

BUSINESS SWEDEN

INSIGHT SERIES 2019

MATERIALS OF THE FUTURE

TRUTH 3: IN THE SHADE OF THE FOREST

Materials engineers are always on the lookout for the next big thing. But customers are increasingly playing an instrumental role in shaping the innovation paths and materials that transform everyday life. In collaboration with Swerea, Sweden's world-class research group, and trend analyst firm Kairos Future, Business Sweden presents a special report in nine parts about the race for stronger, lighter, more sustainable, absorbable – and fully connected materials.

INTRODUCTION: TRENDS AND TRUTHS IN THE MATERIALS RACE

TRUTH 1: DRIVEN BY CUSTOMERS FROM HEAVEN AND HELL

Demanding customers who want more and pay less are a strong incentive for rapidly developing, new and better materials. This will lead to a future with higher degrees of collaboration with customers in order to understand their needs, ideally before they are aware of them themselves.

TRUTH 2: ENVIRONMENTALLY FRIENDLY – SUBJECT TO RESERVATIONS?

The materials of the future are obviously designed in environmentally friendly ways with lightweight, energy saving and low-carbon emissions at top of mind, but how simple will it be to recycle them? Complex, tailor-made materials place high demands on future recycling facilities.

TRUTH 3: IN THE SHADE OF THE FOREST

The forest is a natural source of raw materials for much of what is made using oil today. Nations rich on forests have great potential for developing new, advanced materials industries based on raw materials.

TRUTH 4: HYPER-DESIGNED

There is no reason to believe that the trend towards more intensively designed and customised products will slow down, quite the opposite. In future, materials may even be designed all the way down to atomic level in order to meet increasingly high demands.

TRUTH 5: CONNECTED

Sensors can already be found on many products today, but in the future they will be embedded in materials to a far greater extent as woven fibres, smart coatings, conductive nanotubes or in other forms. The materials will be able to report fractures, overheating and other issues via the Internet of Things.

TRUTH 6: BORN AT THE CROSSROADS

It is increasingly difficult for a single party to develop sophisticated and advanced materials. The materials of the future are therefore rarely born from a single company but in the interaction between several different parties, each with their own expertise, requirements and areas of strength.

TRUTH 7: CREATED BY NEW PIONEERS

New players from the IT and space industry, among others, are beginning to drive material developments to a larger extent. They can often afford to manage major collaborations or, if necessary, develop what they need themselves. Pioneers from other areas are entering the materials industry, both as partners and as competitors.

MATERIALS OUTLOOK 2020: WHERE ARE WE HEADING?

Join us as we explore the seven truths about the materials race in depth.
Go to www.business-sweden.com/en/Invest/industries/new-materials

MATERIALS OF THE FUTURE, TRUTH 3

HIDDEN IN THE SHADE OF THE FOREST

The forest has always been a treasure trove for materials. Trees are one of the oldest resources known to man and we have long tried to find, cultivate and process stronger trees with better properties. The invention of paper intensified these efforts. Later on, in the 20th century, the forest added another string to its bow as cellulose-based fabrics were developed.

Nonetheless, our species has only just begun to explore the vast potential of forests as a sustainable resource for valuable and renewable materials. Will more and more future materials originate from cellulose, lignin or hemi-cellulose? This is looking increasingly likely and the possibilities are endless.

Cellulose-based materials are made from chemically decomposed wood such as fir, bamboo or eucalyptus. The fibres are processed and converted to materials designed for specific purposes – from fabrics and composites to films or other products now made from oil. Cellulose is not the only gem hiding in the

woods. Take for example carbon fibre which is a versatile and strong material which can be made from lignin instead of petroleum.

While the drivers of the transition to cellulose-based industries are numerous, environmental benefits clearly top the agenda. The forest is regenerative by design and so are all of its materials. But sourcing materials from the natural world also makes good economic sense for countries with vast forests and the ability to manage them.

In a survey of companies and experts in industry and academia conducted by Swerea/RISE (Research Institutes of Sweden), sustainability was the biggest factor behind materials innovation. However, one in six respondents considered that “declining access to essential commodities and raw materials,” was a key driving force, which is quite significant. There is much to be gained when economic benefits go hand in hand with environmental progress.

16%

of survey respondents confirmed that reduced access to essential raw materials is one of the most important driving forces behind the material developments of today.

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Cotton has been and remains very important – but new cotton plantations are hardly ever created. As the demand for textiles increases, people are looking high and low for new materials and replacement materials. These can be found in the Swedish forests. Cellulose-based textiles with the same properties as cotton are a win-win for the forestry and textile sectors. New industries and new jobs could be possible within 5-10 years.

