SHIMADZU

# Interpretation of the Plastic Life Cycle Using FTIR/ATR-, EDXRF-, and ICP-OES SPECTROMETRY

Uwe Oppermann[a], Marion Egelkraut- Holtus[a], and Albert van Oyen[b]
[a]Shimadzu Europa GmbH, Duisburg, Germany
[b]CARAT GmbH, Harderhook, Bocholt, Germany, e-mail: Albert.van.oyen@carat-lab.com

## ■ Overview

In the year 2008, the worldwide production of plastics has reached an all-time high at 245 million tons [1]. It is estimated that in the 27 member states of the European Union, around 25 Mt of plastic waste was generated in 2008; 12.1 Mt (48.7%) was landfilled while 12.8 Mt (51.3%) went to recovery [2], and only 5.3 Mt (21.3%) was recycled [3].

As for waste management, the collection and sorting of waste from electric and electronic equipment (WEEE) as well as collection and sorting of plastics, provides the greatest job opportunities, with a total of 40 and 15.6 jobs respectively being created per 1 000 tons of material processed. Plastic recycling alone has the potential to create 162 018 jobs in the EU if the recycling rate increases up to a level of 70% by 2020 [4].

Plastic is most commonly used for packaging as a low-cost one-way product which generally is not reusable or foreseen to be reused. The plastics converting market is dominated by plastic packaging (40.1%) followed by the building and construction sector (20.4%). The plastics industry expects a long-term growth of around 4% globally, well ahead of expected global GDP growth [5]. Europe is still a net exporter of plastic products with a value of 13 billion Euro in 2009, but Chinese production has reached similar levels since 2008 [6].

Figure 1: Plastic waste – a global problem

## ■ Plastic Recycling

From the hundreds different kinds of plastics [7], most cannot be processed when they are mixed. Therefore the plastic varieties have to be separated on forehand, prior to recycling. Furthermore the additives are playing an important role in the quality of the recyclates, where the presence of heavy metals and flame retardants are of high concern.

An additional quality problem is degradation. Plastics are not inert but degrade under influence of UV-radiation, heat and other external influences [8]. From a thermodynamic point of view plastics are meta-stable, which means that (extra) energy exposure will degrade the plastic in unknown rest products.

FTIR spectrometry is a useful tool for determination and identification of plastic. Experimental work has been done using the Shimadzu IRPrestige-21 FTIR spectrometer

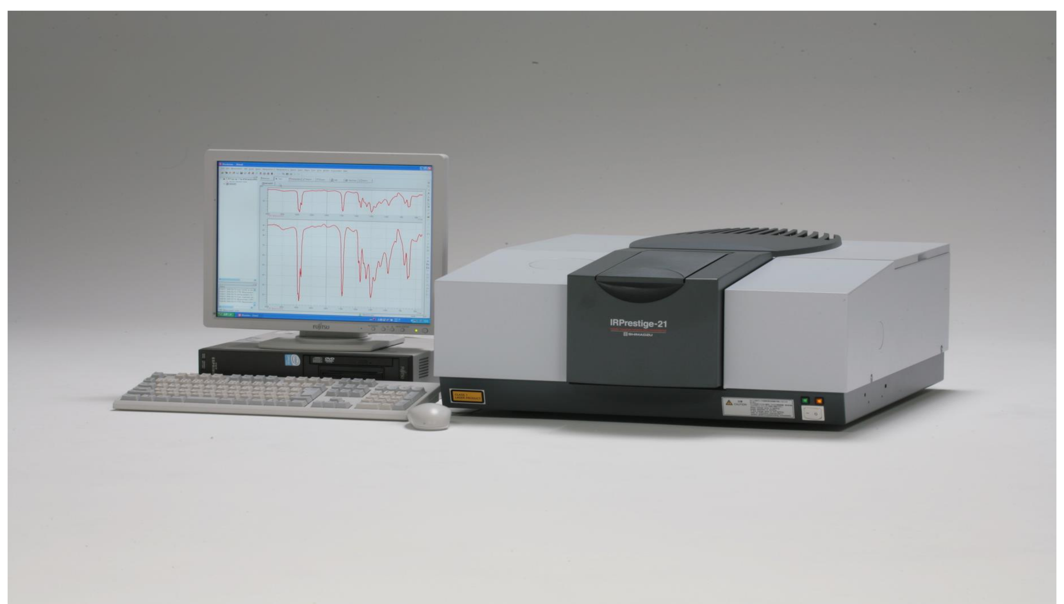

Figure 2: Shimadzu IRPrestige-21 FTIR spectrometer

in combination with commercial available libraries, usually containing the spectra of most common plastics. This method is quick and accurate for identifying plastic from production or pre-consumer waste.

