DETECTING RECYCLED CONTENT IN A TEXTILE PRODUCT

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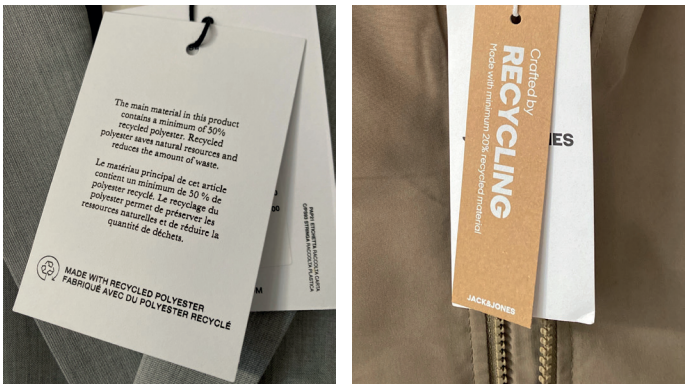
As part of the EU textile strategy and the European Ecodesign Regulation, a minimum recycling rate consumer textiles and clothing is being discussed intensively. Consumers are increasingly finding products on the market that carry the additional information „contains recycled material“ visibly on the hang tag and are advertised as sustainable in this way. In this context, it will be necessary in future to verify product claims, for example regarding the proportion of recycled material. The key question is whether the recycled content advertised in a textile or clothing product can be reliably verified.

The Confederation of the German Textile and Fashion Industry (T+M) and the Textile Research Council (FKT) have investigated this question together with their research and development network, focusing on the two main material components recycled cotton and recycled polyester (rPET), both in pure form and in blends. The project team wanted to identify methodological approaches that are suitable or need to be further developed to be able to detect recycled content in textiles cost-effectively and reliably in the future. Any further challenges should also be identified.

Test series - test methods and evaluation

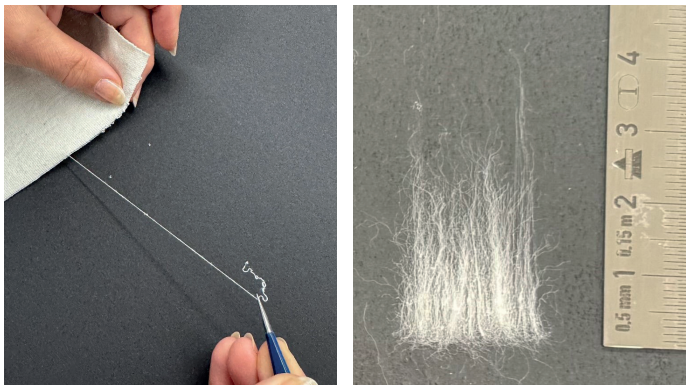
The exact same material samples were provided to each research partner to determine whether the labelled percentages of recycled materials could be verified. Various clothing products with different percentages of cotton and polyester were included, with both recycled and virgin versions of both materials. As each partner is specialised in its own analytical methods, the aim was to find out which techniques of verifying the recycled content in textiles would be most suitable, depending on each partner‘s research field. In addition to technical feasibility, further important aspects were the time required and the costs for such an investigation.



Recycled content on hang tags, photo: textil+mode

All test methods used to differentiate between virgin and recycled materials are currently very costly and therefore not economically feasible for commercial use. Furthermore, standardised testing methods are difficult to apply to materials with a very heterogeneous composition, such as those found in various product types.

This significantly increases the individual effort required for testing. Identifying recycled polyester (originating from recycled PET granulate) already worked well; however, the exact percentage could not be determined. By contrast, there are currently no references or research results for identifying mechanically recycled polyester fibres.


Left: Removing yarns from sample, right: fibre staple from sample, photo: DITF

Recognising recycled cotton is even more complicated. The differences between a virgin fibre and a mechanically processed recycled cotton fibre are almost undetectable. Only the fibre length could be analysed, for example, using a method such as scanning electron microscopy, which is a relatively inaccurate indicator. Moreover, a combination of different test methods must be used for blended fabrics, and there are hardly no standardised reference values to characterise recycled cotton.