Pernilla Walkenström, Head of Bioscience and Materials, RISE

BIOMATERIALS ON THE RISE

Bio-based materials, or biomaterials, have already started to permeate the mainstream. Four out of ten survey respondents confirmed that the materials used in their industries have become more bio-based over the past decade – but the real transition will come of age in the near future. Nearly two thirds believe that materials will become more bio-based over the next decade which is a shift nearly as dramatic as recycling. In other words, biomaterials have crept in here and there, but in the future they will be everywhere.

With regard to environmental issues, “more bio-based” was not cited as having a strong correlation to increased sustainability in the materials field (see figure 1). But from a future perspective, bio-based materials are linked to improved environmental qualities in terms of both production and use.

Although the bioeconomy hasn’t taken shape yet, one in three respondents believe that it will emerge out of necessity from increased materials research in order to meet future environmental challenges. Even if development follows a more modest trajectory, there is good reason to expect more bio-based materials in the years ahead – we simply have no choice.

Cotton is the material that most respondents believe will be in short supply. If it is to be replaced by something else, we will almost certainly have to look to the forest as a source of new, suitable raw materials. The same applies to oil which we currently use for a variety of different plastics and other oil-based materials. In other words, it is very probable that the forest will become an increasingly important source of materials, even if we do not know precisely which ones will dominate. The materials are there – just waiting to be discovered.

HARNESSING SHERWOOD’S RICHES

Biomaterials are advanced and complex. At the same time, it is tempting to imagine that a transition to these materials would be easy. Most forests – just like the myths and legends of Sherwood – are full of riches, and machines and methods for harvesting and processing are already well-established. But this optimistic way of thinking is hampered by reality.

Bio-based materials will require a lot of research, both for development and to make them as affordable and available as possible. In order to manufacture biomaterials on a large scale, we need a new form of chemical industry that can convert cellulose into biomaterials and biofuels. This will not happen by itself.

The great potential of the forest cannot be tapped unless mindsets also change. Forests need to be incorporated into existing production systems, with a view to deliver new types of products to customers and consumers. No material development in the world can guarantee this.

For this reason, both industry and policy-makers need to pave the way for change so that biomaterials stand a good chance of actually providing cheaper, better and, above all, more sustainable products.

34%

of survey respondents believe that a future bioeconomy will be made possible through increased material research and material development.

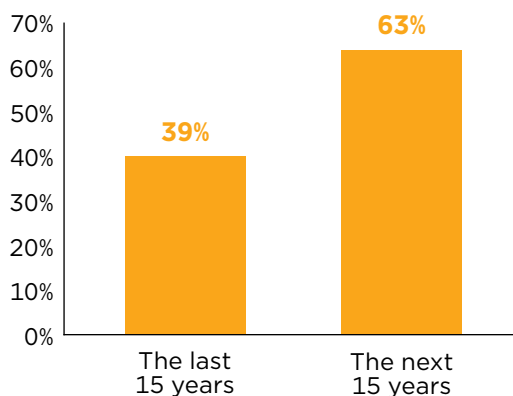


Figure 1: “Materials have become/are becoming more bio-based”. Percentage of respondents who agreed with this statement over the past 15 years and for the next 15 years.

Aluminium and carbon fibre. Titanium and graphite. Metal matrix composites are a family of almost infinite variations of metal combinations, with one another and with other materials. The technology is not exactly new, even the more modern composites originate from the 1950s, but it is becoming increasingly popular. What were the materials of the future during the moon landing may also be the materials of the future today, but for other reasons. They can be designed down to atomic level – and in a hyper-designed future this may be essential.

CELLULOSE - A POSITIVE OUTLOOK

With more than 70% of Sweden's surface area covered by forest, the prospects look particularly strong for the largest economy in the Nordics. Moreover, the forestry industry is well-developed and flexible enough, at least in theory, to be able to make the transition to more advanced chemical production instead of pure pulp and paper production.

Undoubtedly, this would require large investments. But over time, the shift to cellulose-based products could strengthen industries as well as the many towns and local communities that have relied on paper consumption.

Especially on the textile side, there could be opportunities to develop new interesting products that would benefit both the existing textile industry and small communities such as Skutskär or Grums. The textile industry has an obvious role in this context, but it is not the only not the only sector that could benefit.

The automotive industry could also be strengthened by new composites, not to mention the plastics used in many industries and which could be replaced by better alternatives that do not require fossil raw materials.

STRATEGIC RECOMMENDATIONS

- Reach out to the experts who are championing new materials sourced from the forest - from talented biologists to chemists and forestry specialists. They will know what is required to renew materials for your industry.
- Drive and encourage research on forest-based raw materials, even if they do not seem viable in the short term. In the long term, they could lead to better and more affordable materials.
- Encourage innovation and experimentation with new forest-based materials, but be prepared for costly experiments in the short-term. Just like the forest, the bioeconomy grows slowly and needs to be managed.

