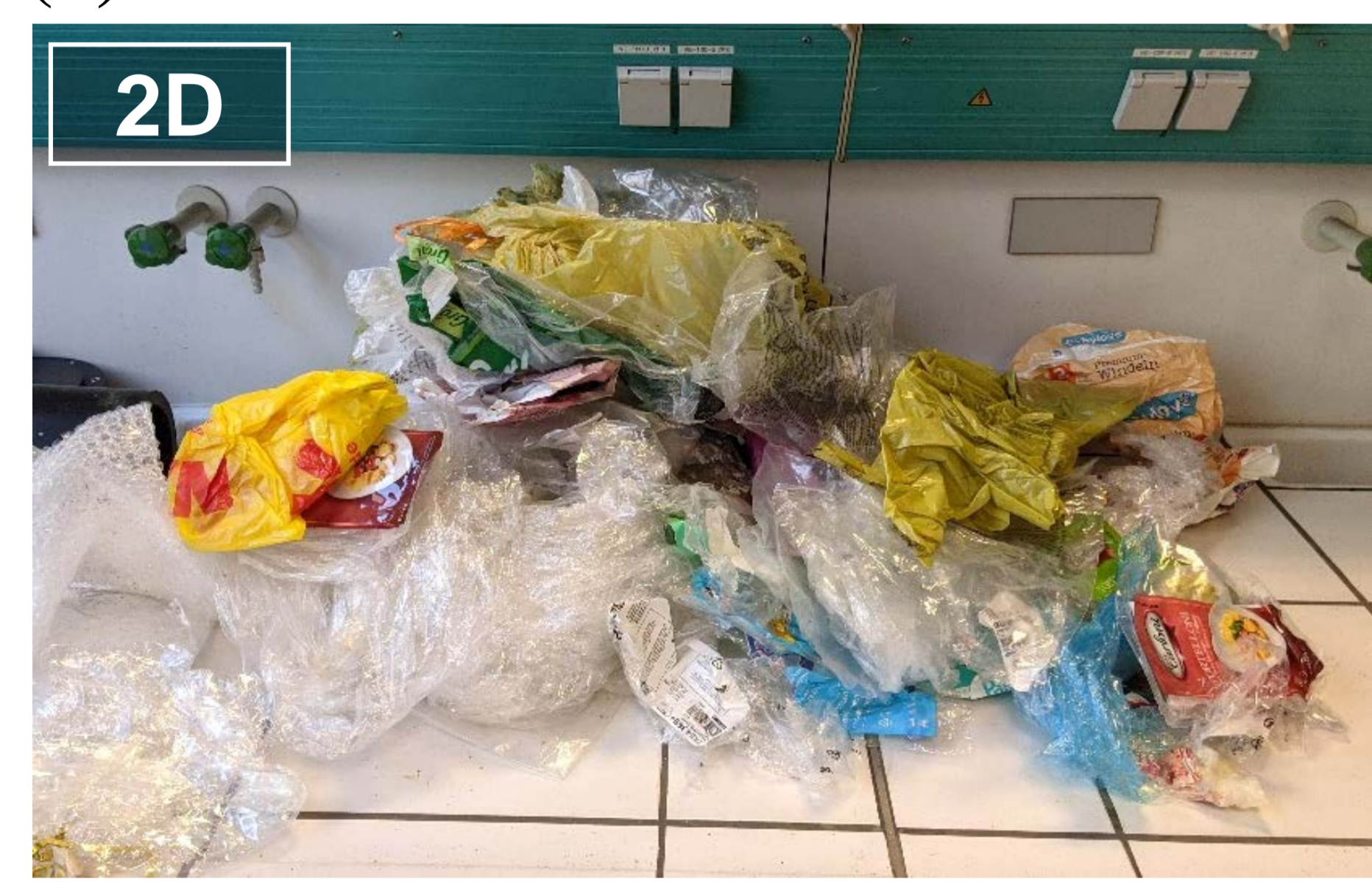


It is impossible to imagine today's society and economy without plastic and plastic packaging. Worldwide, 368 million tons of plastic were produced in 2019, of which 57.9 million tons in Europe. Thereof, plastic packaging accounts for more than a third of all plastic products in Europe and are particularly conspicuous because of their short lifespan and ubiquitous distribution in the environment. Due to its physical properties, packaging made of multilayer films are on the rise.

