INDUSTRIAL PILOT PROJECT

Monitoring of the fluid distribution in soft porous materials in real-time using Neutron Radiography

THE INDUSTRIAL CHALLENGE

In wound management, fluid handling is an important attribute for the wound dressing performance. It is therefore of interest to be able to visualize the mechanism of fluid transportation and distribution in real-time through typical heterogeneous soft porous materials. The challenge is to mimic the fluid transport as close as possible to the reality of a clinical setting. This involves slow flow rates of biological fluids to simulate chronic exuding wounds and to have relevant orientation of the dressing to assess the gravitation impact during patient use.

WHY USING A LARGE SCALE FACILITY

The goal using Neutron Radiography (NR) and Neutron Computed Tomography (NCT) is to obtain more refined information about fluid handling properties of wound dressing material. Radiographic and tomographic imaging techniques are non-destructive and allowed us to study the material in its real state, without risk of altering the original material. In addition, the high interaction of neutrons with hydrogen provides a strong sensitivity for detection of a representative liquid, i.e. horse serum, as opposed to using X-rays in combination with a liquid-based X-ray contrast agent. Moreover, the movement and distribution of the liquid can be studied in 'real-time' inside the material, both in 2D and 3D.

HOW THE WORK WAS DONE

Two different wound pad materials were considered to evaluate the potential of NR (2D) and NCT (3D & 4D) to visualise the fluid transport: (1) a heterogenous PUR (Polyurethane) foam and (2) a fibre-based material with super absorbent particles (SAP). Different test fluids and mixtures were assessed to obtain an environment as close as possible to a clinical setting: (1) a salt solution based on NaCl and $CaCl_2$ known as 'solution A' from standard fluid handling tests (EN 13726) and (2) horse serum to have a wound fluid composition as comparable to wound exudate as possible. Deuterium oxide solution was used to avoid excessive attenuation of the neutrons. By using a fluid pump, the flow rate of the test fluid could be controlled and varied down to 0.1 ml/h/cm^2. A custom-made sample holder was produced by Division of Solid Mechanics, Lund University, with an inlet for the fluid pump and to allow the sample to be either horizontal or inclined at 60 degrees (simulating patient use). The NR and NCT experiments were performed at the NeXT neutron imaging (D50) beamline at ILL (Institute Laue-Langevin) in Grenoble, France, during beamtime shifts of a total of 48 hours. The flow rate and test fluid were assessed by screening with 2D radiography of the fluid transport in real time as well as 3D tomography before and after. To conclude, a 4D tomography was run during the fluid transport using a realistic flow rate of a highly exuding wound (0.1 ml/h/cm^2 for 6 hours). An image processing and analysis protocol was developed by RISE.

THE RESULTS AND EXPECTED IMPACT

One of the successes of the study was the simulated wound fluid containing horse serum with deuterium oxide, which resulted in an optimal NR imaging. This means that wound dressings can be assessed in the most realistic setting possible when monitoring the fluid transport using NR. The analysis also gave insight about differences in fluid distribution depending on whether the fluid contains serum or not. This highlights the importance of using a relevant test fluid when developing wound products, and that standard tests with salt containing fluids may be misleading. In addition, the NCT has enabled us to see the fluid distribution inside the wound dressing material in both 3D and 4D, including at slow flow rates, which are relevant to exuding wounds.

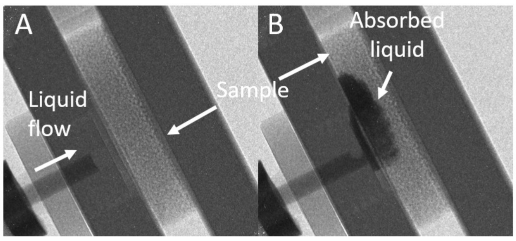

Figure. NR of the wound dressing A) Sample prior to injection of liquid. B) Sample after injection of liquid.

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