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Full Length Research Paper

The Skin: Goal of the EU Polybioskin Project

[1]P. Morganti, [2]M. B.Coltelli, [2]S. Danti, [3]E. Bugnicourt

[1]Professor in Skin Pharmacology, Campania University “Luigi Vanvitelli”, Naples, Italy; Visiting Professor at China Medical University, Shenyang; Director of R&D Nanoscience Centre MAVI, Aprilia (LT), Italy
[2]Researcher in Materials Science, Interuniversity Consortium of Materials Science and Technology (INSTM), unit of Department of Civil and Industrial Engineering, University of Pisa, Pisa, Italy
[3]Innovacio i Recerca Sostenible, Castelldefels (Barcelona), Spain.

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Cosmetic, personal care, sanitary and advanced medications have an increasing global market of about 50 billion dollars. All these products are in continuous contact with the skin and therefore, have to be produced with a high grade of safeness. Moreover they have to be possibly biodegradable and really effective. The EU PolyBioSkin research project aims to produce them by the use of biopolymers obtained from waste materials in order to reduce the petrol-based polymers also. This paper will report some data recovered by the first PolyBioSkin consortium kick off meeting organized by the SME project coordinator IRIS last July in Spain.

Keywords: PolyBioSkin Project; Facial Beauty Masks; Advanced Medications; Electrospinning; Baby Diapers; Chitin Nanofibril; Polylactic acid; Filaggrin.

INTRODUCTION

Cosmetics, personal care, sanitary and advanced medications, designed to protect the skin from the interior and exterior aggressions, had in 2014 a global market value of US$ 47 billion (1,2). The majority of these products, the activity of which is in direct contact with skin and mucous membranes, are still made from fossil-based polymers, non-recyclable and non-biodegradable. Thus, the aim of the EU PolyBioSkin research project is to make innovative bio-based polymers to produce biodegradable non-woven tissues, because of the growing ecological awareness and the consumer demand for products more sustainable for environment, combined with the evolution of the health concept (Figure 1).

These innovative tissues will be produced by the use of two main classes of bio-based polymers, such as polysaccharides, (cellulose, starch, chitin nanofibrils/chitosan) (3,4), and biopolyesters, such as polylactic acid (PLA) and polyhydroxyalkanoates (PHAs) (5-7), all obtained from biobased sources. Thus for example, cationic polymers, as Chitin nanofibrils, acting as biological carrier, absorb protons acting, by the so-called *sponge effect,* as a sink for other counter ions. The increase in ions concentration on the cell endosome results in an increased osmotic pressure that results in membrane rupture and, therefore, the delivery of the desired cargo to the cytosol of the designed cells (8). Moreover, as developed by renewable, sustainable-sourced and advanced technologies, they will be made to offer antimicrobial, antioxidant, and anti-inflammatory activities as well as absorbency, and skin compatibility properties.

Different technologies will be considered in the project such as flat die extrusion and electrospinning. With the development of the electrospinning technology (Figure 2) (9) it is now possible to make complex non-woven tissues with tailored porosity, thickness and strength useful for skin repair and the skin regeneration. It should be reminded that, while wound repair represents a process to create continuity in the skin structure without the tissue reconstruction, regeneration involves restoration of the function and morphology of the original tissue layers. For this reason, wound repair often results in scar formation, while regeneration is achieved without scar formation. This is one of the PolyBioSkin goals.

The aim of the project is, in fact, to solve wound healing without hypertrophic scar or keloid formation, by identifying the ideal combination of bio-materials topography, chemical stimulants and concentration of active ingredients to be employed for supporting the organized arrangement of the natural skin layers. The

