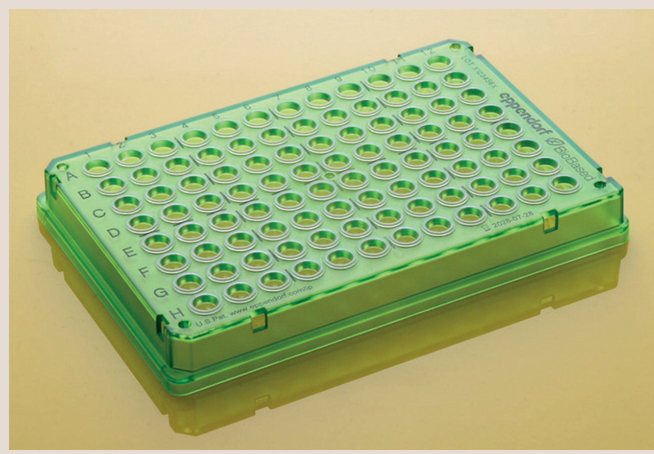
WHITE PAPER No. 118

# Sustainability Demands Quality: No Compromises on Greener Plastics

**Jan Bebermeier,** Eppendorf SE

## Executive Summary

Sustainability is becoming a defining factor in the life science market, with more labware suppliers introducing "more sustainable" products. But at what price? In research, precision is everything – so sustainability must go hand in hand with the uncompromising quality required for reproducible results.
Laboratory plasticware plays a crucial role in experimental accuracy, and switching to more sustainable options should not mean sacrificing reliability. We urge you to critically evaluate product quality and performance when choosing sustainable plastic lab consumables. Because you and we both know: Unreliable plastics lead to failed experiments, consuming more reagents, more consumables, and more time. Poor quality means costly repetitions – wasting resources instead of saving them. The push for sustainability in science must be a step forward, not a step back. Manufacturers and researchers alike have a responsibility to embrace greener alternatives – but only those that meet the highest scientific standards. Because true sustainability is about more than just the environment – it's about ensuring the integrity of your research.




Since fossil oil-based plastic, single-use/disposable consumables have replaced glass ware, they have become irreplaceable in laboratories around the world, providing quality standards that are needed in increasingly demanding research, increasing working safety (no risk of breakage), and saving time (no cleaning). This is a growing challenge in terms of sustainability.
Sustainability is playing an increasingly important role in the perception and purchasing decision of customers looking for laboratory consumables. Products need to become more sustainable – but at what cost? Not just the direct financial cost, but the total cost of using the more sustainable product: What impact does this have on your experiment, your sample, or your results?
There are some examples of more sustainable products where quality has suffered heavily: Remember the wood varnishes that – based on unhealthy solvents – survived as paint on your chair or table for 10 or even 15 years. The first solvent-free alternatives required a new coat of paint after 3 years. The improvement in the chemical composition was paid for with a drastic reduction of longevity, requiring more paint, more labor time to paint, and probably less good wood preservation. Analogous consequences in science would be: Repetition of experiments due to suboptimal working reagents, cracking consumables, leaching of unwanted chemicals.

As we all know, science is far too important to put samples at risk. Science is also far too expensive for countless iterations and science is too time-consuming to waste time on unreliable instruments and consumables.

Conclusion: We all (you as a scientist and we as manufacturer) agree that science must become more sustainable in the laboratories. However, this must not come at the price of poorer performance.
In this White Paper, we focus on plastic consumables with claims on improved carbon footprint and sustainability. Plastic consumables are used every day in laboratories all over the world. But as versatile and necessary they are, they also have a major impact as they are made from (limited) fossil fuels. And finally, it ends up in big bags of plastic waste. Both aspects need to be addressed. Supporting a circular economy by using recycling plastic material is the midterm goal, but the plastic waste mountains are still waiting for a reliable approach: Traditional recycling technologies deliver you shortened polymer chains that may be less stable when being used as tubes in the centrifuge. In addition, the recycling of plastic can introduce leachable substances into the samples when used for the production of lab consumables. Both impacts need to be solved before recycled material can be considered as a valid candidate for tubes, plates, and pipette tips.

