

Environmental and lost masks FFP2 and clinical/surgical masks Analysis with FTIR and ATR

User Benefits

- ◆ Fast screening of samples
- ◆ Analysis space minimal
- ◆ Quick handling using IRSpirit

■ Introduction

Since COVID-19 the people are trained to use protection of the mouth nose area with clinical/surgical or FFP2 masks. All such masks are looking made of cellulose, like paper tissue. They appear white or coloured at top layer depending on the request of user.

What can happen to such masks?

Users will waste them as usual in a waste bin. In surgical environmental it will be biohazardous level waste.

But very often such masks will not find their way into a waste bin. They are visible on the road, ways or in the nature in bushes or mixed with leaves in the wood or on the pavements. Result of use out of the surgical area where the waste is controlled.

Figure 1: a lost, dropped clinical mask found on walking way of a park, one example



And statistically the clinical masks are found more often than FFP2 masks. By feeling it is made from cellulose, it will be seen as paper like, will by expectation degrade to wood and earth in a manner of recycling. Might be for the paper tissues this can be a right thinking – not nice but possible. How is it with the masks- they are looking like made from paper?

They are fully made from polymer and will never be on the level of biodegradable. Might be that the UV-radiation and light exposure will help to crack the long chains of the polymers. As the mask is a medical product of risk class I (as required by Medical Device Directive ("Medizin-produktrichtlinie" (93/42/EWG, MDD)) the mask must be produced under condition of EN14683 and EN149 standards. Additional it must have the CE declaration. [1], [2], [3]

The basic polymer is almost PP but versions of mask from PS, PE, PC and polyester are also known. One demand during production is that the needed layers of polymer shouldn't be woven. So, non-woven layers are needed. A common clinical mask has three layers: thin - extra thick - thin. The thick (fleece) is packed in an envelope of two thin layers. With FFP2 masks it can be 4 to 5 layers of PP.

The PP should have 20 or 25 grams per square meter (gsm) in density.

In this application note it was checked if masks were prepared by one polymer, the Polypropylene (PP). Both style of masks (surgical and FFP) of this application were from different sources - three different companies for the clinical mask and three different for the FFP2 mask (Fig. 2).



Figure 2: 6 different samples, from each style 3; these samples were examined for their content on polymers.

■ Methods

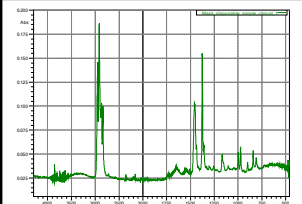

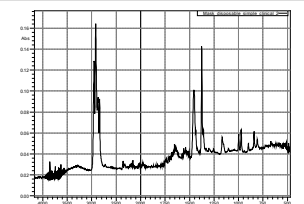

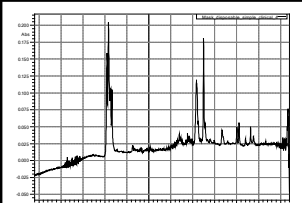

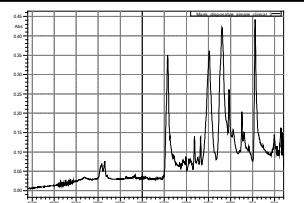
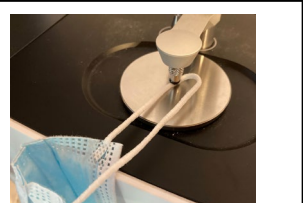
FTIR-ATR

To get a quick overview about materials the FTIR method is the right choice. Within seconds you can identify the material. As it is the talk about solids which will be tested without any chemical treatment. The accessory for the analysis of the solid is the single reflection ATR technique with diamond window. For a good ATR measurement, the substance or polymer must be soft so that it can be pressed homogeneously over the complete measurement area against the diamond window. The measurement window has a size of approx. 2 mm.

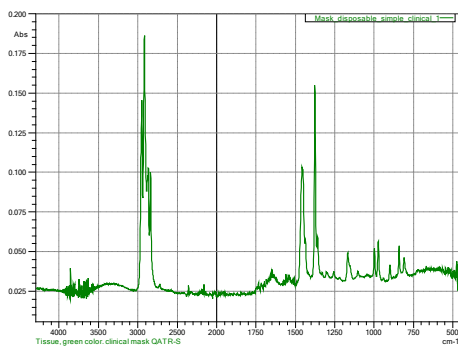
Analysis with FTIR

The material interacts with the heat of the IR light source. It will absorb heat and molecule bonding will move. Each bond has its own energy consumption and generate a unique signal or frequency in the infrared spectrum. As instrument the IRSpirit-T was used. It is a FTIR Spectrophotometer with TGS detector and high energy light source. The QATR-S single reflection ATR accessory was used for the sample measurement.