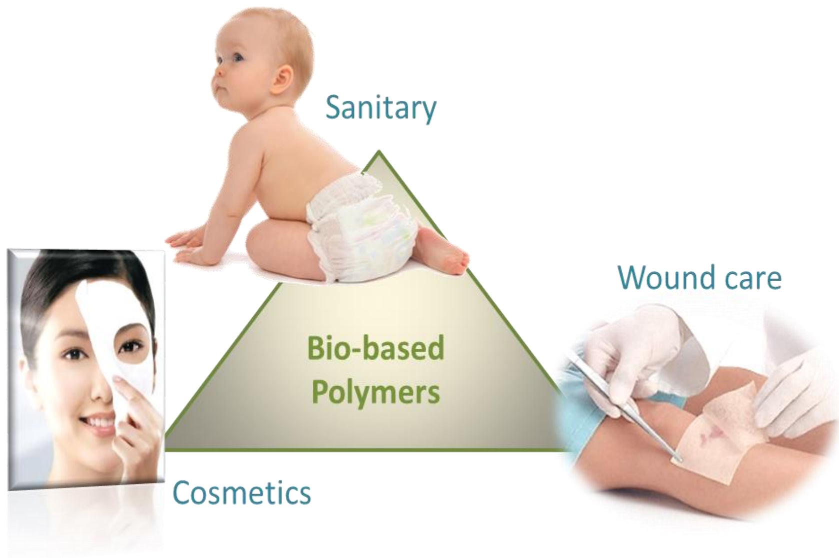

Figure 1: Evolution of the health concept and PolyBioSkin goals

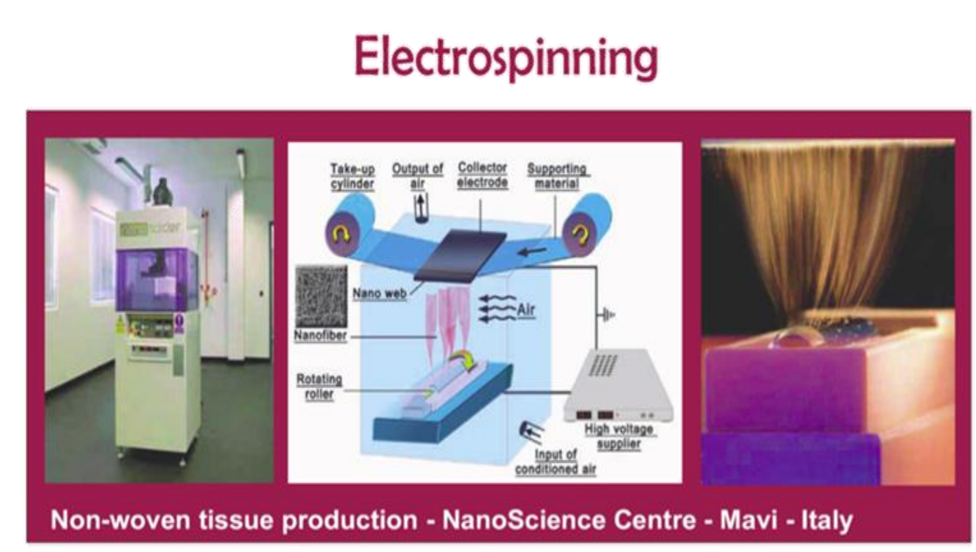

Figure 2: Electrospinning technology

composition of the non-woven tissues to be made by tissue engineering methodologies has to influence, for example, the ability of the materials to absorb nutrients and exudates from the wound bed, modulate water permeability and maintain the nature of cell interactions, also supporting their tensional integrity. All these parameters are indispensable to recreate the mechanical features and the microenvironment of the native tissue by the use of specific scaffolds, reinforced with selected bioactive molecules. The function of scaffolds in the regenerative medicine, in fact, is to direct the growth of cells seeded within the porous structures of the scaffolds or of cells migrating from surrounding tissue, combining together three key elements: cells, bio-materials and signalling molecules (Figure 3) (10). By the use of these well-structured non-woven tissues, it will be possible to mimic the natural characteristics of the skin, providing a favourable environment for its correct regenerative process.

On the other hand, other biodegradable products will be realized by the project, such as diapers with anti-inflammatory and antimicrobial effectiveness and bioactive beauty masks with moisturizing and anti aging activity. These products will be made by the same non-woven substrates, used as environmentally-friendly and skin-friendly vehicles, exploiting the properties of

