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soap, perfumery & cosmetics

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Sun care

The golden touch

Benelux & Germany
Shifting sales routes

Ingredients
Ahead of the game

Bottles, jars & tubes
Eco-conscious luxury

Mosses have great potential as cosmetic ingredients, but have been largely neglected by the industry until now, mainly due to sustainable sourcing problems. In collaboration with the University of Freiburg and Greenovation Biotech, Mibelle Biochemistry now has access to this whole new plant division, produced in the laboratory. For the first time our technology will enable the cosmetics industry to formulate moss-derived ingredients into their products in a commercially feasible and sustainable way.

About 470 million years ago non-vascular land plants conquered the earth[1] – among them were the bryophytes, comprised of hornworts, liverworts and mosses. Mosses are eukaryotic plants. Compared with higher plants, they have no flowers, roots or vascular tissues. Mosses can be found not only in forests, but also in places where higher plants cannot survive due to temperature, altitude or the lack of soil, for example in the hot desert, in cold areas such as the tundra, in mountains 6,000m above sea level, on stones and even in cities on stone-flagged streets.

The magic of moss

Bernhard Henes, **Fred Zülli**, **Holger Niederkrüger**, **Andreas Schaaf**, **Thomas Frischmuth**, **Eva L Decker** and **Ralf Reski** explain how biotechnology is being used to unlock moss for new active cosmetic ingredients

Besides their resilience against direct sunlight, heat, cold and frost, they also possess distinct resistance mechanisms against microbial attacks. They can only cope with huge environmental stresses due to their pristine gene sets. This makes them resistant and versatile in comparison with the more specialised higher plants.

These features have been captured in an article in *The American Scholar*, published in October 2014: *Tough as Old Moss: Credit resilience to environmental change for its longevity*. Recently it was found that mosses even continue to grow having being frozen for over 1,500 years under hundreds of meters of ice[2,3]. All of these adaptation strategies offer unique properties and opportunities for the cosmetics industry, which is always striving for innovation.

APPLICATIONS & LIMITATIONS

Mosses filter all necessary nutrients from the air and rain to survive, but via this process they also accumulate air pollution particles, such as heavy metals, polycyclic aromatic hydrocarbons (PAHs) and dioxins. To protect themselves from these toxins they have developed their own anti-pollution matrix with a large set of antioxidants[4] to mitigate the effects of accumulating toxic compounds.

To use moss as a new raw material in cosmetic products poses a challenge, mainly because collecting mosses from nature is not sustainable, as they grow slowly and are often crucial parts of an ecosystem or even protected by law.

Furthermore, the lack of reproducibility in collecting identical species can lead to high variations in extractables and – in worst cases – to 'out of stock' situations.

Contamination with the aforementioned toxins would lead to high purification costs. And while alternative cultivation in greenhouses is possible, it is slow and consumes a lot of land and water.

This explains the lack of a moss product being used as a cosmetic ingredient so far. The most famous Irish moss, for example, actually is a red alga while Iceland moss is a lichen, even if both are often perceived as mosses.

The use of moss-based products in cosmetics has gained momentum and is now feasible in large-scale cultivations; we demonstrated that the sterile and controlled biotech process is not only reproducible but also sustainable

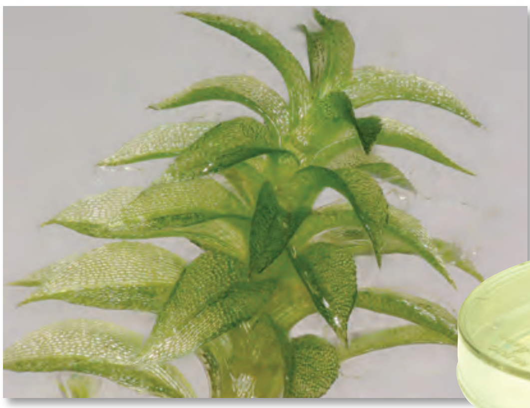
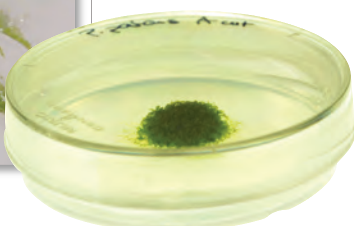


Figure 1 (*left*) *P. patens* leafy gametophyte. Figure 2 (*above*) Protonema used for liquid culture. Figure 3 (*below*) Leafy gametophytes on agar plate



PHYSCOMITRELLA PATENS & CULTIVATION

Despite being extremely small the moss *Physcomitrella patens* is used in many scientific groups as a model organism in different plant research fields. The full genome of *P. patens* has been sequenced. Homologous recombination allows the stable construction of knockout mutants used to study gene function[5].

