fabric and polyester backing. Future work will be planned to quantify these factors. The *in vitro* evaluation of the dressings showed that Silgel is more occlusive than Mepiform and Opsite Flexigrid, emphasizing that Silgel is the most occlusive dressing. Based on these preliminary findings, *in vivo* measurements were performed.

For *in vivo* experiments, the dressings were placed in contact with the skin as follows: Silgel on Sites 1 and 4, fixed with a transparent adhesive band, Mepiform on Sites 2 and 5 and Opsite on Sites 3 and 6. The results are shown in Fig. 3.

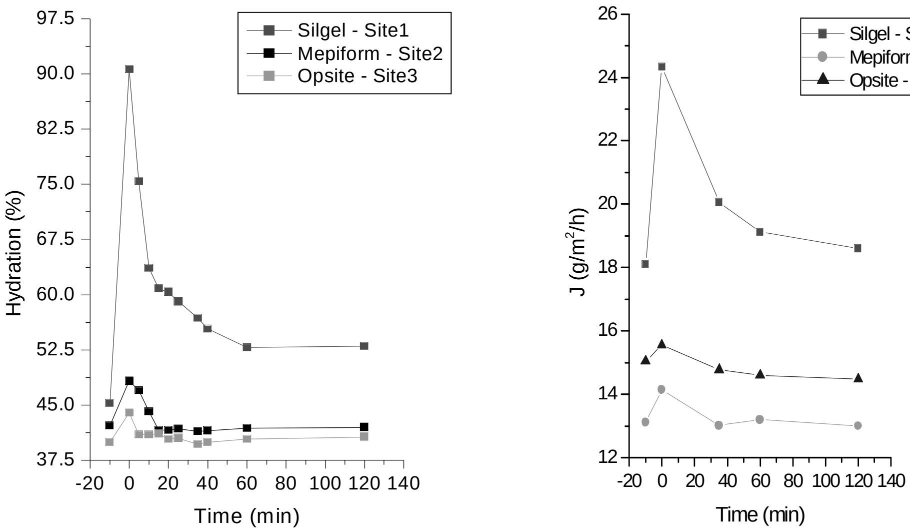


Fig. 3. Sequential changes of skin hydration and TEWL after 24 hours coverage by the three wound dressings. The values measured prior dressings application (controls) are shown at time = -10 min.

Just after dressings removal, both hydration and TEWL were high, reflecting an increase in water content underneath the dressing. Hydration decreased quickly at first and gradually later during the dehydration process. The results shown in Fig. 3 confirm the capacity of Silgel to be more occlusive than Mepiform and Opsite. After 120 minutes, skin hydration at Silgel site is still high in comparison with the value measured before its application, while hydration due to Mepiform and Opsite return to the control value after 40 minutes. TEWL values after occlusive dressings removal are in agreement with the hydration results, being much higher at Site1 occluded with Silgel than at the Mepiform and Opsite-treated sites. These findings suggest that Silgel is the most occlusive dressing of those investigated.

In the above experiments, the Silgel was covered with Scotch tape in order to fix it on the skin. The effect of this on occlusion was studied in another set of experiments, were two samples of Silgel were attached to the skin with only the edges covered with the Scotch tape. The results showed that in the case of Silgel, both hydration and TEWL are lower when 1) the dressing is not covered with the Scotch tape and 2) surface water is wiped off before the measurement. Unlike Silgel, both hydration and TEWL measured immediately after Mepiform removal showed no significant change irrespective of whether water was wiped off or not. From these results it can be concluded that Silgel is more occlusive than Mepiform and the Scotch tape significantly increases its occlusivity.

Dressings application on the skin leads to a decrease in flux density, as expected. Opsite makes an exception, however, which is difficult to understand and asks further investigation. Flux density coming through the Silgel is not changing in time, because of its thickness and paper backing. Unlike Silgel, the flux density coming through Mepiform and Opsite increases after 30 minutes of occlusion and remain constant afterwards. The results are easy to understand if skin-dressings system is substituted by an electric circuit in series, as described schematically in Fig. 4.