The aim of more sustainable consumables is to reduce negative environmental impacts. This includes saving resources such as fossil oil, reducing the plastic waste, and – holistically – reducing the carbon footprint. When discussing the sustainability footprint of plastic items, it quickly becomes clear where the overall path should lead. The central midterm goal is to achieve a closed loop, that means: the recycling of plastic and the production of new plastic from old plastic.

### Recycling material in products: A reality check

The first laboratory consumables made from recycled plastic are now available on the market. As a company committed to enhancing our sustainability footprint, we are keenly interested in new products that incorporate recycled materials. We compared 1.5 mL microtubes and 50 mL conical tubes made with 20% recycled material from a third-party supplier to their traditional fossil-oil sourced counterparts from Eppendorf.

### Centrifugation

Microtubes from another manufacturer of 1.5 mL have a 20% share of recycling plastic. The tubes are specified for up to 24,000x g and a temperature range of up to +100°C. The Eppendorf applications team performed some centrifugation runs at 24,000x g in a non-refrigerated centrifuge with temperatures of up to +40°C. All six used tubes were deformed at the lower part of the tube body and showed liquid loss (see Figure 1). The control run was performed with six Eppendorf 1.5 mL Safe-Lock tubes at 30,000x g without deformation and without liquid loss.

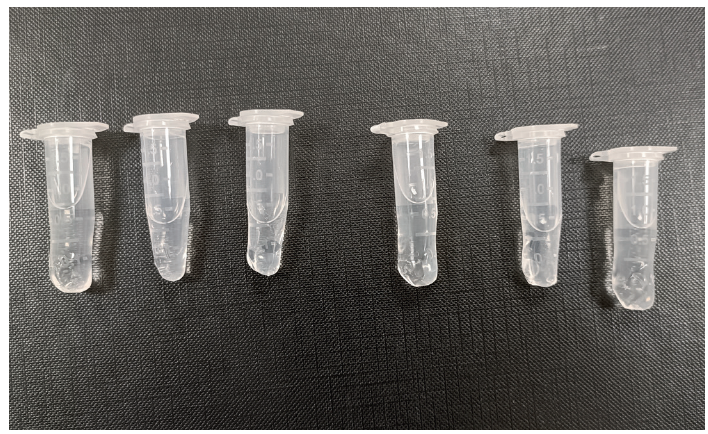


**Figure 1:** 1.5 mL microtubes with 20% recycling content from third-party supplier after centrifugation at 24,000x g and temperatures of up to +40°C, tubes are deformed during the run

50 mL conical tubes (made of 20% recycled plastic) were tested for centrifugation stability as well. The conical tubes are specified for up to 15,000x g and a temperature range of up to +100°C. All six tested conical tubes from the external supplier showed white cracks after centrifugation at 15,000x g at 4°C as well as at 25°C. The reference tubes of Eppendorf (50 mL, fossil-sourced) were tested at 19,500x g w/o any damages at both temperatures.

### Lid tightness

The lid tightness of the selected tubes was tested with demineralized water. The conditions were 100°C and a mixing rate of 1,000 rpm for 30 min. Seven of the eight 1.5 mL microtubes of the supplier popped open during incubation, leading to a liquid loss due to evaporation. In contrast, the reference test with Eppendorf SafeLock 1.5 mL tubes showed no breakdowns.
The 50 mL conical tubes of the third-party supplier showed a similar pattern. All tested conical tubes showed evaporation and significant liquid loss during thermo-mixing. The reference conical tubes of Eppendorf performed well.

### Leachables

In a third test, the occurrence of leachables was analyzed. Ultrapure water was filled into the various consumables to be tested during 30 minutes at 95°C and with a mixing frequency of 1,000 rpm. Three replicates were performed. For each incubation procedure, the absorbance spectrum was generated by an UV spectral scan from 200 nm to 800 nm. This test was done with 1.5 mL microtubes as well as with 50 mL conical tubes of the third-party supplier.