The fact that post-translational modifications, such as protein glycosylation, are common in eukaryotes, including *P. patens*, provides the prerequisites for developing a production platform for glycosylated recombinant proteins as potentially powerful active ingredients for the pharmaceutical industry.

The visible part of the moss plant is called the leafy gametophyte (figure 1).

Leafy gametophytes can re-differentiate into protonemata: from the leaf back to moss stem cells. This filamentous protonema (figure 2) is a root-like system that rebuilds new leafy gametophytes by budding – hence differentiating again.

By cutting protonemata or leafy gametophytes, new protonema grows (figure 3). This unique mechanism is proposed as an ideal study model for research on epigenetic changes[6] because it constitutes an easily inducible reprogramming cascade.

It is even possible to grow this moss in a controlled bioreactor using liquid media. For this, a regular slicing of the moss is needed and the plant material is converted into homogenous, floating protonema cells with a high surface for energy, substrate and product transportation.

Professor Ralf Reski from the University of Freiburg is one of the founders of Greenovation Biotech, the company using this approach. It developed a reproducible and sustainable liquid cultivation system in a bioreactor to cultivate *P. patens* in up to 500l, axenic (free of other organisms) conditions. *P. patens* is cultivated on solid and in liquid inorganic media photoautotrophically (whereby energy is generated from light and carbon dioxide).

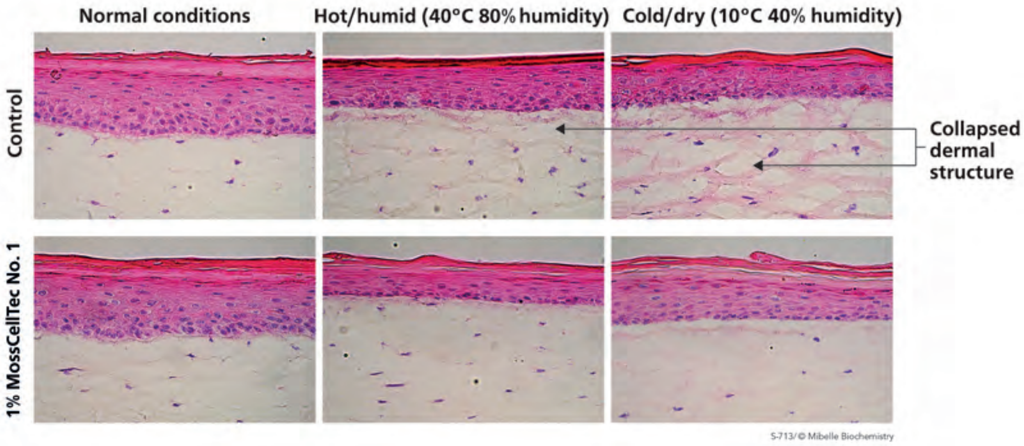
Greenovation Biotech developed a GMP production platform using *P. patens* for biopharmaceutial products including growth hormones and human glycoproteins[7,8].

This system allows Mibelle Biochemistry to grow the pristine wild-type *P. patens* on a large scale to produce raw materials for completely novel and natural cosmetics. Using this powerful technology any desired moss species that adapts to liquid culture could be grown, disclosing promising new prospects for the industry.

Mibelle Biochemistry developed a new cold pressing (>200 bar) extraction method to be able to collect all water-soluble ingredients. This mild method allows for a completely natural end product – containing plenty of potent ingredients – to be obtained.

Figure 4

Skin adaptation to environmental changes in hot-humid conditions (40°C, 80% relative humidity (RH), 30 minutes) and cold-dry conditions (10°C, 40% RH, 15 minutes). Hematoxylin-eosin staining



MOSSCELLTEC NO. 1

An example of a powerful application is MossCellTec No. 1, which demonstrates a protection effect in reconstructed skin that is exposed to hot-humid and cold-dry conditions (figure 4). To this end, a water extract of the moss *P. patens* was dried on isomalt and tested *in vitro*. A 3D human reconstituted skin model was treated with 1% MossCellTec No. 1. It was found that skin treated with MossCellTec No. 1 showed superior adaptation to environmental changes in comparison with untreated skin.

The disrupted collagen structure cannot compete with the resilience of the treated sample. This effect can be used and marketed for cosmetic products, and is just one of many potential future applications of moss-derived raw materials.

Mosses were on the frontline among the species that actively transformed primitive earth into a green planet. They encode genes and proteins long abandoned by higher plants.

The use of moss-based products in cosmetics has gained momentum and is now feasible in large-scale cultivations. We demonstrated that the sterile and controlled biotechnological process is not only reproducible but also sustainable. This is an exciting opportunity for the production of novel cosmetic ingredients and opens up a completely new field that uses the plant division Bryophyta ●

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