Interview

Topic	AlgaeTex - Algae-derived biopolymers for the application of textiles
Interviewee	Andrew Yip (adidas AG), Christoph Peiner (Institut für Textiltechnik (ITA) of RWTH Aachen University)
Moderator	Sea-Hyun Lee (BIOTEXFUTURE PMO)

Introduction

Algae has immense potential as a bio-feedstock to replace crude oil for manmade textiles. Using algae as a renewable resource for producing biopolymers and textiles circumvents the challenges of competing with low fuel prices by creating higher-value applications. In this way, the German textile industry can act as a catalyst to shift away from fossil-fuels – towards a bioeconomy where algae are a major source of biomass.

AlgaeTex aims for algae-derived biopolymers for the application of textiles. It is a project within the BIOTEXFUTURE innovation space, which is funded by the German Federal Ministry of Education and Research (BMBF).

What lies behind AlgaeTex will tell us Andrew Yip (adidas AG) and Christoph Peiner (Institut für Textiltechnik (ITA) of RWTH Aachen University) in today’s interview.

Q&A

Question: **Andrew and Christoph, thank you for taking part in this interview on AlgaeTex. Let's dive into the first question: What is currently going on in AlgaeTex?**

Christoph: Currently we are working simultaneously on different parts of the project from algae cultivation and polymerization routes for fatty acids to spinning strategies for algae based polymers. For example, the Frauenhofer group is working on new feeding strategies for the algae to improve the growth rate. One approach they are taking is investigating how different light applications impact growth behavior. Moreover, the group at Fraunhofer IGB is developing new methods to optimize the extraction of fatty acids from the algae by cracking the algae and drying them afterward.

Andrew: The team at Fraunhofer IGB is investigating how specific variables affect the growth behavior of the algae and their productivity regarding fatty acids. We are interested in high fatty acids productivities as they will be polymerized into our final material.

Christoph: Furthermore, the colleagues at Uni Bayreuth are trying to polymerize fatty acids into polyesters and polyamides. They investigate what type of polyester and polyamide can be synthesized out of the substances that could be extracted from the algae within the further project. Moreover, they compare the composition of bio-based to fossil-based polymers in regard to mechanical properties.

Andrew: Right now, as the algae growth is being optimized by the team at Fraunhofer IGB, the team at University of Bayreuth is exploring alternative routes to new biopolymers without using algae to produce several materials with different physicochemical properties and environmental impact. Finally, we will substitute the new biopolymers with components of the algae oil and try to find a good balance between a high composition of renewable materials and good physicochemical properties.

Christoph: At the same time, at ITA we use alternative bio-based materials to set up a spinning process that will achieve the closest possible properties to industrial-scale yarns. To check whether the polymers function the way we would like them to, we have created testing facilities. In these facilities, we test small amounts of polymers and bond yarns. Furthermore, we will test whether the polymers would be knittable at a large scale. In short innovation cycles between the spinning and knitting department at ITA we investigate how the properties or the spinning processes need to be changed to create knittable, reproducible, and processable yarns. As soon as we receive enough algae based polymers, we want to produce the highest possible amount of good quality yarn from this algae-based material and then produce demonstrators to show around these algae-based fabrics.

Andrew: On the side of adidas we have our team of engineers who have their corresponding partners. For example, we have material scientists and chemical engineers who are working very closely with the University of Bayreuth to get through a lot of troubleshooting to decide which polymers are the most interesting or the most promising. We have a team of textile engineers as well who are working with the team at Institut für Textiltechnik (ITA) of RWTH Aachen University to help troubleshoot and guide the work around the fibers spinning preparation or textile making preparation. The team of engineers performs lifecycle assessments to detect industrial-relevant polymers with great benefits for the planet. All in all, they make sure that all the partners and all the pieces are aligned.