The verification of recycled materials of cellulosic origin (e.g. cotton) for the production of regenerated fibres in the chemical recycling process is not considered here. Nevertheless, it is important to mention this aspect for the sake of completeness, as recycled input material for the production of regenerated fibres requires a separate examination

Dimensions of the verification process

The proportion of recycled content can be investigated at different levels and using different methods. Whether they can be detected depends heavily on these factors.

Different test methods must be used for each material type, and these must be combined for blends. It has been shown that verification at all levels - from the product to the fibre to the polymerization level - is currently very complex:

- Product level: Analysing and clearly identifying recycled materials and proportions of recycled materials in the end product is particularly challenging due to material mixtures and additional treatment (e.g. colouring, finishing or coating). The necessary testing methods are not only expensive, they also have significant limitations in terms of accuracy.

- Fibre level: Tests such as Scanning Electron Microscopy (SEM) or mechanical analyses do provide useful information about the origin of the fibres, but come with high costs and have specific requirements. Currently, test results can only be interpreted, rather than used for clear identification. In addition, no clear difference can be detected between mechanically recycled cotton and virgin-fibre cotton, as the fibre type is the same and may only differ in the fibre length distribution. The fibre length distribution describes the different lengths of individual fibres in a certain section, in a spun yarn for example.

- Polymerization level: The molecular analysis can provide valuable findings, such as the identification of polymer damages or chemical residues. Currently, the methods are very expensive and the results are often inaccurate, especially in complex recyclate mixtures with different material types. The technological effort is currently disproportionate to the value for the vast majority of textile products.

Influence of incorrect material labelling on the test methods

Currently, there are many products on the market for which the material composition is not correctly labelled for various reasons. Which means the composition does not match the actual material content of the product. As previously mentioned, the test method to be used depends on the material being analysed. Therefore, the declaration is the only reference for determining which method to use and for verifying that the values obtained are correct. However, such reference is extremely important but often lacking.

Labeling of textiles, photo: textil+mode

Differentiation and geological consideration of recycled origins

Waste is generated at various stages along the production chain of a textile product. The closer the product is to becoming a finished product, the more difficult and costly it is to recycle this waste. Furthermore, the reprocessing and recycling sites are often far apart from the original manufacturing site, which makes the process even more difficult. Type, origin and available quantity of textile waste have a significant impact on the technical feasibility of recycling and the quality of the recycled materials

The availability of recycled materials from textiles, the costs of their processing at different locations and their actual integration into

Differentiation of textile waste

- Pre-industrial waste is generated during the extraction and processing of raw materials such as cotton or wool, e.g. by-products of fibres that are a by-product of production. This waste is generated at the places where the raw materials are obtained and is usually fed directly back into the fibre cycle because it is relatively pure and technically easy to recycle. In principle, these by-products can be labelled as recyclates, but it is hardly possible to recognise them in the end product or in further processing.

- Post-industrial waste is generated during production, such as selvedge, fabric trimmings or production scraps. This waste is usually clean. As the material compositions can be separated more easily because there are uniform and can be more easily recycled (depending on the material). Unfortunately, these materials are often only available in small quantities in the EU, as clothing is mainly produced abroad. Some production locations, such as Turkey, India or Bangladesh, have already established recycling methods for these production wastes. After further mechanical processing, theses recycled materials are fed back into the spinning process. However, they are not explicitly identified as recycled materials.

- Post-consumer waste includes textiles that are consumed in the EU and then donated or disposed of, such as used clothing, shoes or home textiles. They usually consist of complex material mixtures. This alone makes it difficult to recycle them. In addition, there is a lack of economic infrastructure to collect and sort them. For this reason, only a small proportion of this waste is actually processed into recycled content. This is a key challenge in implementing the circular economy targets demanded by the EU.

- Pre-consumer waste includes textiles such as used clothing, shoes or home textiles, which are consumed, for example, in the EU and then donated or discarded. These items usually consist of complex material mixtures, which in itself makes them difficult to recycle. In addition, there is a lack of an economically viable infrastructure for collecting and sorting used textiles, especially for recycling. For this reason, only a very small proportion of this waste is actually processed into recycling material. This is a key challenge for implementing the circular economy targets set by the EU.

the actual production process also play an important role in the scalable feasibility assessment.