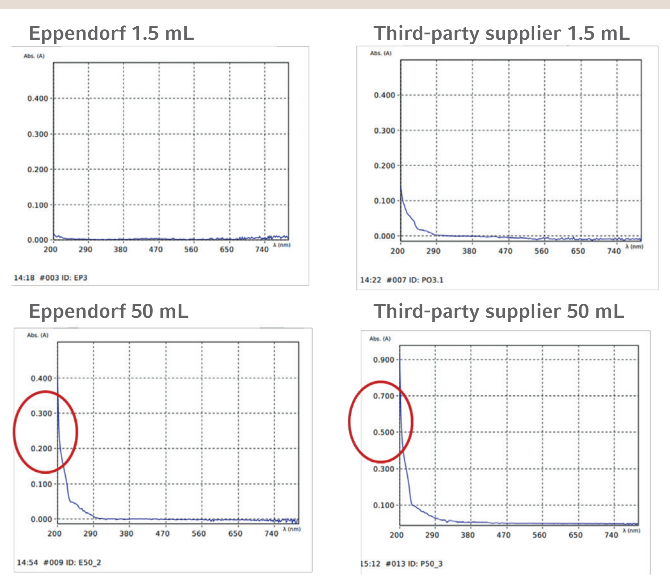



**Figure 2:** Analysis of the UV-absorption spectra (from 200 nm to 400 nm) of 1.5 mL microtubes and 50 mL conical tubes from Eppendorf (left column) with 100% fossil-sourced and a third-party supplier (right column) with 20% recycling content; extraction performed at 95°C for 30 minutes.

As shown in Figure 2, an analysis of the absorption spectra shows significant differences between the leachable profiles from Eppendorf tubes (fossil-sourced) and those from the third-party tubes (20% recycling content). Indeed, higher absorbance values are globally measured with the third-party tubes, mimicking spectrum of nucleic acids and thereby potentially falsifying their measurements.

### Foaming

The 50 mL conical tubes of the third-party supplier showed foam when being filled with demineralized water (four of four tested tubes). This indicates a contamination with some kind of surfactant. The reference Eppendorf conical tubes did not show any foaming.

The testing confirmed results from our own prototype plastics with simple recycling material: Production of plastic items with recycling material is possible but the performance in the laboratory of these produced parts is critical.
To be clear, all suppliers of laboratory plasticware must do their best to develop consumables with shares of recycling material. It is clearly a good starting point to use small amounts of recycled material in the plastic items and then gradually increase the proportion. However, the market launch should be limited to products that can actually meet the quality performance required by science. Products with recycled content, which have a strong negative impact on quality and therefore on valuable samples, also damage the reputation of recycling plastic in general. A material that we will all need in the future.

But why are recycled materials such troublemakers?

## Challenges

The main challenge for recycled plastic in the laboratory are the extreme conditions in science. The temperature range extends from -80°C to +121°C for standard applications. High gravitational forces due to centrifugation of up to 30,000x g, mixing frequencies and finally a wide range of chemical substances. All these conditions must be met in parallel as the same sample is incubated, mixed, centrifuged, and combined with other reagents.

**Figure 3:** Plastic particles produced by mechanical recycling of plastic*

**Some issues are particularly critical for recycled materials but not limited to these aspects:**

> Problem of constant proportion of high-quality recycled material for high-throughput production: This can lead to a variable percentage of recycled material in the product. The possible mixtures must all be tested for the harsh conditions in the laboratory. The situation will improve over the next few years with the expansion of recycling services around the world.

> Problem of different colors: This is an optical issue – recycled plastic (especially post-consumer material) is usually obtained from different materials, resulting in different colors. Glitter or inclusions in tip boxes made from multi-colored recycled plastic may be acceptable, but clear plastic is required for tips, plates, and tubes as you need to see the samples. This challenge will improve over time as availability of recycled plastic increases and technologies to separate used plastic continue to improve. This will also reduce the cost of single colored recycled plastic.

