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Microalgae as sustainable source of powerful actives

The sea has always been an immense source of precious materials, nutrients and inspiration to humanity as a whole. Throughout the centuries mankind has turned to the sea to obtain products to sustain its life and its evolution. The vast expanse of water covering our planet has been at the origin of life and is fundamental to the equilibrium of physical and biological cycles on Earth. Its oceans and their depths are interwoven with our history as a species as well as being at the very root of legends and myths giving birth to many of our civilisations.

Today's 'green' cosmetic industry has turned to the sea in a quest to search for novel ingredients in order to provide elements of improved efficacy, natural origins, innovation and sustainability to modern cosmetic products particularly as regards active materials. It initiated a 'blue' trend which is here to stay, offering an exciting and seemingly infinite spectrum of possibilities. As always, it is essential that such product strategies are implemented following a code of respect for the environment, true industrial scale to satisfy the real needs of cosmetic manufacturers which may expand across borders and a renewable approach which does not entail tampering with the ecosystem or altering natural biodiversity.

One particularly interesting and rich group of marine organisms which is capable of providing a wealth of benefits for cosmetic application is microalgae. Modern patented technology allows us to obtain specific species in sufficiently large quantities to satisfy the formulator's quality and performance needs by controlling the farming environment and ensuring true sustainability and safety. An extremely important step in the production phase is the use of green energy produced via closed circuit waste recycling systems where the resulting CO_2 is purified and fed as an essential metabolic element to the microalgae, ensuring the whole process has the lowest possible carbon footprint (Fig. 1). The carefully controlled greenhouse system allows isolation from external contamination while exploiting

the most favourable climate and sunlight conditions of the Mediterranean thanks to its geographical location.[1]

Back to the future

The origin of microalgae starts almost at the beginning of life itself. They are microscopic single-cell organisms that can survive independently, feed and multiply ensuring the functioning of major biological cycles and the maintenance of biodiversity on Earth.

Microalgae grow thanks to photosynthesis, and thanks to their internal metabolism can produce naturally original and unique compounds and are therefore of huge interest for the cosmetic industry. These miniature chemical plants are being studied and used as a biomass also for other purposes such as sourcing green energy and generating food supplements.

By feeding on the riches of the ocean, microalgae concentrate all the beneficial properties of the marine environment. The biomass can be purified and when integrated into cosmetic formulations, microalgae extracts provide the skin with valuable compounds which are essential to

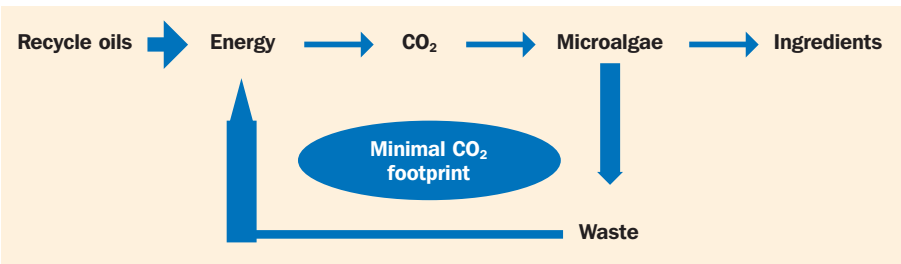

Figure 1: *Sustainable eco-friendly process.*

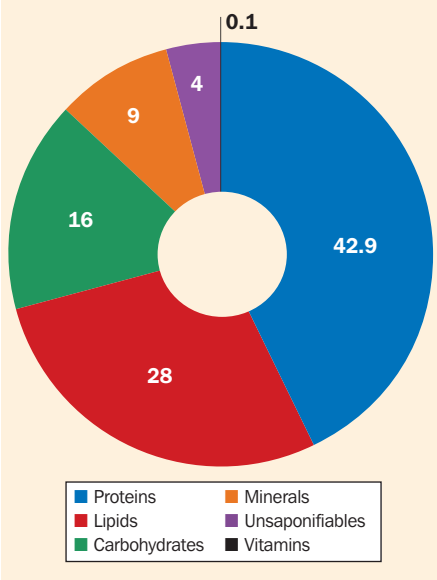

Figure 2: *General composition of microalgae (approximate).*

its metabolism and contribute to its health and beauty (Fig. 2).