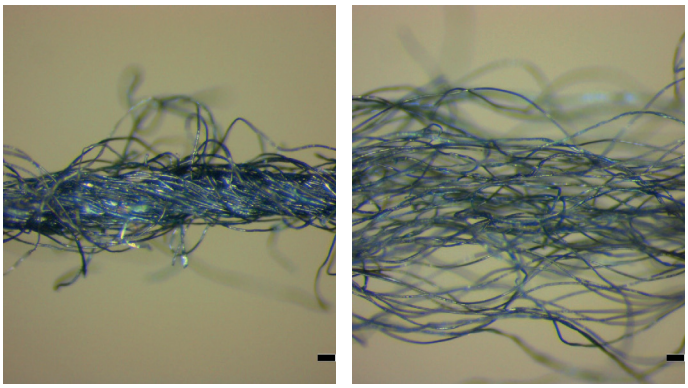
Both the place of origin of the waste and the production phase in which it arises influence the economic and environmental sustainability and technical feasibility of recycling.

This differentiation of the various parameters is essential, since not all waste streams are equally accessible and thus economically recyclable into recyclates.

The aforementioned goal of returning raw materials from every processing stage to actual end products as secondary raw materials is proving to be very difficult, especially in the EU. On the one hand, the necessary infrastructure for collecting and sorting used textiles and for processing them into a secondary textile raw material in a technically and cost-efficient manner is lacking.

In addition, the waste generated in Europe (pre- and post-consumer waste) is very difficult and costly to recycle due to its divers composition.

These are, for example, rPET types that are currently coming onto the market: These are obtained from chemical recycling processes by glycolysis, hydrolysis or enzyme treatments, as well as physically



Macroscopic image of yarns with recycling content after removal (left) and untwisted (right) Photo: DITF

by the use of special PET solvents. Although these types of rPET only make up around two per cent of the rPET market, they are rising significantly. However, it is completely unclear to what extent they can be classified in terms of their macromolecular properties. A great deal of research is still needed to be able to evaluate these alternative rPET types qualitatively and quantitatively.

Another possibility for obtaining PET as a secondary raw material is recycled material from other industries, such as rPET granulate from bottle production. This opens up an additional dimension to the sources of recycled textile material already described, as it goes beyond the textile origin and therefore needs to be considered separately.

For the sake of completeness, sources of recyclates from outside the industry are also listed here, as they may well be relevant for the production of textile recyclates glycolysis, hydrolysis or enzyme treatments, as well as physically by the use of special PET solvents. Although their share is only about two per cent of the rPET market, it is increasing significantly.

Conclusion

Existing testing methods – such as chemical, physical and optical analyses – do offer approaches for identifying recycled materials or individual material components. However, it is currently not possible to accurately and reliably verify the recycled materials due to significant practical and technical limitations.

Standardised reference values are missing for both recycled cotton and recycled polyester. The results are based solely on scientific interpretations, but these are not necessarily comparable or valid. Furthermore, the high costs of the tests are completely disproportionate to the value of the interpretative results. The tests are complex, labour-intensive and therefore costly. To monitor markets effectively, large, heterogeneous quantities of textiles have to be tested. More cost-efficient and scalable testing methods are therefore essential. On the one hand, a correct material declaration would be a helpful reference for determining the appropriate testing method and, if necessary, selecting a suitable combination of several methods. On the other hand, a correct declaration would render the necessity of testing absurd.

Research needs and solutions

In order to be able to detect recycled content in textiles efficiently and economically, the existing testing methodology must be fundamentally improved or/ and new methods developed. Furthermore, it is essential to have the corresponding basic data and the resulting reference values.

On the one hand, existing test methods can be optimized. However, digital verification methods would also be possible, such as blockchain technologies and marker technologies, which could also offer first innovative solutions. Research and science are required to develop more economical and reliable methods. An analytical examination of new rPET types is also essential.

This research is essential in order to consistently meet the objectives of the EU Textile Strategy and the requirements of the Ecodesign Regulation and the Green Claims Directive. If quotas for the use of recycled materials for textiles in products regulated by law, it must be clear that without clear traceability of recycled materials in the end product, the legislative initiative cannot be verified and has no effect.

The research community that has collaborated in this report considers future cooperation for the joint development of reference values and standards to be crucial for the possible success of verifying the use of recycled materials in textile products.

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