> Problem of reduced length of polymer chains: Mechanical recycling can shorten the polymer chains. The shorter the chains are, the less stable and compact the final polymer is. Stability is relevant for high g-forces such as tubes in centrifuges. Additives of virgin material will be necessary, which requires detailed development times.

> Problem of leachables: In contrast to virgin plastic material, recycled plastic shows a by far higher rate of leachables. Leachables may influence samples. New recycling technologies are probably required to avoid leachables.

**More details are available in White Paper 080.**

All these problems will be solved by new technologies and more experience.

*Image Source: Shutterstock

Based on our intensive research and development work, we have decided to restrict the use of recycled material to areas that do not come into direct contact with samples as a first step. This means, no recycled material in tubes, tips, or plates until we are sure of the performance of the material.

Since mid-2024, a growing number of Eppendorf tip racks have been made from 100% recycled plastic (lower part of container), see Figure 4. This special recycled material from (industrial) post-consumer source guarantees a constant flow of high-quality plastic. As described, there is no direct contact of the recycled plastic with the samples.


**Figure 4:** Eppendorf rack for epT.I.P.S.® where the lower part of the container is made of 100% recycled plastic from (industrial) post-consumer source

We are optimistic that new recycling technologies will come onto the market, enabling the use of recycled plastic for critical applications such as laboratory consumables. Current mechanical recycling, which is used for many standard plastic applications, does not appear to be sufficient for critical laboratory plastics.

**Biobased material**

Crude oil and by this, virgin plastic, is finite. One alternative could be biobased plastic which is produced from renewable resources.

Switching from primary fossil oil-sourced plastics (hereinafter shortly referred to as "fossil-sourced") to biobased resources can reduce greenhouse gas emissions and offers potential for a (more) circular economy.

Today, many bioplastics are made of feedstocks obtained from carbohydrate-rich plants such as sugar cane, corn, potatoes or wheat. At first glance, these so-called first-generation bioplastics appear to be a good alternative to petrochemical plastics as they reduce the consumption of fossil resources, but a closer look at the life cycle reveals a mixed picture, especially due to their direct competition with food. As alternative approach to recycling, Eppendorf has developed consumables made from another biobased plastic. By using 2nd generation biobased material from waste streams such as agriculture waste, e.g. wheat straw, food waste, or waste oils, such as used cooking oil (UCO), this raw material is recycled for a second life in the laboratory. The entire process is monitored and certified by ISCC PLUS, an independent organization.

Following the market launch of the Eppendorf Tubes® BioBased in 2022, Eppendorf has successively expanded its portfolio of biobased consumables*. Both the epT.I.P.S.® (with and without filter) and our Eppendorf twin.tec® PCR Plates are meanwhile also available as biobased versions. The famous "Eppi®" – Eppendorf Safe-Lock Tubes BioBased are added to our portfolio mid of 2025. We are very pleased that biobased consumables are being well received by more and more users. Further biobased products are in development.

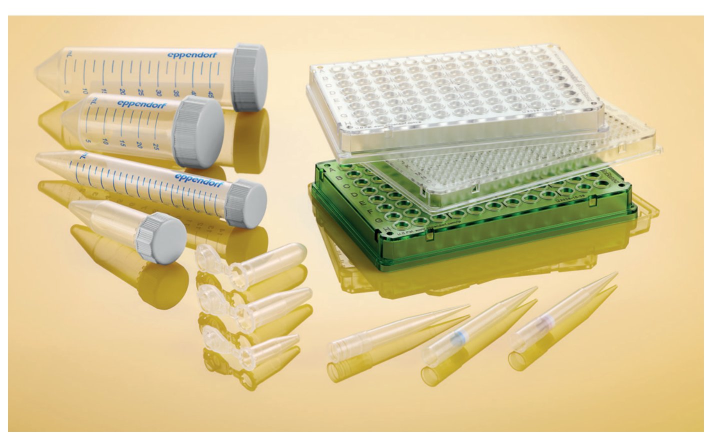


**Figure 5:** Biobased consumables by Eppendorf

*Eppendorf biobased consumables have different amounts of biobased raw material. Based on the mass-balance-approach, the percentage varies from 86 to 100%, depending on the specific product type.