The main component is constituted by proteins, which are especially interesting as a source of amino acids. They act primarily as water-binding, conditioning and structural agents, while some show antioxidant properties and even wound-healing abilities.

Lipid composition is also particularly relevant and varies with the species. In order to differentiate from vegetable oils, microalgae are often rich in long chain fatty acids such as C20 or C22 and are a well-known source of omega-3. The lipid content includes liposoluble vitamins (A, D, E and K), phospholipids, glycolipids, sterols and carotenoids, all known to play a beneficial role in protecting the skin against the ageing process.

Additionally we find a selection of carbohydrates including sugars, starches and fibres. These can play a major role in skin hydration and conditioning. Carbohydrates are well known to absorb and retain water.

Furthermore there is also presence of unsaponifiables, minerals and vitamins that are species specific. Most importantly, these can help to protect lipids and proteins present in the skin.

With such a diverse and rich composition microalgae offer a vast potential of beneficial actives to the cosmetic chemist.[2]

Thanks to its advanced research and backed by its long term involvement with the green biofuel industry, Natura-Tec developed Marine BlueVital C, a high performance natural and fully Ecocert material based on patented microalgae technology in order to offer a highly effective anti-wrinkle active ingredient designed to combat the signs of ageing and restore optimum skin condition. Such benefits are particularly sought after by the majority of consumers since, by opposing the stresses of modern life, current and future cosmetics can thus help stimulate our sense of wellbeing.

Developed from the *Cylindrotheca fusiformis* microalgae species,[3] a diatom with an elongated silica shell shape (Fig. 3), Natura-Tec's Marine BlueVital C shows a complex structure of ingredients beneficial to the skin, such as amino acids; eicosapentaenoic acid (EPA), an omega-3 that plays a role in inhibiting leukotrienes which are mediators of inflammation;[4] carotenoids, particularly fucoxanthin, a major antioxidant[5] and sterols, especially cholesterol, well known for its role in maintaining

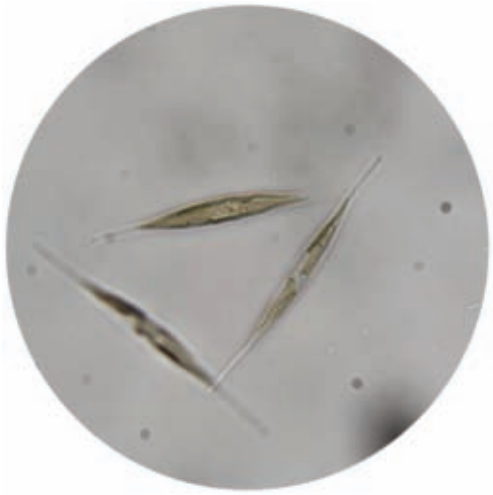

Figure 3: *Cylindrotheca fusiformis diatoms.*

good skin condition and structure.[4]

As a powerful anti-wrinkle active and antioxidant, Natura-Tec Marine Bluevital C acts to remove free radicals and helps prevent cell structure damage in the dermis layer. It stimulates the synthesis of collagen (a protein responsible for supporting skin growth and organisation) and elastin (helping to maintain skin elasticity, tone and texture) (Fig. 4).

Ageing process

Ageing of the skin occurs at several levels. The antioxidant defence system modulates the level of reactive oxygen species (ROS) that are produced during cellular respiration and energy metabolism. During skin ageing, cells lose their ability to regulate the general ROS and suffer from oxidative stress. In the epidermis and dermis, a decrease in keratinocytes and melanocytes, as well as fibroblast proliferation and migration, leads to a decline of cellular activity and protein synthesis (Fig. 5).

