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Who's investing in marine biotech?

Investors in sustainable chemistry are easily visible, generally have high profiles and a distinctive market focus. But who and where are the companies making similar investments in marine biotechnology? While examples such as BASF's funding of Solix Biofuels to generate novel specialty chemicals from microalgae can be found, such investments are not obviously within the spotlight, precisely because aquatic bioresources supply a wide range of industry sectors.

These marine-origin molecules are currently the unsung heroes and potential warriors of bio-based materials. It is often overlooked that the entire area of genomics and indeed the success of biotechnology endeavours is based on an aquatic organism – *Thermophilus aquaticus* – which provided the Taq enzyme making polymerase chain reactions possible. An important reporter gene comes from a fluorescent jellyfish *Aequoria victoria*. And the most specific alkaline phosphatase enzyme comes from Arctic shrimps.

If marine bioresources are thought of as providers of industry inputs, it is usually in the sectors of nutrition, nutraceuticals, cosmetics and food. Marine hydrocolloids, marine- and freshwater-origin antioxidants such as carotenoids, derivatives of chitin (chitosans and glucosamines) and high-intensity omega fatty acids are well-established. The market for marine hydrocolloids (carrageenan, agar and alginates) used as ingredients in food already exceeds $1bn, according to recent industry reports, and companies such as CEVA and CyberColloids have been investigating and commercialising other molecules that can be extracted from seaweeds.

More esoteric products and ingredients from microorganisms and invertebrates such as sponges and corals include cosmetics such as the 'light-responsive enzyme (plankton extract)' in Estée Lauder's skin cream *Resilience*, Sederma's ingredient *Venuceane* from extremophile bacteria, which the company markets as an antioxidant, anti-ageing component, and Aqua Bio Technologies' *Zonase*, an enzyme from salmon eggs used for exfoliation and skin rejuvenation. Added to this list are a growing number of marine-origin pharmaceuticals, including painkillers and anti-cancer agents, such as Elan's *Prialt*, Pharmamar's *Yondelis* and Eisai's *Halaven*. Royal DSM is also collaborating with animal health company Merial to use DSM's algal expression system to create new veterinary vaccines and Novozymes is working on a novel antimicrobial peptide isolated from the marine worm *Arenicola*.

Tremendous advances in metagenomics have helped to pin down the specific activities of genes and gene products, in order to generate innovation from unculturable organisms. This leads onto the modern high-throughput, intelligent screening that is needed to manage the cornucopia of biochemical diversity that has been released from marine organisms. Once a gene is identified, or a biosynthetic pathway worked out, clever marine chemistry and synthetic biology transfer to an industrial organism is then possible.

Promising 'blue biotech' areas for the chemicals industries are novel enzymes for more efficient biocatalysis or replacement of chemical syntheses, enzymes for production of new platform and specialty chemicals, and novel biomaterials. Enzymes from aquatic organisms are already a significant contributor to industrial processes and products. Marine microorganisms tolerate a wide range of conditions and are sometimes dependent on them – extremes of cold, heat, pressure, pH, salt concentration and unusual non-oxygen chemistries result in enzymes with behaviours different from those of terrestrial organisms. Marine-origin lipase and detergent-stable proteases tolerant of temperature extremes allow flash-cleaning and coldwater laundry, saving energy and reducing impacts. Alginate lyases, carrageenanases and agarases allow the production of derivatives of marine hydrocolloids with additional industrial functions and bioactivities.

Marine-origin enzymes are often specific for difficult-to-manage processes, including chiral separations, epoxidations, production of novel halogen derivatives, debromination or hydrolysis of organophosphorus compounds. One example is an organophosphorus hydrolase from a sea-hare, assigned to Novozymes for further use. Companies such as Verenium, Ingenza, BioSyntha, Libragen or European Screening Port are leading in the area of finding new enzymes, biotransformations and biochemicals for their commercial partners' and customers' processes.

Novel materials from the sea include adhesive molecules from shellfish such as mussels and barnacles. A joint project between Vienna University, the Fraunhofer Institute IFAM Bremen and NUI Galway Ireland is identifying, isolating and characterising an adhesive from the barnacle *Dosima* and hoping to exploit it commercially, and engineered silica structures using sponge biosynthetic pathways are being developed by academics and German start-up companies.

A lot of work is being done. However, a big effort is needed in the short term to map where marine-origin molecules and materials are being used, how much is being spent on them, and exactly how we do and can benefit from them.

The *OECD Key Biotechnology Indicator* report of 2012 recognises how difficult it is to assess the number of non-biotechnology firms that use industrial biotechnology. The CSA MarineBiotech, an EU FP7-funded project, is laying the groundwork for an ERA-NET in Marine Biotechnology, for larger-scale coordination of trans-European R&D efforts, which should provide more focus on this challenging topic (www.marinebiotech.eu). EuropaBio, the European trade organisation for biotechnology, is also developing a public-private partnership in industrial biotechnology, in which marine bioresources should surely play a part.