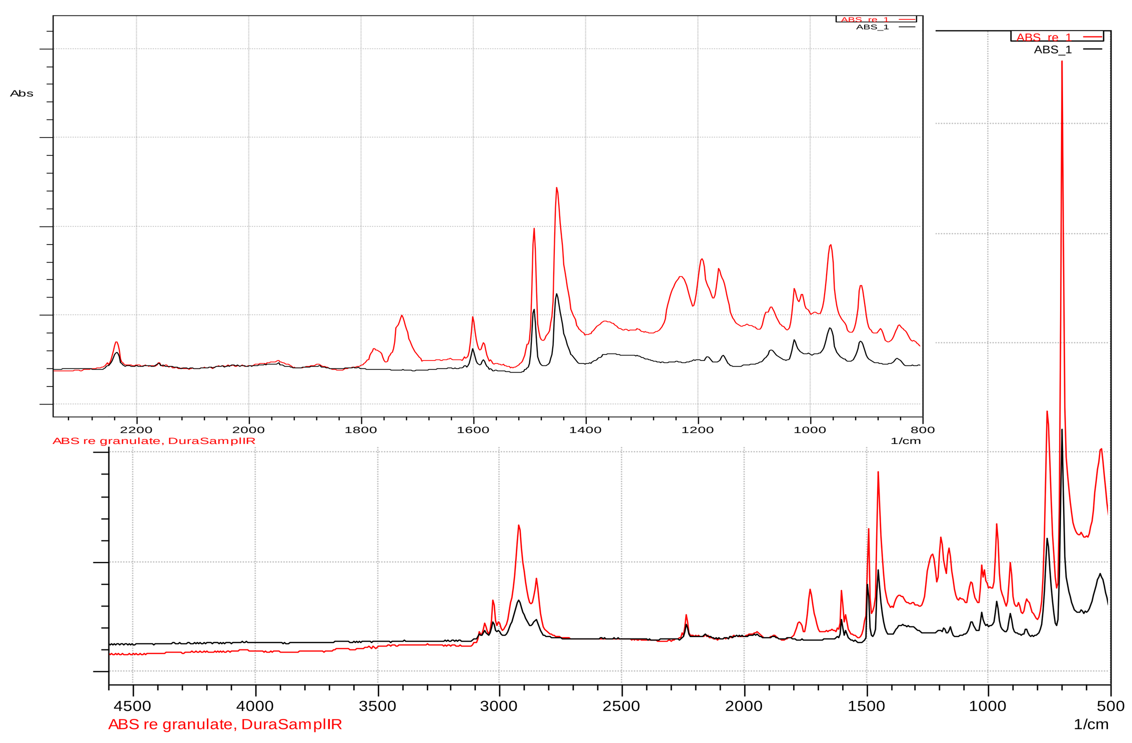

Figure 3: FTIR-ATR absorption spectrum of virgin ABS (black) and recycled post consumer ABS (red)

The above mentioned additional peaks are the result of contamination and are not recognized by traditional libraries. The contamination could be polycarbonate and/or polybrominated diphenyl ethers (PBDE's used as a flame retardant in plastic).

Further analysis with the EDXRF spectrometer EDX 720 gives more information of the elements present in the plastic. The presence of bromine and synergist antimony shows that the recycled ABS contains low concentrations of flame retardants. Furthermore highly toxic cadmium is detected. As cadmium is not allowed anymore according to RoHS (EC 2011/65) in concentrations higher than 100 mg/Kg, this material is not usable in consumer plastics anymore.

| Element | Virgin ABS [mg/Kg] | Recycled ABS [mg/Kg] | Possible function |
|---|---|---|---|
| Cl | - | 357 | Flame retardant |
| Br | - | 1985 | Flame retardant |
| Sb | - | 1356 | Synergist flame retardant |
| Ba | - | 209 | Filler |
| S | 120 | 660 | Production, Filler component |
| Cd | - | 257 | Stabilizer |

Table 1: Results of X-ray screening and RoHS analysis of virgin and recycled ABS

## ■ Plastics in the environment

Plastics are organic substances (carbon-backbone) which are sensitive for degradation. Industrial circumstances are completely different from environmental circumstances where due to the plastic's sensitivity against UV-radiation, the carbon-backbone will be broken and oxygen is adopted. Herewith mechanical stability is reduced and plastic deposits in the oceans is grinded down by waves in smaller pieces known as micro plastics (particle size < 5 mm).