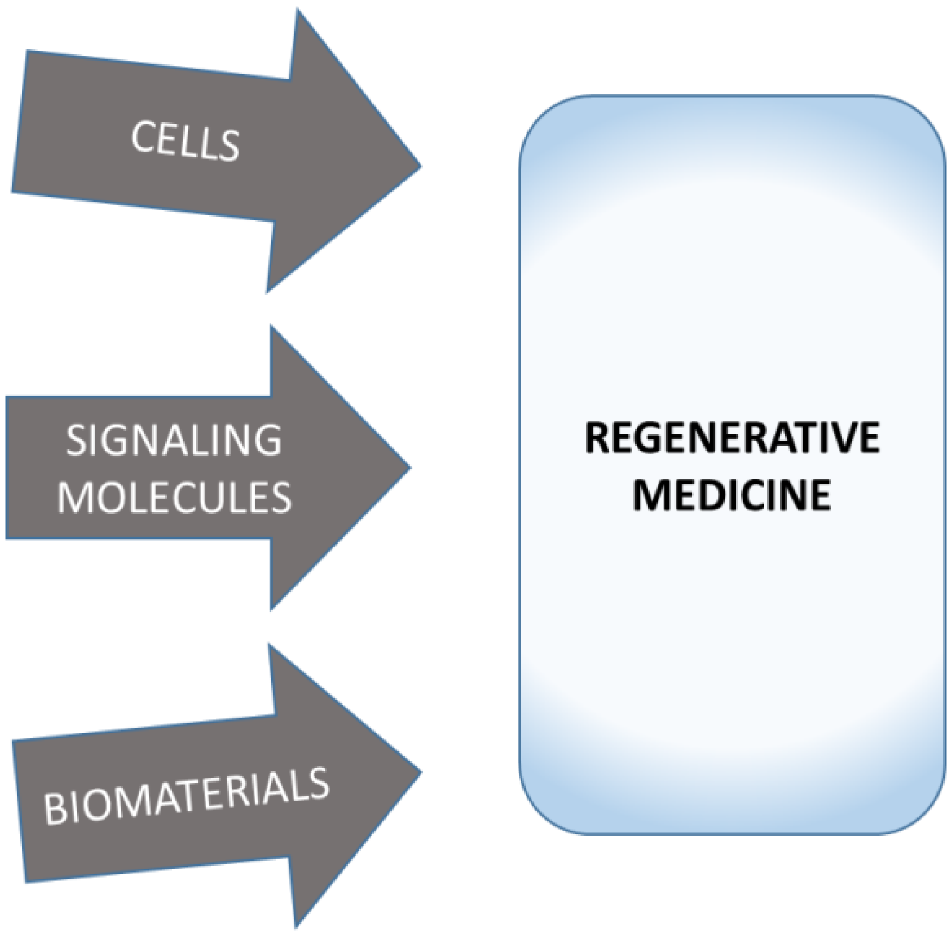

Figure 3: The three Key elements of the regenerative medicine

active ingredients entrapped into their innovative structures. Over the next three years, therefore, these categories of products (i.e. diapers, facial beauty masks and medical dressings) will be developed and validated from all the experts constituting the PolyBioSkin consortium, keeping into account their environmental and economic sustainability and compliance with safety and regulatory requirements. This consortium, in fact, combines the expertise of twelve partners from seven European countries, including five partners from academia and technology institutes: Consorzio Inter Universitario di Scienza e Tecnologia dei Materiali (INSTM, Italy), the University of Westminster (UK), Association pour la Recherche et le Développement des Méthodes et Processus Industriels (ARMINES, France), Tehnoloski Fakuktet Novi Sad (Serbia) and University of Gent (Belgium); six industry participants (SMEs): Innovacio i Recerca Sostenible (IRIS, Spain, project coordinator), Bioinicia (Spain), Fibroline (France),Texol (Italy), MAVI Sud (Italy) and Exergy (UK), as well as the European Bioplastics association (Germany).The first kick-off meeting, hosted from the project coordinator IRIS, has been held in Castelldefels, Barcelona, Spain the past 17 July of this year, to define the general program and put the basis of collaboration, interchanging the different scientific and technical knowledge of all the participants (Figure 4). During the two days of meeting all the project partners have reported their own experiences, indispensable to develop the ambitious program of making these innovative bio-polymers and tissues by the use of renewable raw materials, obtained from biobased sources. Smart products that may respond to stimuli such as pH, temperature, biological factors, light, etc, in order to arrive at the desired location, exerting their desired function to overcome the skin barrier. So doing, it will be possible to realize effective and safe products with a reduced environmental footprint (Figure 5) (11) for a sustainable economy, respecting Planet biodiversity.