Some hinged snap-cap microtubes made of 90% 2nd generation biobased material are available from another supplier. The tubes are specified for up to 30,000x g and a temperature range of up to +100°C. As part of regular testing, these biobased tubes have been used in internal tests. The test was performed with 1.5 mL microtubes.

An important process step for microtubes in the laboratory is the centrifugation of these tubes (with samples). Several test tubes were centrifuged at 22,000x g. At temperatures of +4°C with active cooling, the external biobased tubes performed well. In a second run, the tubes were used in a non-refrigerated run (temperatures of up to +40°C). During the second run, small white cracks appeared in the tubes. Some of the tubes tested were broken at the bottom, although they were used within the official specifications, see Figure 6.

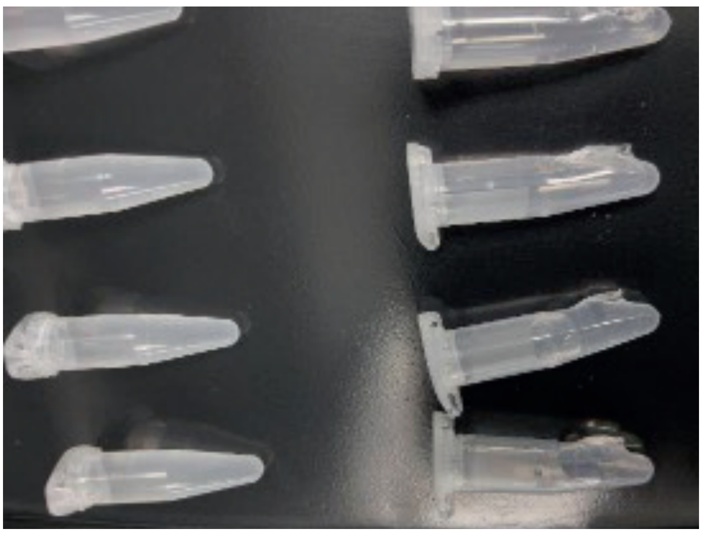


**Figure 6:** Comparison of Eppendorf 1.5 mL microtubes (left) with 1.5 mL biobased tubes of third-party supplier (right) after centrifugation at 22,000x g at up to +40°C

The reference test with Eppendorf Safe-Lock Tubes 1.5 mL showed no cracks.
In a chemical analysis, the occurrence of leachables was analyzed.

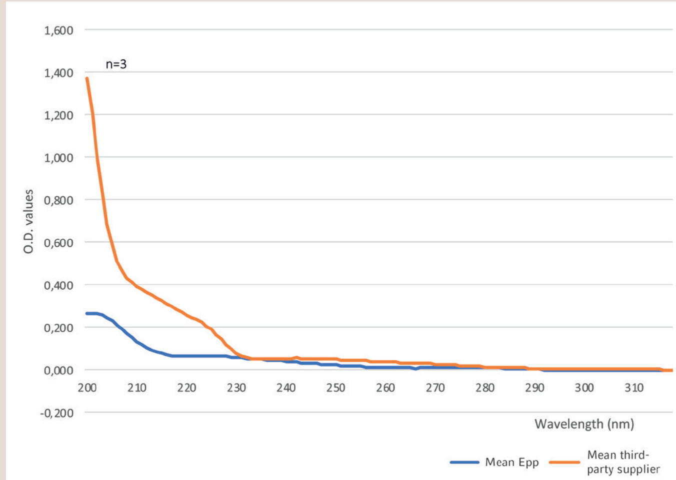



**Figure 7:** Comparison of Eppendorf 1.5 mL microtubes (left) with 1.5 mL biobased tubes of third-party supplier (right) after centrifugation at 22,000x g at up to +40°C

