Smart System for Light Treatment of Chronic Wounds

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Outline

1. The MEDILIGHT Project
   Project partners

2. Health Facts
   Wound types, number of cases, costs, remedial measure

3. The MEDILIGHT SYSTEM
   a. Illumination System + URGO Wound Dressing
      Flexible, high power/efficiency, homogenous illumination
   b. Electronics & Software
      Light controlling and timing, measurement of oxygenation and temperature

4. In-Vitro Testing
   Different healing stages, inhibition of bacteria growth, prevention of overshooting epidermisation,
   final promotion of skin cell growth
**Project Facts**

- **Duration:** 02/15 – 01/18
- **Project Costs:** 3 Mio €
- **Co-funded by the European Union as a H2020 Research & Innovation Action**
- [www.medilight-project.eu](http://www.medilight-project.eu)
Health Facts...

- Chronic (non-healing) wounds:
  - Diabetic foot ulcers
  - Pressure ulcers
  - Leg ulcers (venous stasis ulcers)

  - Significant reduction of quality of life
  - Infections, amputations and even death
  - Increasing with aging of the population

- 170 Mio. people worldwide affected

- Costs are 40 billion € per year

- Difficult to treat

- Therapeutic effect of visible light has been proven

- Blue light: antibacterial effects at the skin surface
The MEDILIGHT System

1. Illumination System
Flexible, Heat Management, Breathability
(re-usable on the same patient)

2. Electronics
Controlling, Logic, Wireless, Battery (non-disposable)

3. URGO Wound Dressing
Several functional layers
The MEDILIGHT System
The Illumination System

LEDs

Back Reflector (Light Harvesting)

Diffusor Layer(s)

URGO Wound Dressing

Wound
The Illumination System – Example Prismatic Diffusor
Diffusor: Efficiency vs. Homogeneity

![Graph showing optical transmission vs. half apex angle for different materials. The graph indicates the best balance between optical efficiency and homogeneity.]

- LEDs
- Back Reflector (Light Harvesting)
- Diffusor Layer(s)
- URGO Wound Dressing
- Wound
Illumination System – Increased Back Reflectance

- Optical Efficiency vs. Back Reflectance
- Diagram showing the components: LEDs, Back Reflector, Diffusor Layer(s), URGO Wound Dressing, Wound

Graph indicates an upward trend as Back Reflectance increases, suggesting improved optical efficiency.
The URGO Wound Dressing

Waterproof backing

Highly absorbing layers

Soft adherent layer (in contact with the wound)
The Illumination System – Diffusor Measurements

Homogeneity $\frac{I_{\text{min}}}{I_{\text{max}}} [%]$ vs. Optical Power Density [a.u.]
Illumination System – Final Design

**URGO Wound Dressing**

<table>
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**Wound**

*direct contact*

*with spacer*
Illumination System – Homogeneity

- with spacer
- direct contact
Illumination System – Homogeneity
Electronics & Software
Flexible LED Foil Prototype (substrate made of PEN)
Measurement of Blood Oxygenation

\[ S_pO_2 = \frac{HbO_2}{HbO_2 + Hb} \]
Absorption of Light in (Oxygenated) Hemoglobin

Oxygenation & Temperature

\[ \frac{V_{\text{red}}}{V_{IR}} = \frac{V_{\text{rms}}(\text{RED}) - V_{\text{DC}}(\text{RED})}{V_{\text{rms}}(\text{IR}) - V_{\text{DC}}(\text{IR})} \rightarrow \text{SpO}_2 \]

Pressure Applied

Pressure Released
In-Vitro Testing of Bacteria and Skin Cells
## The Different Healing Stages

<table>
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<tr>
<th>Healing stage</th>
<th>Infection (Bacteria)</th>
<th>Cleansing (Macrophages)</th>
<th>Granulation (Fibroblasts)</th>
<th>Epidermisation (Keratinocytes)</th>
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| Purpose       | • Limitation of cell proliferation  
• Inhibition of virulence  
• Formation of biofilm  
  
• Modulation of macrophage activity (inflammation mediators)  
• Enhancement of granulation phase  
  
• Proliferation  
• Migration  
• Dermis synthesis (collagen)  
  
• Proliferation  
• Migration  
• Differentiation  |
| Light Schedule | Confidential Data     | Confidential Data       | Confidential Data         | Confidential Data            |
| Device Application | Permanent  
| Sensors | Temperature  
\(O_2\) | Temperature  
\(O_2\) | \(O_2\) | \(O_2\) |
In-Vitro Testing of Bacteria

• Image analysis software „ZMFsoft“ developed
• Different blue light irradiation times and cycles tested
• Image acquisition performed 24h after irradiation
• Evaluation of colony count, area, radius and eccentricity
• Subsequent statistical comparison between the light and control experiments
• Growth inhibiting effects were found for different strains (details are confidential)

→ Reduction of colony size!
Prevention of Overshooting Epidermisation
preventing the wound to close too early (in premature healing phase)
Conclusion

MEDILIGHT...

• treats chronic wounds with blue light
• flat, flexible, and homogenous illumination system
• Breathability (management of patient’s exudates)
• Heat Management (from LEDs)
• Measurement of blood oxygenation
• Monitoring the temperature
• Growth of bacteria was significantly reduced
• Indications for proliferation of skin cells
• Overshooting of skin cell growth in early wound healing phase was prevented
Thank you for your attention.

Basel, Switzerland