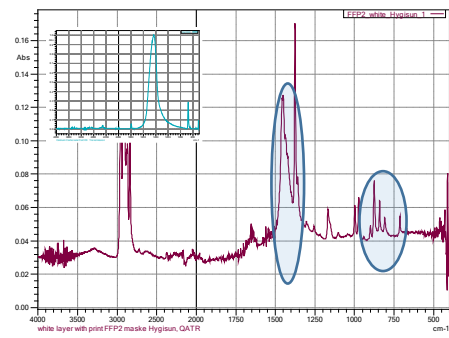
■ Table 1: Analysis of a typical three-layer clinical mask, picture of the mask part and belonging infrared spectrum, three layers for the mouth part and loop for fixing at ear.

IR Spectrum	Part of mask	IR Spectrum	Part of mask
 Polypropylen	 Greenish-bluish layer	 Polypropylen	 White layer
 Polypropylen	 White inlet – the fleece	 Polyethylenterephthalat	 Band, white, flexible ear loop

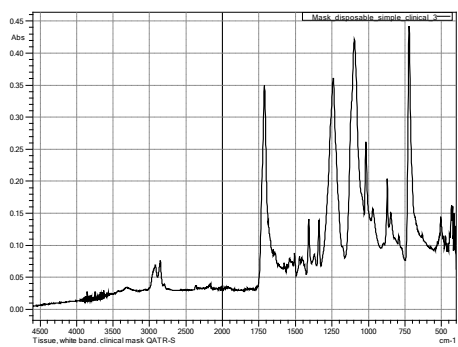
■ Main polymers in 6 mask samples



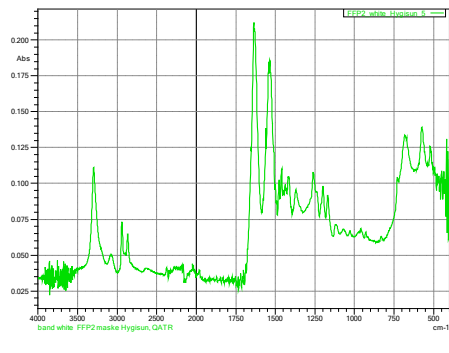
(a) Polypropylene - PP



(b) Polypropylene plus CaCO₃



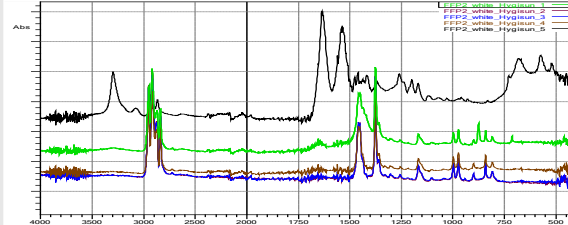
(c) Polyethylenterephthalat - PET



(d) Nylon – Polyamid (PA)

Fig. 3 a-d: Four infrared spectra which show the mayor polymers for the production of clinical and FFP2 masks, (a) is a pure polypropylene, (b) is PP and it includes CaCO₃, which has function as whitener, stabilizer but also as fire extinguisher/flame retardant, see CaCO₃ spectrum at left upper edge of the mayor spectrum, (c) PET which is part of one of the ear loop and (d) which is part of another ear loop too.

■ Table 2: Six different samples of Mask from two groups - clinical Mask and FFP2 – are listed with number of layers, and the used polymer as identified with Infrared spectroscopy.

Mask	Layer	Polymer	Remark
Clinical White –blue green	<u>3 layer</u> white fleece blue green Ear loop	PP+ traces water PP PP+ traces water PET (all spectra table 1)	Not found inorganic whitener nor flame retardant, Water because of used mask.
Clinical White –green IIR	<u>3 layer</u> white fleece green Ear loop	PP PP PP+CaCO ₃ (fig. 3 (b)) PET (fig. 3 (c))	Inorganic salt in green layer be used as flame retardant and stabilizer
Clinical White –white	<u>3 layer</u> white fleece white Ear loop	PP PP PP Nylon	No flame retardant, nor whitener
FFP2 Hygisun	<u>4 layer</u> White with print Fleece 1 Fleece 2 White wo print Ear loop	PP+CaCO ₃ PP PP PP Nylon	 <p>IR spectra from FFP2 Mask with 4 layers and ear loop</p>
FFP2 Easylife	<u>5 layer</u> White with print Fleece 1 Fleece 2 Fleece 3 White wo print Ear loop	PP PP PP PP PP PET	
FFP2 Karina L4	<u>5 layer</u> White with print Fleece 1 Fleece 2 Fleece 3 White wo print Ear loop	PP PP PP PP PP + fat traces Nylon	Used mask, fat from skin!