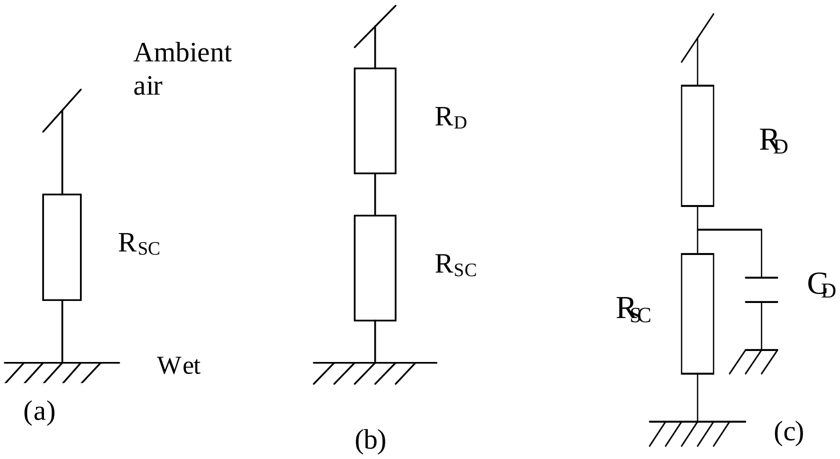


Fig. 4. Schematic diagram of the equivalent electrical circuit equivalent to the skin-dressing system (a) before dressing application, (b) immediately after dressing application, (c) during dressing application.

Initially, the circuit is formed only from the diffusion resistance of the skin, the output reading being equal to the flux density given by the skin itself. The dressing application can be modeled with a resistance $R_D$, (Fig. 4b) together with a capacitor, $C_D$ (Figure 4c), representing the skin/dressing interface where free surface water accumulates; in other words, $C_D$ represents the water holding capacitance of the dressing. The characteristic 1/e time necessary for an equilibrium flux to be established was found to be ~10 min. In addition, there is moisture built-up at the interface causing the hydration of the SC to increase and as a consequence its resistance to decrease. This is why the flux density measured 30 minutes later after dressing application is higher that the one measured at t=0. The subsequent measurements showed no change of flux density above noise, which can conclude that a steady-state has been reached.

An idealized diagram of the flux density-time curve measured during the occlusion process could look like the one shown in Fig. 5.

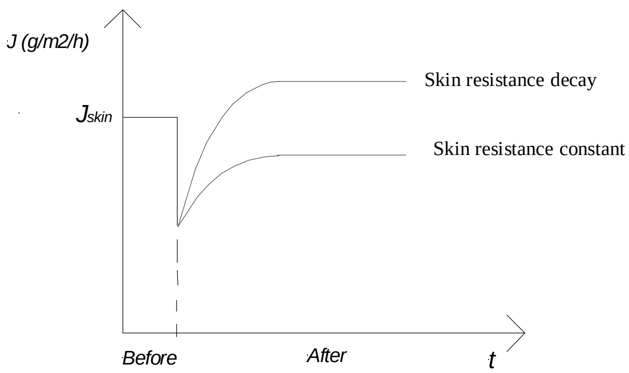


Fig. 5. Schematic diagram of flux density measured during occlusion process, where “Before” and “After” represent the fluxes measured before and after dressing application, respectively.

Immediately after application of the dressing, it has to reach steady-state with temperature, humidity and moisture content. Irrespective of this, the membrane adds a diffusion resistance to the system (Fig. 4b) and therefore the flux generally decreases, as the diagram in Figure 5 shows. As equilibrium is reached, the flux will tend towards a new value, generally higher than that immediately after application as: 1) temperature increases, which generally increases $D_m$ (diffusion coefficient), 2) humidity gradient is established, 3) moisture may accumulate and this may lead to additional transport paths and 4) skin occlusion leads to lower skin diffusion resistance. Depending on the rate the processes mentioned above take place, the equilibrium flux density will tend to values lower or higher than $J_{skin}$.

## 4. Conclusions

The *in vitro* evaluation of the three wound dressings indicates that Opsite is the most permeable dressing to water vapour, followed by Mepiform and Silgel, *in vivo* measurements confirming these findings. If hydration aids wound healing, then Silgel may be more effective than the other two.

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