Additionally, the barrier function of the skin depends on the stratum corneum extracellular lipid matrix, which includes ceramides, cholesterol, and free fatty acids. Cholesterol in cosmetics can help maintain skin's normal function. It is also a stabiliser, emollient, and water-binding agent.

One of the primary elements in keeping skin healthy is making sure the structure of the epidermis (outer layer of the skin) is intact. The mechanical resistance of the epidermal barrier is mainly due to the functional elements: corneocytes, corneodesmosomes, lipids (including ceramides, cholesterol), microbial peptides, natural moisturising factor (NMF) and sebum.[6]

The sebum protects human skin surfaces from lipid peroxidation due to exposure to UV light and other sources of oxidation that can damage collagen fibres and causes the accumulation of abnormal elastin. While the oil and fat components of

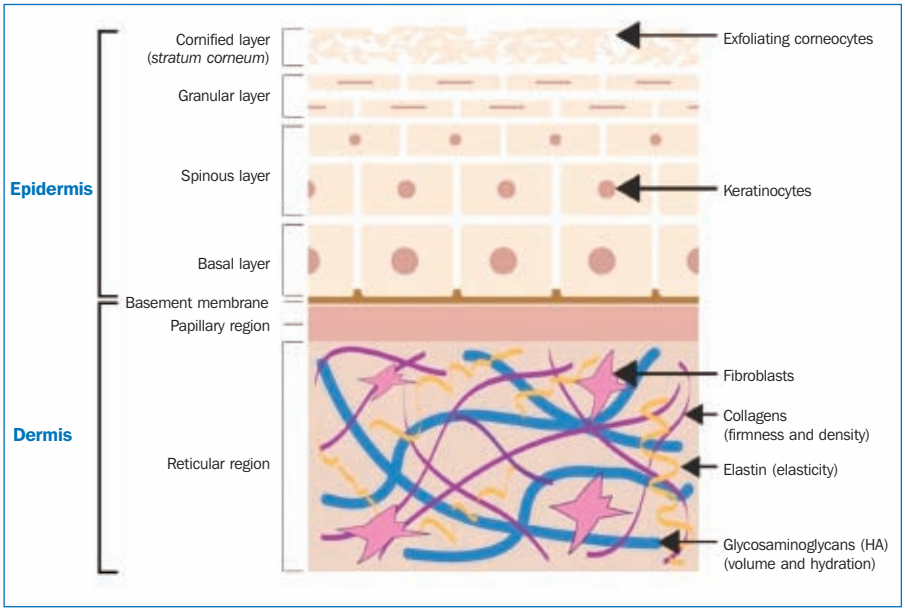

Figure 4: *Skin structure.*

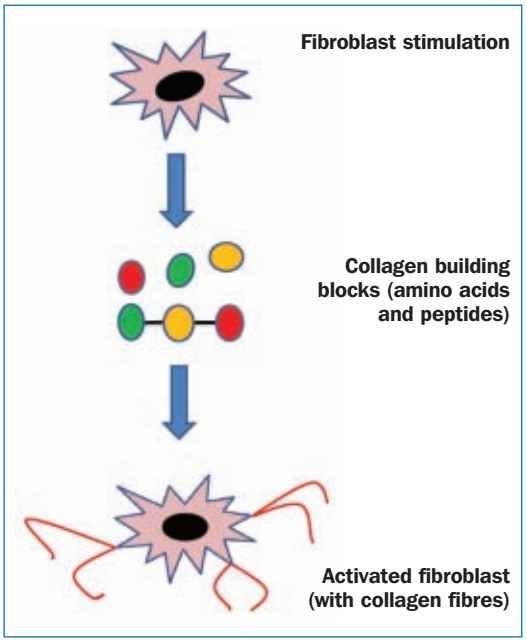

Figure 5: *Collagen production with fibroblast stimulation.*

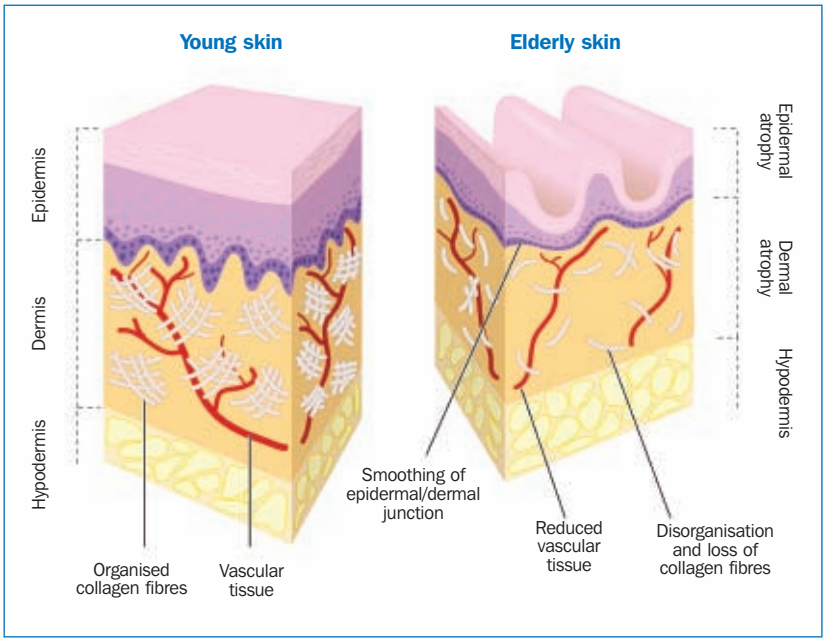

Figure 6: *Skin ageing changes.*

the skin prevent evaporation and provide lubrication to its surface, it is actually the intercellular matrix, along with the skin's lipid content, that gives skin a good deal of its surface texture and feel.[7,9,10]

The intercellular matrix is the skin's first line of defence against water loss. When the lipid and NMF content of skin is reduced, we experience surface roughness, flaking, fine lines, and a tight, uncomfortable feeling. The longer the skin's surface layer (*stratum corneum*) is impaired, the less effective the skin's intercellular matrix becomes (Fig. 6).

Our research shows that Natura-Tec Marine BlueVital C (now referred to as 'the new marine active') encourages the production of collagen and elastin, dermo-proteins naturally found in the skin. Such proteins are generated and found in the dermis and provide structure and support to our skin. The ageing process diminishes the skin's