The results in Figure 7 clearly indicate that the tested biobased tubes from another manufacturer provide leachables to the sample. Leachables which may have a negative impact on the sample itself or the performance of downstream applications like an enzymatic reaction. Leachables can also be detected in low-quality fossil-sourced plasticware. Sustainability should not make compromises regarding performance. In general, the data underlines that biobased materials, like fossil-sourced materials, have differences in quality and performance. An investment in high-quality consumables should be considered investing when working with valuable samples.

### How to avoid quality dead ends?

As science is extremely complex, requires expensive materials, rare sample materials and has to cope with the limited working capacities of scientists, the used materials must meet the highest possible quality standards. This is the responsibility of the suppliers. The development of biobased plasticware requires even more research and development work than that of conventional fossil-sourced plasticware.
Every type of consumable made from Polypropylene (PP) has a unique material fingerprint. For biobased alternatives to truly replace fossil-sourced plastics in high-performance lab environments, they must replicate this fingerprint in every detail – without compromising on quality. This is not a trivial challenge. It requires deep material science expertise, rigorous development, and extensive testing – both during manufacturing and under real laboratory conditions.
At Eppendorf, we set a clear and uncompromising goal: Biobased consumables must perform exactly like their fossil-sourced counterparts. Nothing less will do.
Thanks to our stringent development and validation processes, we can confidently state that Eppendorf BioBased products meet the same exacting technical specifications as their fossil-sourced reference products. Whether made from fossil or renewable resources, our consumables are subject to identical manufacturing protocols, testing procedures, and quality acceptance thresholds – ensuring that every product upholds Eppendorf's trusted standards for precision and reliability.
This level of consistency is not just a benchmark – it's essential. In cutting-edge research and highly regulated environments, reproducibility and experiment quality depend on dependable tools. With Eppendorf, you don't have to choose between sustainability and performance. You get both. All testing is performed by Eppendorf internal QA controls and/or trusted external partners. Equivalent certificates are available through the Eppendorf eShop (www.eppendorf.com).

### Future

Plastic products and the associated waste pose a challenge. Although they are indispensable for many experiments in the laboratory, there is the problem of using limited resources and there is the post-usage problem of waste.
Biobased materials of the second generation clearly can save limited fossil oil resources and reduce the carbon footprint of the product (see White Paper 93). They can be fed into the recycling process in the same way as material derived from fossil oil. However, switching to biobased materials does not solve the waste problem: Only a very few biobased plastics are degradable. However, this usually comes at the price of lower material quality and only over a long period of time and in defined environmental conditions, which are not possible for laboratory consumables in particular. However, they are a promising starting point that needs to be further developed.
In principle, biobased materials represent a bridging technology between fossil oil and a fully circular economy. The medium-term goal is to develop plastic recycling strategies for clean and reliable processes.
The goal is clear: A gradual closing of the loop. Closing the loop by re-using material of existing consumables also solves the waste issue.
But each new type of material must meet the high-quality requirements needed for successful science.

## Acknowledgments

The author thanks Jana Schmidt, Rafal Grzeskowiak, Hanae Koenig, Lena Andersen, and the applications team in our Belgium facility for the data, the detailed discussions, and extended reviews.

## About Eppendorf

Since 1945, the Eppendorf brand has been synonymous with customer-oriented processes and innovative products, such as laboratory devices and consumables for liquid handling, cell handling and sample handling. Today, Eppendorf and its approximately 5,000 employees serve as experts and advisors, using their unique knowledge and experience to support laboratories and research institutions around the world. The foundation of the company's expertise is its focus on its customers. Eppendorf's exchange of ideas with its customers results in comprehensive solutions that in turn become industry standards. Eppendorf will continue on this path in the future, true to the standard set by the company's founders: that of sustainably improving people's living conditions.

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