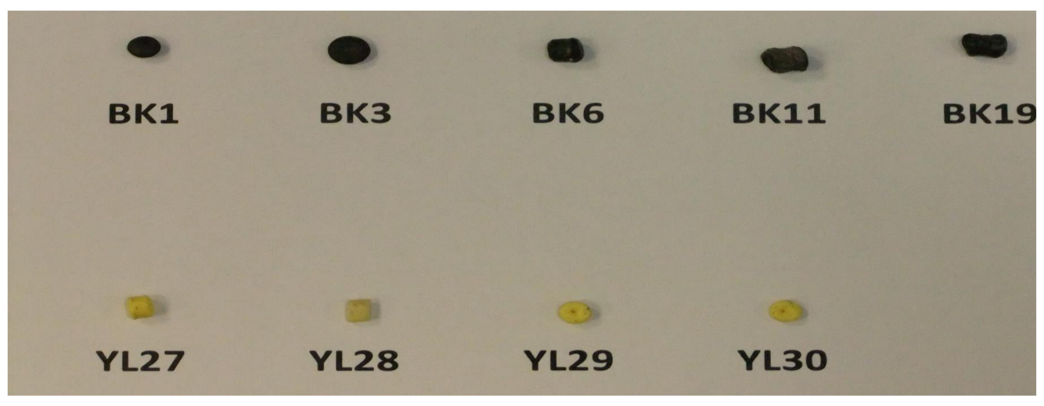


Figure 4: Beached industrial pellets (kindly submitted by J.A. van Franeker, Imares)

Characteristic peaks in the IR-spectrum show that the material is based on polyethylene. The beached pellets have also been subject to EDXRF- and ICP-OES analysis. The yellow pellets are containing high cadmium concentrations up to 5000 mg/Kg, and are most probably material of a masterbatch.

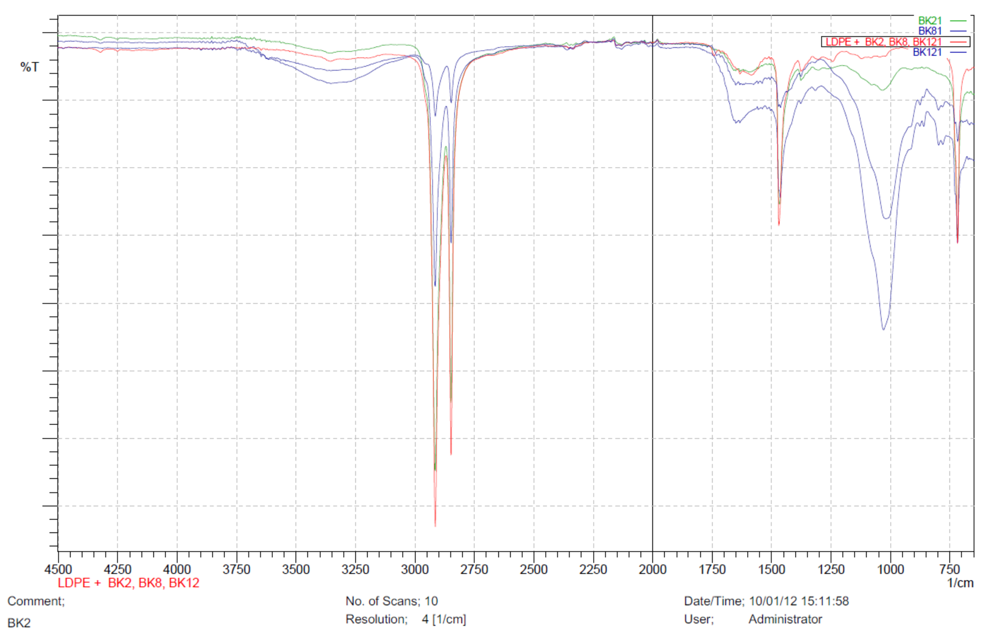

Figure 5:

## ■ Conclusion

FTIR-, EDXRF-, AND ICP-OES spectrometers are important tools in plastics analysis. Standard commercial FTIR libraries are not accurate enough to describe post-consumer plastics and needs additional input. Heavy metals like lead and cadmium will also influence the reuse of this man-made material and is a source of pollution. More analytical efforts are necessary to describe the possible recycling application of man-made material.

## ■ References

[1] BIOIS, Plastic waste in the environment, EU Commission 2010 http://ec.europa.eu/environment/waste /studies/pdf/plastics.pdf
[2] FORWAST, 2010, Policy recommendations, p. 43. (http://forwast.brgm.fr/Documents/Deliverables/Forwast_D63.pdf).
[3] (BIOIS) Plastic waste in the Environm, loc. cit., p. 73.
[4] Friends of the Earth, Report of September 2010, more jobs, less waste, p. 16, p. 31
[5] Plastic Europe, plastics – the facts, 2012 p.5.
[6] Plastic Europe, plastics – the facts, 2012 p.12.
[7] Wikipedia: plastics http://en.wikipedia.org/wiki/Plastic
[8] Handbook of UV-degradation, G. Wypych, 1st edition ChemTec Publishing 2011, ISBN 978-895198-46-1

***Shimadzu Europa GmbH***
*Albert-Hahn-Str. 6-10*
*D-47269 Duisburg*
*+49(0)203/7687-0*

*shimadzu@shimadzu.eu*

CARAT
Control and Research Analysis Thermoplastics