

Optical, spectroscopic and thermal analysis of fibers released during laundry washing cycle

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Introduction

- On the pathways of **microplastics**, some are delivered directly into the environment in form of small particles. This type of pollution is known as **primary microplastics**. They can be added to cleaning products, perfumes and shampoos or they can be released during laundry washing in form of a microfiber, which will through household and community wastewater end up in marine environment. Such wastewater is partially treated before release into rivers and seas, but not enough to be completely fiber free.
- Textile industry is one of the **biggest contributors** of primary plastics. Most used synthetic materials are **polyester and polyamide**, whose fibers are analyzed in this work.

Laundry washing cycle

- One way to lower the amount of released fibers is using specially designed **laundry bags**, which capture fibers during the washing cycle and prevent their release into the environment. The clothes were put into the GUPPYFRIEND Washing Bag and put into washing machine on 40 °C on 1000 rpm. The detergent powder containing oxygen-based bleach (5-15%) was used.
- After washing, the laundry was carefully removed from the bag and all potential **microfiber** particles were carefully collected. Captured fibers were analyzed with FTIR, optical microscopy and DSC before and after the washing cycle.



Source: <https://guppyfriend.us/products/guppyfriend-washing-bag>



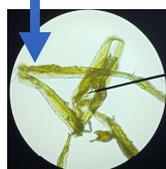
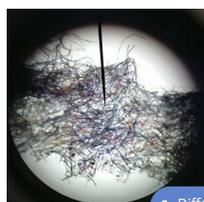
Name	Picture	Description
Red fiber		Red color in shape of yarn
Yellow fiber		Yellow color, stringy shape
Short fiber		Black color, most common shape
Long fiber		Gray-black color with reticulated structure

Optical microscopy analysis

- Four characterized fibers were imaged under the optical microscope.
- It is clearly seen that each of the particles consists of several fibers.
- Some fibers of the particle, such as "yellow (40X) and red (10X) fibers", appear torn, as if they were burned. It indicates some form of **chemical degradation** during washing.



Short fiber (10X)



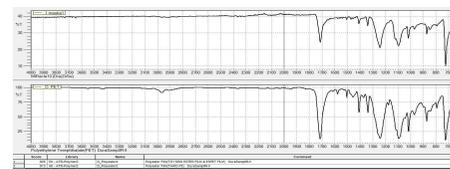
- Different colors of fibers (4X and 10X) is observed, indicating that this is a mixture of different fibers from multiple pieces of clothing.

FTIR analysis

- The reasons why using this method is the best for the analysis of microplastics are its **non-destructive nature**, which allows the collection of more results using different instruments, and spectroscopic analyzes can provide rich information covering both the surface and surface properties of molecules, which allows the characterization of morphology and chemical composition.

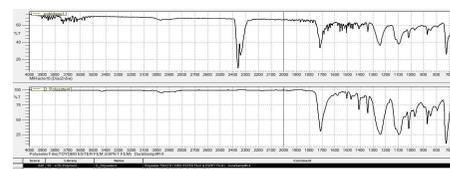
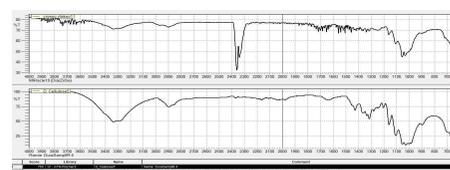
Preparation of clothes

- Each garment was before washing analyzed by FTIR to verify the validity of its **synthetic origin**. This confirmed the synthetic composition of the clothes, and it consists of polyester (PES) and polyamide (nylon) polymers. In several cases, a high accuracy of the matching of the obtained spectra of polyester (PES) with the spectrum of **polyethylene terephthalate (PET)** was observed.



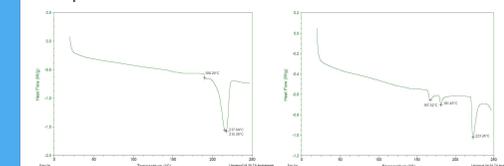
Fiber analysis

- The particles detected to be from PES and PET are "short fiber" and "yellow fiber", making them microplastic particles obtained from the clothes. The FTIR spectra of "red fiber" and "long fiber" show the **presence of cellulose**, which can be explained in several ways. The first explanation is the probable presence of cotton, and another explanation is the occurrence of chemical degradation.



DSC analysis

- Since there was a **mismatch** between the FTIR spectra of the fiber after washing with known fiber sources, it is suspected that some **degradation** happened. DSC analysis is done to check if any, and if yes on which temperature partial thermal degradation has occurred. DSC analysis was done for temperatures from 20 °C to 250 °C.



- Since none of the samples melted at temperatures close to the washing temperature (167 °C > 40 °C), it can be determined that there was **no change in the fiber structure** due to the temperature change. Thermograms of other fiber sources had not given any signs of thermal deformation.

Conclusion

- A comparison of the results before and after the wash cycle showed that **some FTIR spectra were mismatched**. This could lead to the conclusion that a **partial degradation** occurs during the washing cycle, which affects the correct identification of the released fibers. Also, it can be assumed that some amount of **cellulose was absorbed** onto the fibers. Besides, the assumption that there was a **technical error** must not be left out.
- This work showed that FTIR analysis can give many information about microplastics, but there are still some drawbacks that should be overcome in further FTIR research. Thanks to FTIR spectroscopy, it has been proven that a **certain amount of microplastics is separated every time synthetics are washed**. Therefore, textile materials should be improved so that they undergo minor changes during washing.

References

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