That is pretty much what is going on right now. We are in the middle of setting our first milestone, which is producing materials based on these new biopolymers that we are developing without algae as a feedstock. Essentially, we are using a replacement for the algae right now so that we can determine the best biopolymer and biomaterial. Once we have enough algae available, we know the best process to extract what we want out of that algae. In the best case we can simply substitute that into the same chemical pathway we are developing now without algae in the same processes and we should hopefully not get any surprises and get a good material in the end.

Question: What was behind the project AlgaeTex and how was this project called to live?

Andrew: I could say from a motivational standpoint from adidas, that we are always looking at ways to reduce our environmental impact and reduce our carbon footprint as a company. A lot of our carbon footprint comes from the materials that we use. Everyone involved in apparel or footwear goods has the same problem as our businesses continue to grow but the impact on our planet also continues to grow. Thus, we are looking at the next generation materials that replace fossil fuels with renewable resources and obviously, that has already happened in a significant way where you can get a lot of materials like polyester or nylon that are coming from renewable resources such as corn, sugar beets or castor oil crops. These renewable resources can be grown specifically to be used as a base material for textile fibers. The problem with this is that further stress on the planet is caused due to industrialized farming and monocultures, which in a lot of ways competes with the food industry. Therefore, the motivation behind AlgaeTex was to replace fossil fuels with second-generation biofuels, which do not compete with our food production.

Christoph: This was a perfect answer. I might add the following: The motivation why we are working on this project and try to create textiles from algae-based feedstock is to understand how we can adjust the growth of algae, the composition of the fatty acids, and the chemical composition of the algae. We work on the chemical routes which process bio-based materials to biopolymers. We also check how textiles can be created on an industrial scale-out based of sustainable, new and innovative materials that probably do not have the same properties as fossil-based materials or polymers.

Question: Why is algae a better resource than conventional material for yarn as you mentioned that yarn is one of the main products that you want to produce out of these new bio-based materials?

Andrew: I think the biggest potential of algae is that it can grow on non-airable land. It can grow in places that other things can't. It can grow much quicker to dense populations than other crops as well. Therefore, you can grow algae in places where otherwise nothing else would grow. In that instance, you can convert for example a forest or grassland into a farm, because there will not be any land-use change issues or any of the other kind of potential negative impacts since algae can grow in places that you would otherwise put a parking lot. With algae there is a lot of potentials in using waste inputs as feedstock. You can potentially use wastewater or use waste CO_2. These are things that are a little bit outside of the scope of what we're looking at, but these are important reasons why we are interested in algae in the first place. I think you can see in other industries, that the short lifespan of algae also allows for a lot of quick development of different strains so you can test to see if your population of algae could increase a certain percentage of content of specific molecules that are interesting to you on a much quicker time scale than it would be to kind of genetically modify a soybean and wait for the next generation to grow.

Question: We were talking about the quick growth rate of algae. Can you explain a bit in detail on how to cultivate algae?

Andrew: In our project, we are specifically using photobioreactors as tanks, which have been developed at the Fraunhofer IGB. The reason why we are using that method as opposed to open pond techniques is because of higher control. In these reactors, we can determine exactly the amount of light and amount of CO_2 the algae are going to receive. Also, we can control the mixing of nutrients inside the bioreactor and nutritional uptake resulting in the algae producing as much liquid content or whatever else content we are most interested in.

Additionally, these modules could theoretically be placed anywhere in the world, because as I mentioned before, algae can grow on non-airable land. Because we have this high degree of control, we can isolate the different variables to optimize algae cultivation. We are working with one of the perennial experts in this field to determine how this could scale into the future, what it would look like in the future if there were algae photobioreactors just placed for example next to a warehouse in India.

Question: How does the cultivated algae turn into polymers?