These complex, stacked structures of up to nine thin different material layers pose a new challenge to waste management systems, especially when it comes to sorting and processing. However, their share in waste plastic packaging is still under discussion. The presented research provides indications on the occurrence and weight share of multilayer film in the yellow bag collection of the separately collected waste (SCW) in Austria.

(1) Material



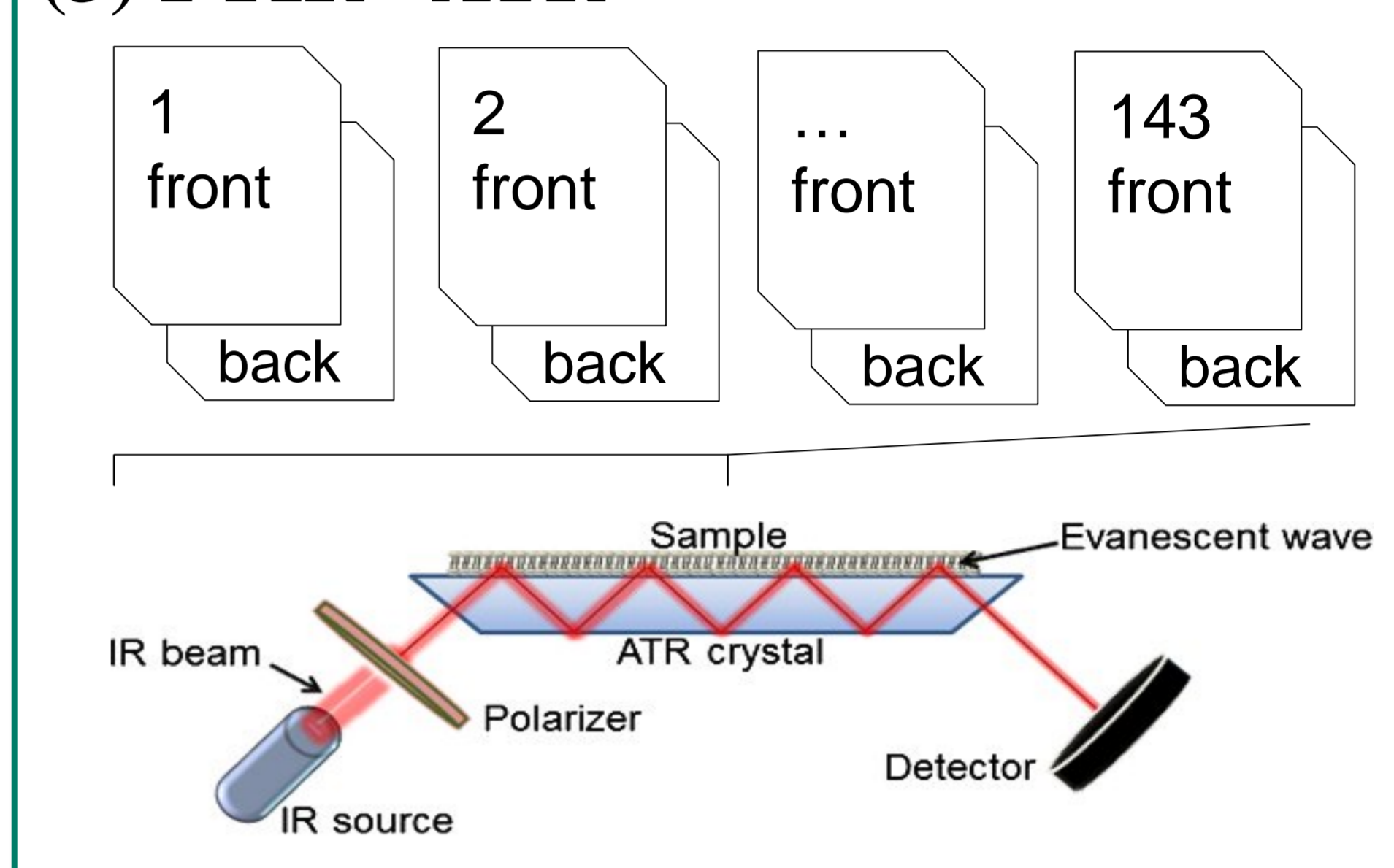
- 2D plastic packaging from SCW
- Sample size of **10.4 kg**
- Lower Austria, winter 2021
- No particles $d < 40\text{mm}$
- No medical waste plastic packaging