ability to regenerate such important elements of its structure leading to a disorganised state which results in the formation of wrinkles and expression lines which then become deeper and more marked with time. Skin becomes less supple and loses its smooth appearance. It is therefore essential to stimulate the skin's ability to maintain its regenerative metabolism by providing essential elements and nutrients which help it maintain and protect its healthy state.[8]

In vitro tests

The new marine active is a powerful anti-wrinkle active which strongly stimulates production of structural skin proteins. *In vitro* tests showed the capacity of the new marine active to stimulate cellular proliferation and *ex novo* synthesis of collagen. The treatment of skin fibroblasts with the new marine active significantly increased collagen synthesis compared to an untreated control cell culture.

Collagen synthesis study

Different dilutions of the active were added to the wells containing cells in confluence. Cells were exposed to each solution for 24, 48 and 72 hours. At the end of incubation period, medium was collected in order to determine the concentration of fibrillar collagen produced and released by the cells. The determination of collagen synthesis was carried out by quantitative dye-binding method.

The new marine active has an immediate and significant efficacy on collagen synthesis at 2% (Fig. 7). At a smaller dosage it has a time dependent excellent efficacy. When used with 0.5% it shows almost the same collagen production as with 2% over a slightly longer period (Fig. 8).

In vivo test

In vivo tests carried out with a formulation containing 1.5% of the new marine active, show a significant and visible anti-wrinkle activity.

The aim of the test is an *in vivo* evaluation of possible changes of the wrinkles, after the repeated hemi-facial application (2 times per day) of a cosmetic formulation on healthy skin of two cosmetic products (active formulation containing 1.5% of the new marine active/placebo formulation without active).