Abbreviations: PP = Polypropylene, PET = Polyethylene terephthalate,
Nylon=Polyamide, FFP2=filtering face piece class 2, protection against aerosol
and corona virus, a medical mask level

■ Result

All three layers of the fleece were made of polypropylene (PP). Only the ear loop consisted of PET. The fleece as non-woven material was seen in the FTIR-Spectra. Because of the fleece substructure as ordinary bulk a lot of gaps filled with environmental air were pressed against the ATR-measurement window. As for a good plane baseline a good contact of material with the diamond crystal is needed the spectrum showed influences in the baseline. It was water vapour traces and a shifted baseline.

The fleece is showing such up and down of the surface, having pores. So, it is measured more environmental air which adds water vapour profile and CO₂ signals into the infrared spectrum. It is influencing the regions at 3370 cm⁻¹, between 2400 to 2000 cm⁻¹ with view of diamond absorbance and overlaying the bonded water at 1660 to 1500 cm⁻¹ with vapour profile. The water vapour effect is even much better visible with a fleece washed with soap under water, and then dried. The water signals are at 3370 cm⁻¹, 1650 cm⁻¹ and as offset starting from 920 to 500 cm⁻¹.

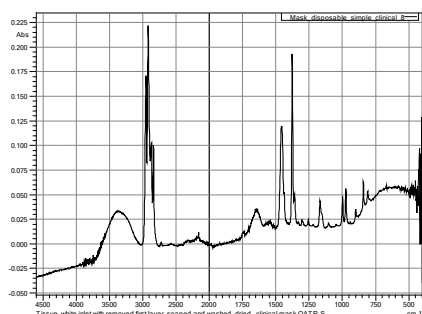


Fig. 4: fleece washed and dried, showing the pickup of water. This should visualize the water region in the infrared spectrum. The water vapour will add a rotation fine structure into the spectrum at water position.

These 6 masks (fig. 2) were produced in compliance with the ISO/CEN regulation. In table 2 is described how many polymers are involved to produce the different masks. All in common have the requested polymer polypropylene for all the used layers. These are in common three layers for the clinical mask and four to five layers for the FFP2 mask.

The difference is to see in the ear loops which were in these samples from nylon or PET.

In one case of the FFP 2 mask the inner layer contained traces of fatty acid. The mask was a used one, so it was reasonable. Contact to skin could have caused this.

The clinical masks showed differences in the content of whitener /stabilizer of the outer layer, the one which is not in contact with the skin. The green mask showed content from calcium carbonate which is whitener but also stabilizer and a flame retardant.

All inner layers -the thicker fleeces- were all made from polypropylene and nothing different.

■ Conclusion

The FTIR-spectroscopy is very helpful technique for the speedy identification of raw materials. With the support of the Library Search also untrained persons can have easily results. All masks were from polymer. They were not biodegradable. Masks in nature will stay there for long time. Recycling of masks is an issue in discussion[4].

■ Literature

- [1] Respiratory protective devices - Filtering half masks to protect against particles - Requirements, testing, marking; German version EN 1499:2001+A1:2009
- [2] Medical face masks. Requirements and test methods STANDARD by British-Adopted European Standard, 08/22/2019.
- [3] "Polyethylene Terephthalate for containers for preparations not for parental use", EP10.6, 01/2008_30115, corrected 7.3
- [4] Study of Recycling Potential of FFP2 Face Masks and Characterization of the Plastic Mix-Material Obtained. A Way of Reducing Waste in Times of Covid-19, Cristina Crespo et al., Waste Biomass Valorization. 2021; 12(12): 6423–6432

■ The Package IRSpirit

- *Main Unit*
IRSpirit-T: Fourier Transform Infrared Spectrophotometer compact, speedy and stable, with TGS Detector and KBr-window
- *Accessory*
QATR-S with diamond window and fixed anvil pressure
- *Software and Libraries*
LabSolutionsIR and integrated libraries