Andrew: When you think about algae you typically think of a photosynthesizing organism, which needs minerals, air, light, and water to grow. What we are doing here is introducing a couple of other variables and a couple of other inputs and nutrients that force the algae to be fatter or different than your average algae strain. I guess this is a nuanced difference between how we are cultivating algae and how algae would grow naturally in a pond in your neighborhood. With that said, what we are trying to do is extract oils from algae and therefore we go through certain chemical processes which convert that oil into what is eventually going to be a thermal plastic biopolymer. Algae has been used in our industry before but mostly as a filler material, so essentially you could take algae biomass to dry, sprinkle it into another material at a certain percentage and use it that way. But in contrast to that, we are trying to establish a paradigm shift where algae become an actual raw material source, similar to the oil extracted from the ground and converted into thermoplastics. What we are doing here is extracting oil from algae and going through certain chemical processes that I cannot give too much detail about yet but we are converting them into thermoplastics that could be used to spinning into fibers and yarns and knitting up into fabric.

Christoph: To give a rough overview of the chemical processes: first, you extract monomers from these algae-based oils, then polymerize the monomers that you have just extracted and eventually you try to get a functional polymer out of the reactor. This is basically like cooking. We choose different cooking recipes and examine the properties of the resulting polymers.

Andrew: What excites me the most about our project is that the extracts we are trying to get out of algae had previously been interesting for the biofuels industry. I do not think it is rocket science, because you can explain the procedure to an average person that a typical product of adidas based on fossil fuels costs a bit more than what you fill up at the petrol station. So there is a little bit of an added economic incentive to help the algae industry to grow if we extract these oils and use them in sporting goods products versus extracting that oil and converting it into biodiesel for example. I think what is also interesting about this method of extracting resources from algae and converting them chemically is that you are left over with all the other bits of algae. These leftovers could be carbohydrates, proteins, or biomass. This creates an industry of value chain that did not exist before. This model of maximizing the co-products in their value is really interesting and exciting because it helps make the economic equation work out at the end versus just growing algae for one specific thing and throwing the rest of it away.

Question: What are possible applications or other options for algae other than textiles exist?

Christoph: I think what is important to know at this point is that the textile industry has a very high need for sustainable materials that they can use. If you want to create a polymeric material inside a reactor you need to know specific reaction parameters before your reaction, such as the melting point or the viscosity. With that said, changing the reaction parameters can lead to a polymeric material with different physicochemical characteristics. Therefore, you can use the mix inside the reactor to create polymers for different industries by altering the parameters.

Andrew: I agree with Christoph. We are trying to develop a thermoplastic polymer that is multifunctional and can be used in multiple applications. In the textile industry, we already have established multifunctional polymers such as nylon or polyester. These you can use in multiple applications as well. For example, cotton is exclusively used in the textile industry as a fiber. Thermoplastics can be extruded into a yarn, but you could also extrude them into a filler or something else, which has a commercial use. We hope that we can successfully develop a multifunctional thermoplastic polymer, wherefore one day industry partners might approach us and ask what is leftover and what they can do with it - whether these leftovers are proteins, carbohydrates, or something else.

Question: What have been the biggest obstacles in the project so far?

Christoph: The biggest obstacle that we had in this project is the corona pandemic. In this consortium, many people are working simultaneously towards the same goal. We were able to overcome this obstacle of not being able to meet physically by using digital ways of communication, such as video tours. And we are keeping in touch regularly, exchanging on our successes and our obstacles within the team. This was very well organized by Andrew and our colleague Maren Herter (adidas AG). I am very happy that we overcame these obstacles so far and we are looking forward to finally meet in autumn to see our colleagues and the guys we are working with face to face.

Question: AlgaeTex has a project period of three years. It has already been running for about one year. What have you achieved so far and what are your next goals for the remaining two years?

Andrew: The most exciting thing that we have achieved in the first year is identifying some super interesting and promising biopolymers. So, things that are relatively new or uncommon in the industry, but specific compositions like polymer recipes that the partners have come together and created. That is exciting about the first year. We have also gotten some indications in terms of the algae growth and cultivation that have been promising as well but up to this point, I would say what is most exciting is that we have a few different candidates that seem to be worthwhile.