The instrumental controls have been

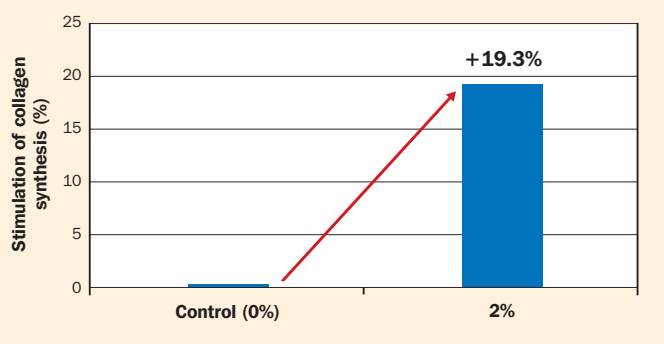

Figure 7: *Capacity of Natura-Tec Marine BlueVital C to stimulate synthesis of collagen on fibroblasts at 2% in 24 hours.*

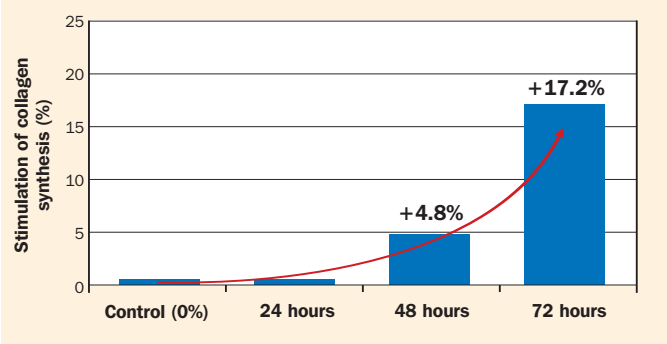

Figure 8: *Capacity of Natura-Tec Marine BlueVital C to stimulate synthesis of collagen on fibroblasts in 24, 48, and 72 hours at 0.5%.*

performed before the beginning of the test to obtain a skin basal condition evaluation (T0), after 30 days (T1) and after 56 days (T2) of application.

The cutaneous micro-relief evaluation has been performed by a Dermatop Blue system that uses the Breuckmann technology based on a patented fringe projection unit using blue light combined with imaging techniques (Fig. 9).

Images are then re-elaborated by the Dermasurf software that uses a scale of colour to visualise depth and volume of wrinkles. Purple colour expresses the depth and extent of the wrinkle (Fig. 10).

Results are then expressed in % of variation of the medium instrumental value and the average clinical score with reference to the basal values at the fixed times.

Over a period of 2 months, the wrinkle depth decreases by 10.4%, and the wrinkle volume decreases by 12% when compared to the original skin condition.

Additionally, a volunteer panel confirmed a dramatic improvement of the elasticity, hydration and softness of the skin with more than 95% of panellists expressing particular satisfaction when using the formula containing the microalgae extract.

The new marine active is therefore a key ingredient that helps strengthen skin while restoring its natural suppleness, radiance and beauty. It stimulates and supports the underlying structure of the skin, helping to reduce the appearance of lines and other signs of ageing.

Conclusion

Obtained by a sustainable and ecofriendly manufacturing process, microalgae extracts fully comply with the natural cosmetic trend and help cosmetics evolve into products for the future generations.

'Green' cosmetics have an important role in our efforts to build eco-awareness and grow to a more sustainable lifestyle. 'Blue' cosmetics emerge as the dominant and future innovation for the cosmetic industry.