(2) Hand Sorting Analysis

Category 1	Category 2	Example
Primary food packaging	Bakery products	Bread, rolls, pastry
	Coffee	Coffee bags
	Dairy	Sliced cheese, yogurt lids, mozzarella sachets
	Dry food	Rice, noodles, cereal
	Fresh produce	Packaging of various fruits and vegetables
	Frozen food/convenience	Frozen vegetables, convenience food and dough
	Household packaging	Bags with zip fastener, freezing bags, cling film
	Meat	Meat, sausages, cold cuts
	Snack, metallised	Salty and sweet snacks with metallic coating
	Snack uncoated	Salty and sweet snacks without metallic coating
Secondary food packaging	Beverages	Wrapping of six-packs
	Primary product packaging	Construction/workshop
Primary product packaging	Construction/workshop	Cement bags, tools, oil
	Dry pet food	
	Garden	Soil, mulch, bark chips
	Household products	Clothes bag, toner, clothing
	Sanitary products	Wrapping of toilet paper, kitchen roll
	Toys	Lego sachets
	Wet pet food	
Secondary product packaging	Gift wrapping	Wrapping paper, ribbons, cellophane
	Mail order	Mailing bags, air cushion foil, bubble wrap
Bags	Generic bags	Transparent or colored single use multi-purpose plastic bags
	Carrier bags	Classical carrier bags
Foils	Generic foils	Pieces of various unspecific foils

- **N=842 particles**
- Visual inspection
- Determination of weight
- Categorization
- Documentation