Figure 4: Participants to the PolyBioSkin Research project

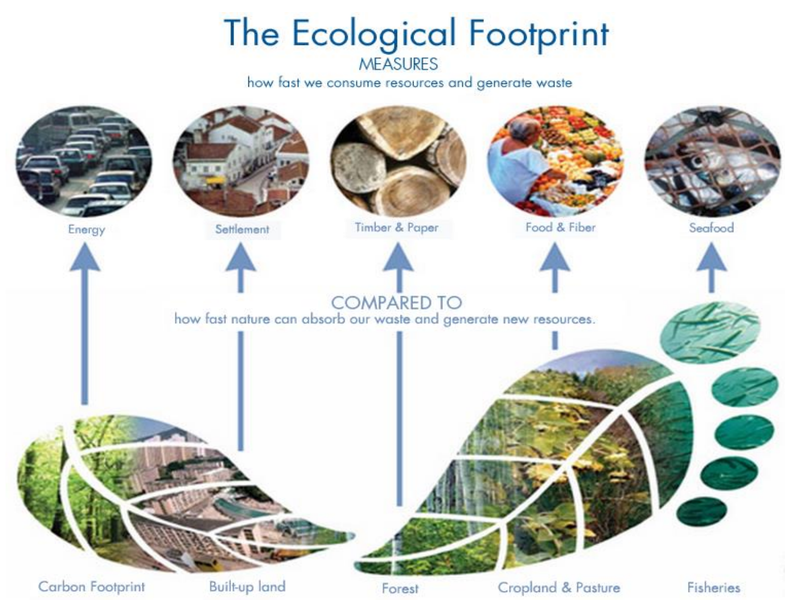

Figure 5: Environmental footprint (reproduced with permission from ref. 11)

The skin substrate

Naturally the knowledge of the skin substrate characteristics and necessities is another point to be deepened. The skin function, in fact, is to serve as barrier, protecting externally the human body from infection agents, chemicals, systemic toxicity and allergens, while internally helps to maintain homeostasis and to protect from enhanced water loss (Figure. 6) (12). Moreover, this barrier function differs between

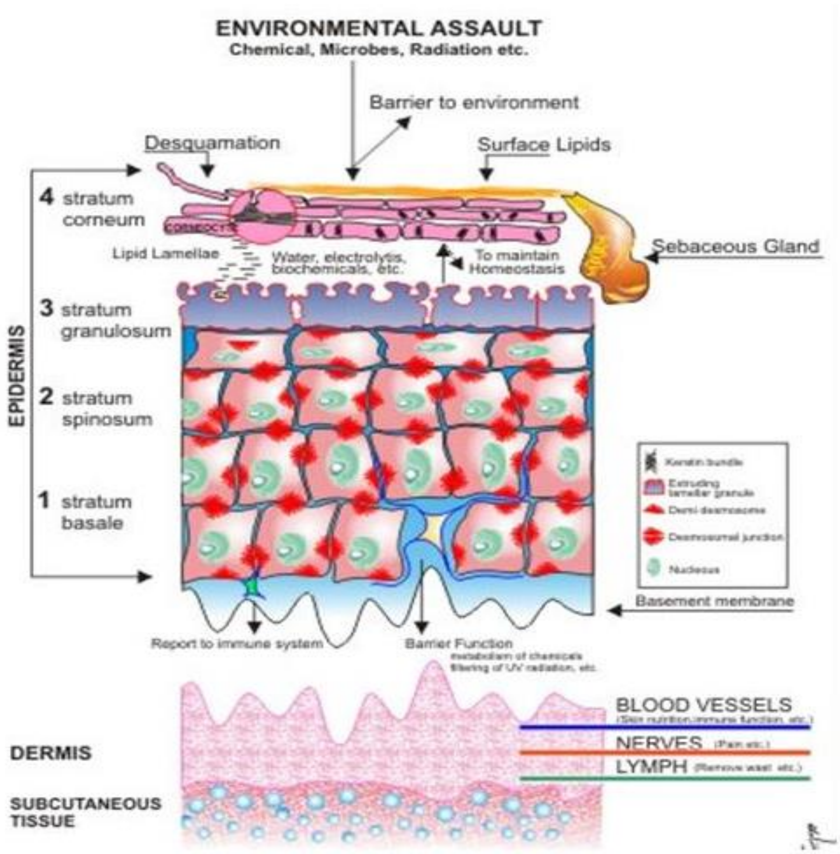

Figure 6: Skin barrier functions.

individuals due to biological variation, as a result of inherited genetic variations, negative environmental or extrinsic factors and age. While many genetic changes determine a person predisposition to a skin barrier defect, extrinsic factors, such as the weather and detrimental skin care practices, interact with these genetic changes, determining its severity improving, for example, the permeability barrier function. However, the skin barrier greatly depends on the structure and composition of the uppermost layer of the epidermis, the stratum corneum (SC), which is made up of flattened and a nucleated cells surrounded by a continuous and organized lipid matrix (13).