Modern research and production technologies allow us to look at the very roots of our marine eco systems in order to provide innovative solutions to the cosmetic formulator. As the famous Spanish architect Antonio Gaudi once said: "Originality consists of returning to the origin". PC

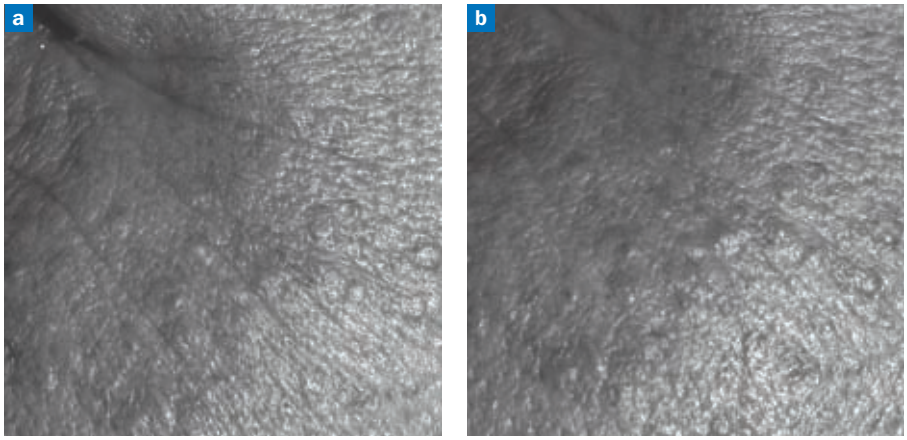

Figure 9: *Photographs of wrinkles crow's feet* **a)** *before, and* **b)** *after two months application of a cream with 1.5% Natura-Tec Marine BlueVital C.*

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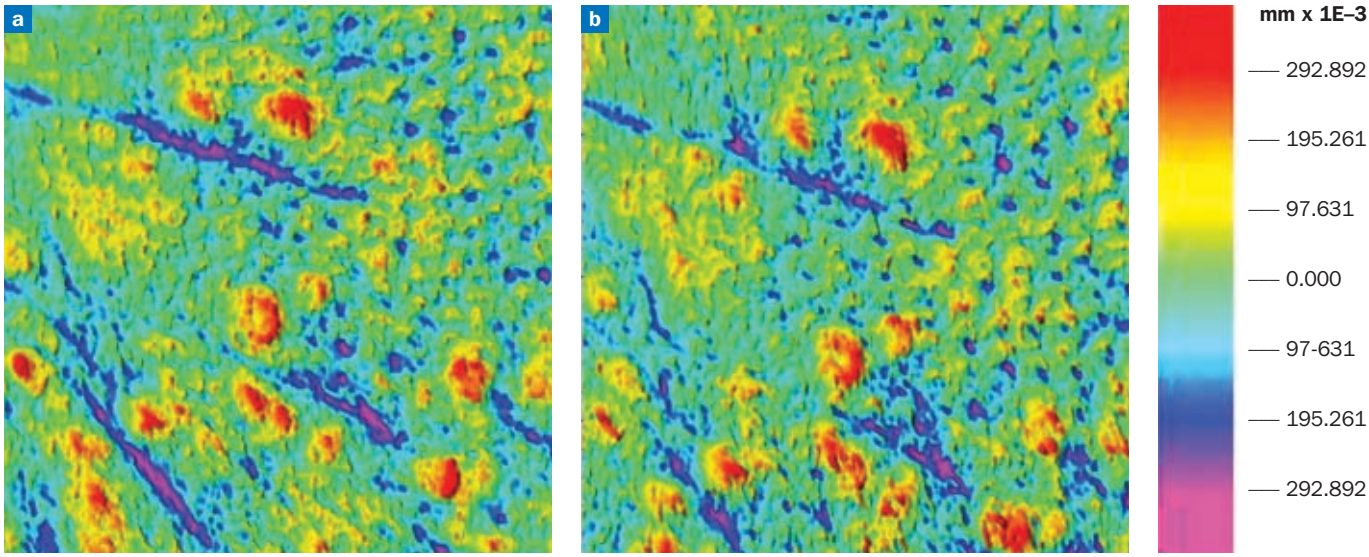

Figure 10: *Images, created by Dermasurf software, show* **a)** *before, and* **b)** *after two months application.*