(3) FTIR - ATR



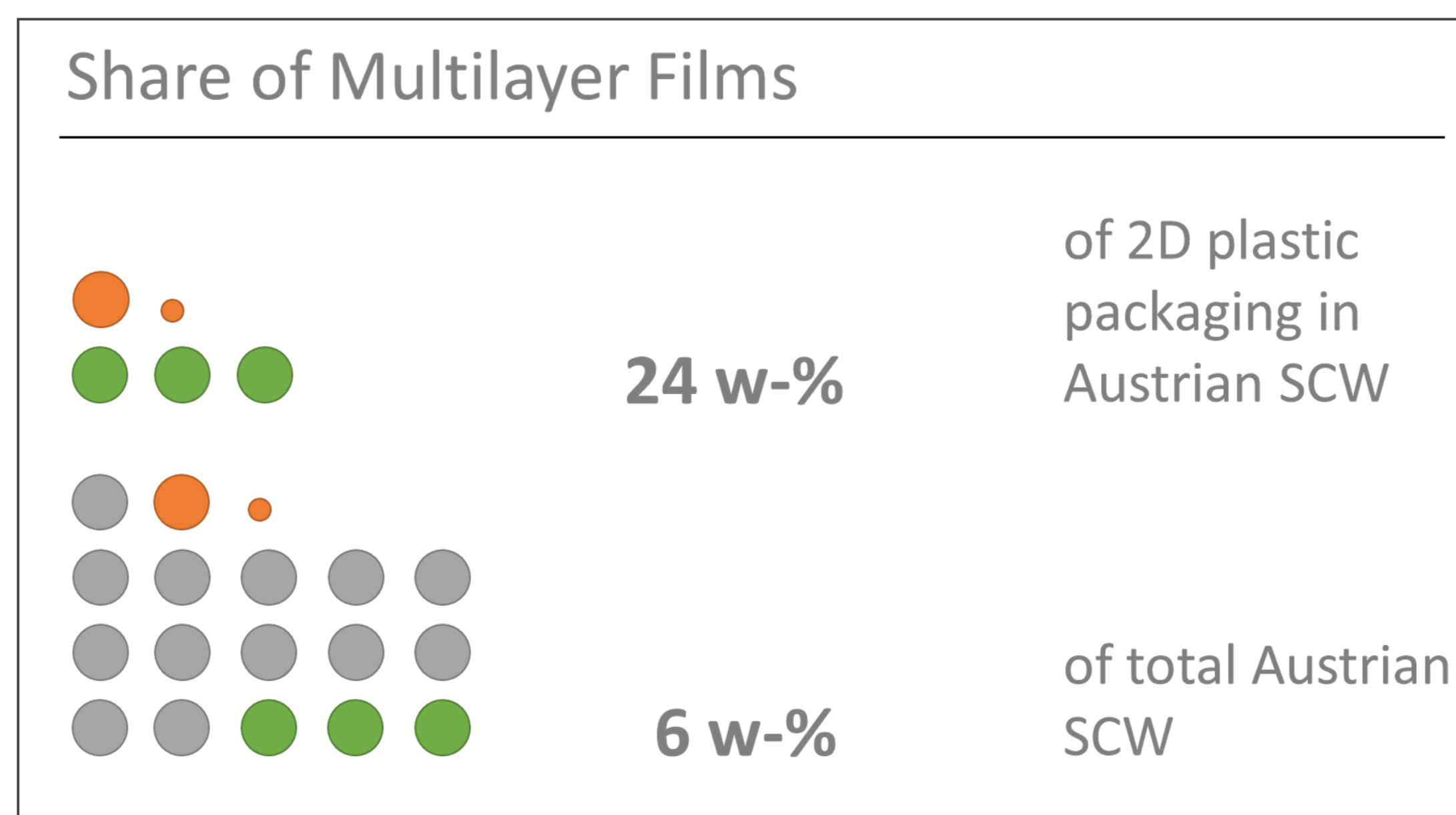
- Inspection of **n=143 particles**
- Differing results of polymer type for front and back of same sample qualify sample as multilayer film.