The composition of SC lipid matrix, composed by cholesterol, free fatty acids and ceramides, is made of a highly ordered, 3-dimensional structure of packed lipid bilayers, known as lipid lamellae. However, not only the lipid composition but also the lipid organization is crucial to prevent the excessive water loss through the epidermis and to avoid that compounds from the environment permeate into the viable epidermal and dermal layers, provoking an immune response. Thus the amount of water and compounds which enter the skin is dependent not only on the thickness of the SC, number of layers of corneocytes, their size and cohesion, but also on the proteins involved in the keratinizing process and their organization in the SC, tuned into the quality and quantity of both lipids, and water. Additionally, filaggrin (FLG) (Figure 7) is another crucial component for the alignment of keratin (14,15). This protein, cross-linked into a mechanically robust cornfield cell envelop, provides a scaffold for the extra cellular lipid matrix, giving structural and mechanical integrity to the SC. On the other hand its degradation products, known as natural moisturizing factors (NMF), account in part for the water-holding capacity and maintenance of acidic pH of the SC, regulate the desquamation enzymatic activity, lipid synthesis and inflammation (16). Thus, the ingredients used for healthy or diseased skin, could change the lamellar organization and the packing of the lipid matrix, interfering with the production of barrier lipids and the maturation of corneocytes, thereby modifying the skin permeability.

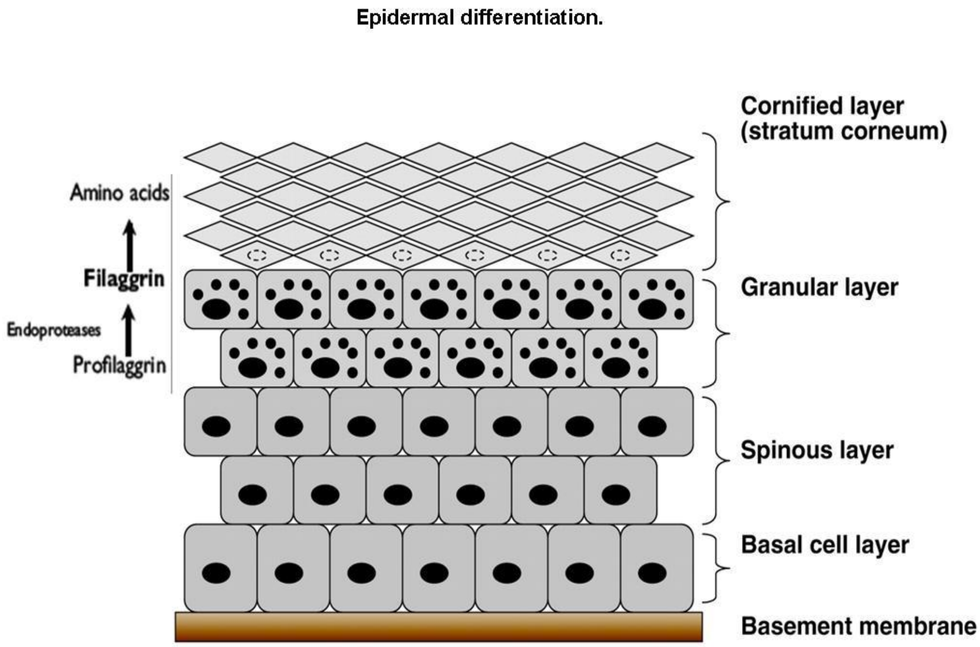

Figure 7: Filaggrin Function (Figure modified from Southerland et al (15)).

CONCLUSION

In conclusion, it results important to deeply know the active ingredients and the vehicles used to treat the skin as well as to understand the interactions between topically applied substances and the epidermal biochemistry to enhance the possibility to tailor a proper skin care. This are naturally other goals of the PolyBioSkin project, that considers the skin barrier dysfunction and sustainable repairing technologies central to each programmed treatment and product.

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