70%

of Sweden's land area is covered by forest. The largest proportion of the forest is used and managed by the forestry industry.



What do you do with all the forest waste? Perhaps it can be refined to black lye which can be purified into dimethyl and then used to power trucks. Sweden could convert all its vehicles if the government gives the go-ahead. Or decide not to tax alternative fuels when they are found to be a good tax base. We must think further ahead than five years. Long-term profitability is key and rules and regulations related to sustainability need to be introduced.

Lars Hultman, CEO, Swedish Foundation for Strategic Research

YEAR 2030: START-UPS IN THE FOREST

Today, the forest may be the most promising materials resource for countries like Sweden. Admittedly, steel and metal are just as important to our basic industries as before, but the forest is becoming more and more relevant for investors, researchers and politicians.

We are in the process of creating a new industry, one that is driven by raw materials from a living and renewable element of nature. While it has taken time to put forests in the spotlight, activities are now gathering pace. Interestingly, there are plenty of areas in which to invest – from textiles to plastics – which are attracting foreign capital and inspiring a start-up-like culture among industry giants in the forestry sector.

PUSHING THE FRONTIERS: 4 BIOMATERIAL INITIATIVES

- **Wallenberg Wood Science Center:** WWSC is a joint research centre and collaboration between KTH Royal Institute of Technology, Chalmers University of Technology and Linköping University. The base is a donation from Knut and Alice Wallenberg Foundation. The forest industry supports WWSC via the national platform Treearch.
- **BioInnovation:** A strategic innovation programme financed by VINNOVA, The Swedish Energy Agency and the Swedish Research Council Formas, as well as by participating organisations. BioInnovation's aim is to create the best possible conditions for producing new bio-based materials within three priority areas: chemicals & energy, materials, construction & design.
- **RISE Bioeconomy Research Programme 2018-2020:** An international multi-client programme focusing on global trends and market forces related to research areas such as lignin refining, nanocellulose processes and applications, renewable products and barriers, tissue products and processes and resource efficient pulp mills.
- **RISE Roadmaps toward the future bioeconomy 2015-2025:** Presents researchers and companies with strategic steps for achieving the bioeconomy through 8 roadmaps, covering the priority areas: pulp mill biorefineries, lignin-based carbon fibre, nanocellulose materials, cellulose textile materials, bio-based composites, the food industry and pulp mills in symbiosis, biofuels for low-carbon steel, sensors for increased resource efficiency.



SWEDEN – A NATION RICH IN FORESTS AND MINERAL RESOURCES

Sweden is Europe's leading mining nation and a global forest industry giant. These natural resources formed the bedrock for Sweden's industrialisation. And they remain important today. But times are changing. Digitalisation is eroding demand for newsprint and new technology is driving innovative applications for traditional metals and high-tech metals. Sweden hosts mineral deposits like graphite, lithium, rare earth metals.

The shift towards sustainable development and renewable materials is transforming the forest industry to a stronger orientation towards higher value products. Innovative companies are using Swedish wood to develop new bio-based materials such as barrier films, chemicals, carbon fibre, textile fibers and other applications with industry-changing potential.



ABOUT THE AUTHORS

Swerea (now RISE Research institutes of Sweden): In 2018 two thirds* of Swerea was acquired by RISE Research Institutes of Sweden (RISE), continuing its scientific work as a part of a total force of 2700 researchers and experts with extensive industrial knowledge and experience of how to accelerate research results into innovation for practical use. RISE is a unique mobilisation of resources with the aim to increase the pace of innovation in our society. It is owned by the Swedish State and work in collaboration with and on behalf of the private and public sectors and academia, with the ability to take on a variety of roles in the innovation system.

** 1 third of Swerea created the new metal research institute Swerim.*

Kairos Future: Kairos Future is an international consulting and analysis firm that helps companies take leaps towards the future. Through trend and scenario analysis and support in innovation and strategy, we help customers with the big picture and the direction for the future. Kairos Future was formed in 1993, our head office is situated in Stockholm and we have partners worldwide.

Business Sweden: Business Sweden helps Swedish companies grow global sales and international companies invest and expand in Sweden. We ensure that international companies can rely on our knowledge, experience and extensive network to identify new business opportunities and achieve an accelerated return on investment. Business Sweden is present in 50 of the world's most promising markets and owned by the Swedish Government and the industry, a partnership that provides access to contacts and networks at all levels.



We help Swedish companies grow global sales and international companies invest and expand in Sweden.

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