Results Recycling Potential of Multilayer films

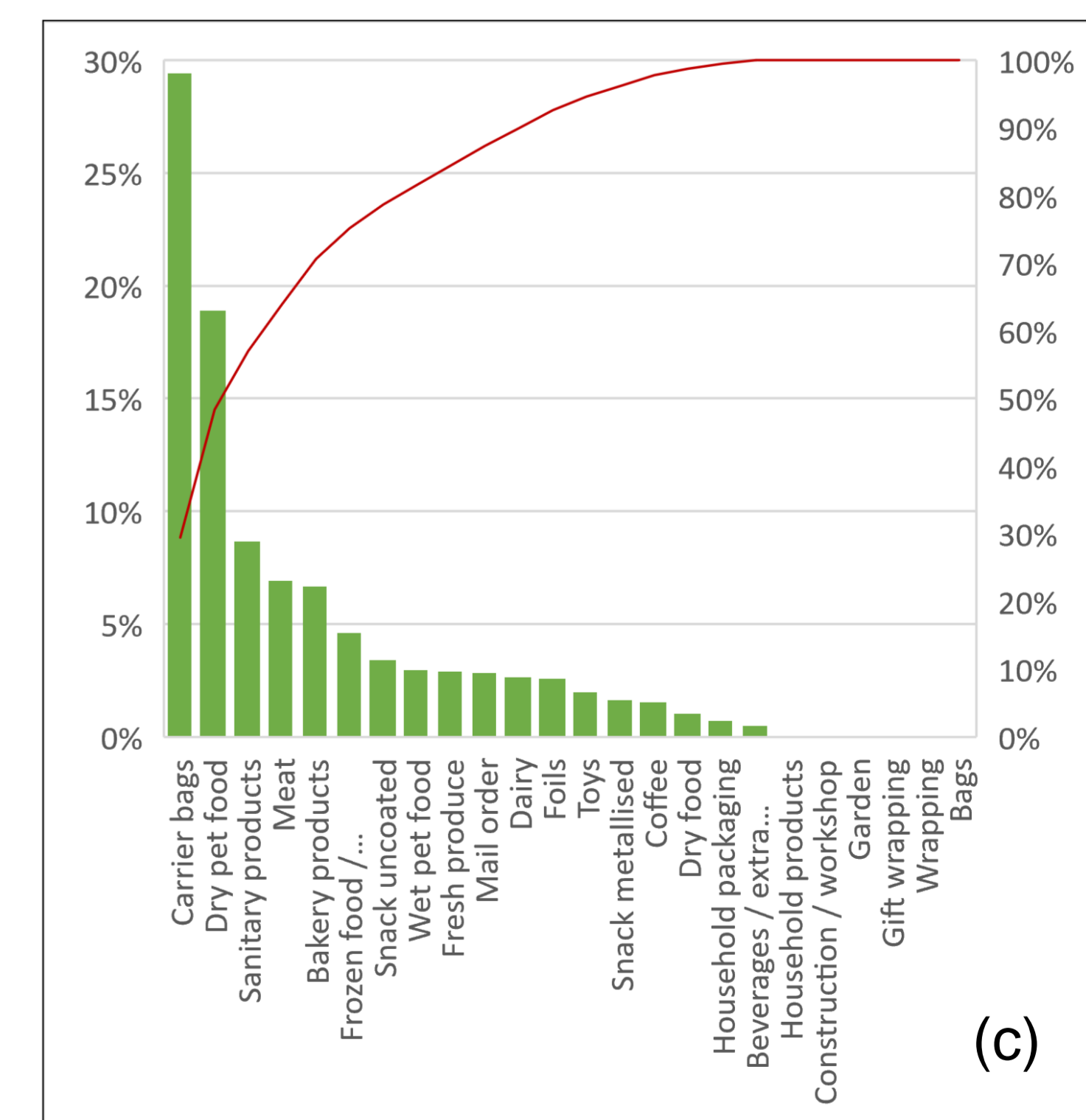
The total share of multilayer films in the **yellow bag** is calculated to be **6 w-%**, whereby the share of multilayer films in the **two-dimensional (2D) plastic packaging** is **24 w-%**. The 24 w-% are found to be almost equally split among packaging categories primary food packaging, primary product packaging, and plastic bags. The main packaging groups in which multilayer films tend to accumulate are primary food packaging (share 49 w-%), generic plastic bags (34 w-%), and primary product packaging (19 w-%). Combining the Austrian plastic packaging recycling efficiency of 25.7 w-% with 171,000 tons of plastic packaging collected in 2020 and the finding of 6 w-% share of multilayer films, results in a total of 10,260 tons of multilayer films per year in Austrian waste plastic packaging. A brief overview of the findings can be found in see Fig. 1.

	PE	PP	PET	PA	PDMS	PE/PP	PA/PP	PET/PA	?
PE	42	8	15	8	0	0	0	0	3
PP	8	52	4	0	0	0	0	0	4
PET	15	4	0	0	0	0	0	0	1
PA	8	0	0	0	0	0	0	0	0
PDMS	0	0	0	0	0	0	0	0	1
PE/PP	0	0	0	0	0	2	1	0	0
PA/PP	0	0	0	0	0	1	0	0	0
PET/PA	0	0	0	0	0	0	0	1	0
?	3	4	1	0	1	0	0	0	1

(a)



(b)



(c)

Figure 1: (a) Material variety of FTIR-ATR inspected plastic packaging, (b) Estimation of the total share of multilayer films in the yellow bag, (c) Pareto diagram of the presumably most common product groups where multilayer films tend to accumulate.

