Creams and Oils: Possible THz Coupling Media for Rough Surfaces?

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***Abstract-Ex vivo* and in vivo studies of human skin using reflected terahertz radiation (THz) have revealed that THz has potential for use in medical diagnosis of skin diseases. Detected signals could be enhanced via the application of creams or oils. This idea is similar to that in therapeutic ultrasound: hydrophilic gels improve the coupling of the acoustic wave to the stratum corneum (SC). The use of creams or oils to enhance THz coupling to the SC has not been previously explored. This paper elucidates the impact of two types of commercially available ointment on three different pseudo-skin phantoms at THz frequencies.**

I. Introduction

The optical properties of ex vivo and in vivo skin in the terahertz (THz, 1 THz = 10^{12}Hz) range have been reported in [1] and [2]. The transmission of THz through skin is attenuated by water in the skin and also by the strong reflection from the air-skin interface. Reflection loss could be reduced by using the Brewster angle, and/or introducing a coupling material that either reduces the surface roughness of skin or is index-matched to skin. This abstract presents an initial study of two materials that may be useful as THz coupling media, and results are presented to show the improvement in transmission from the use of one of these materials on pseudo-skin phantoms.

A. Possible Coupling Media

Petroleum jelly (white petrolatum, USP) and mineral oil (Sigma Aldrich) were used. The advantages of both materials are their non-toxicity and low absorbance at terahertz frequencies. Both materials are also derivatives of petroleum thus can be considered as similar substances of different viscosity.

B. Pseudo-Skin Phantoms

The test samples used were: the lining of lamb intestine, collagen burn dressing (Integra™), and 180 grit sandpaper. They all have rough surfaces—a property similar to the outermost layer of skin, the stratum corneum. The lamb intestinal lining was washed and dried. Collagen burn dressing was patted dry but was still moist. Sandpaper was included because it is non-organic so hydration and thickness are not variables.

II. Experiment and Results

A thin layer of petroleum jelly was applied to each of the test samples mentioned in Section B and the transmitted signal from a pulsed THz system was measured. The experiment was also repeated using mineral oil and varying thickness of petroleum jelly. There was no increase in the detected signal amplitude with the mineral oil, but an increase was observed when a very thin layer of petroleum jelly was spread on all samples. Results for sandpaper are shown in Figure 1. One difficulty encountered was quantifying what "very thin" is and repeating the thickness experimentally. In addition, there was no increase after three or more repeated applications of petroleum jelly—a decrease was observed instead. The two organic samples were also inspected under an optical microscope before and after application of the jelly and oil. The petroleum jelly cells appear to fill the gaps in the sample, thus may be assisting in smoothing the surface of the sample resulting in reduced diffuse reflection. The actual mechanism that is contributing to the improvement is worth investigating as the results could help identify other potential coupling media. A more controlled experiment is also needed.

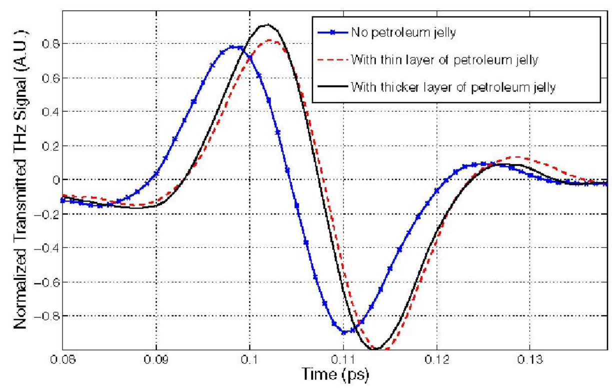

Figure 1. The amplitude of the treated sandpaper (solid and dashed lines) is higher than before treatment.

III. Conclusion

We have investigated the potential use of a coupling medium to improve THz transmission. Although the study is rudimentary, the initial results appear promising. Further investigations will include a larger variety of potential coupling media and simulation results to support empirical studies.

References

[1] A. Fitzgerald, E. Berry, N. Zinov'ev, S. Homer-Vanniasinkam, R. Miles, J. Chamberlain, and M. Smith, "Catalogue of human tissue optical properties at terahertz frequencies," *Journal of Biological Physics*, vol. 129, no. 2-3, pp. 123–128, 2003.

[2] E. Pickwell, B. Cole, A. Fitzgerald, M. Pepper, and V.Wallace, "In vivo study of human skin using pulsed terahertz radiation," *Physics in Medicine and Biology*, vol. 49, no. 9, pp. 1595–1607, 2004.