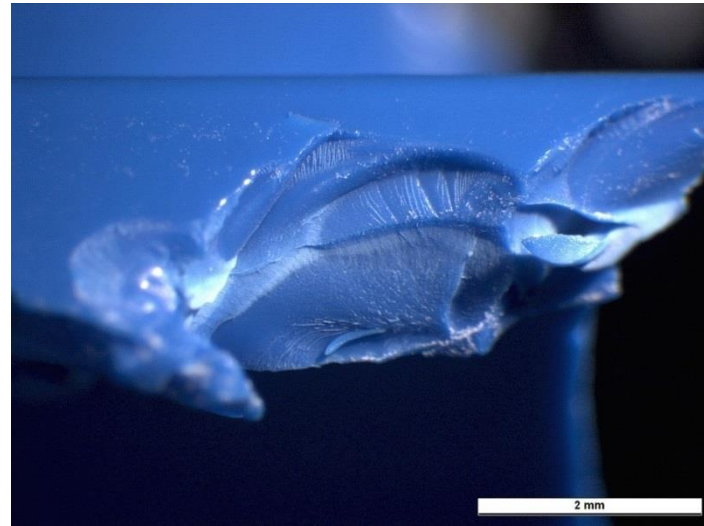


Polymers, Composites and Coatings

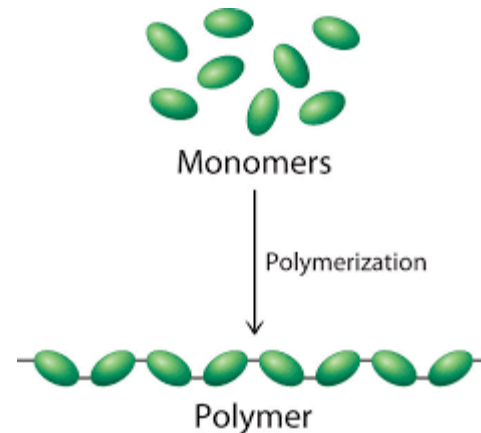


Monomer

- Mono=one, mer=part

Polymer

- Poly=many, meros=parts
- A large molecule that contains many monomers
- Thermoplastic (PE, PP, PVC...)
- Thermoset (Epoxy resin, polyurethane, polyester resin)
- Elastomers (SBR, EPDM..)



- Fillers
- Plasticisers
- Antioxidants
- Flame retarders
- Colorants
- UV stabilisers

- Binder/Binders
- Pigments
- Fillers
- Additives

A coating can in some instances contain more than 200 different components

Three most used analysis:

- FTIR-ATR

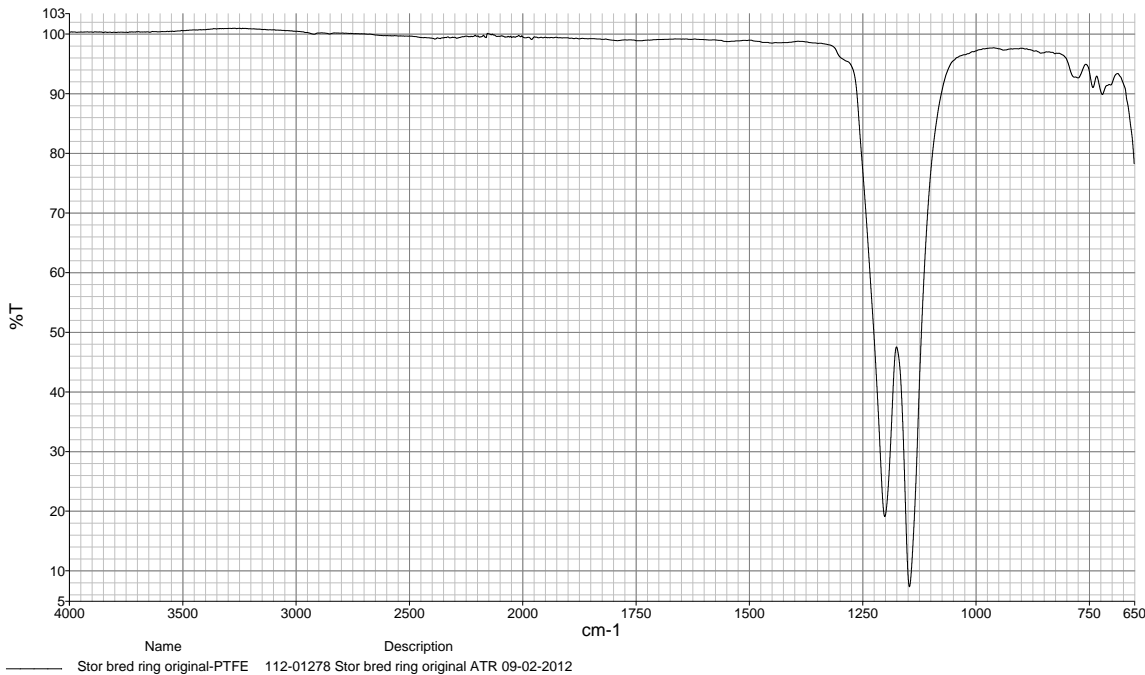
- TGA

- DSC

FTIR (Fourier Transform InfraRed) analysis



Chemical fingerprint - Identification of the polymer type



Thermogravimetric analysis - TGA

A thermogravimetric analyser measures the change in mass of a sample as the sample is heated, cooled or held at constant (isothermal) temperature.



Used to determine e.g.

- Moisture content
- Material composition
- Thermal stability and degradation
- Fibre content

ASTM E1131-08

↓
↓
TABLE 1 Suggested Compositional Analysis Parameters
↓
↓

Material	Sample Size mg	Flow Rate mL/min ^A	Purge Time Min	Temperature				Heating Rate °C/min	Gas Switchover °C
				Initial	X	Y	Z ^B		
coal	20	50	5	ambient	110	900	900	10 to 150	900
elastomers	20	50	2	ambient	325	550	750	10	600
thermoplastics	20	50	2	ambient	200	600	750	10	600
lubricants	20	40 to 500	1	50	150	600	750	10 to 100	600
thermosets	20	50	2	ambient	200	550	750	10	600

^A May differ depending upon instrument design.

^B Z is not necessarily the final temperature.



Parameters:
20 mg
Flow rate 60 mL/min
Heating rate 10°C/min
Gas switchover 600°C

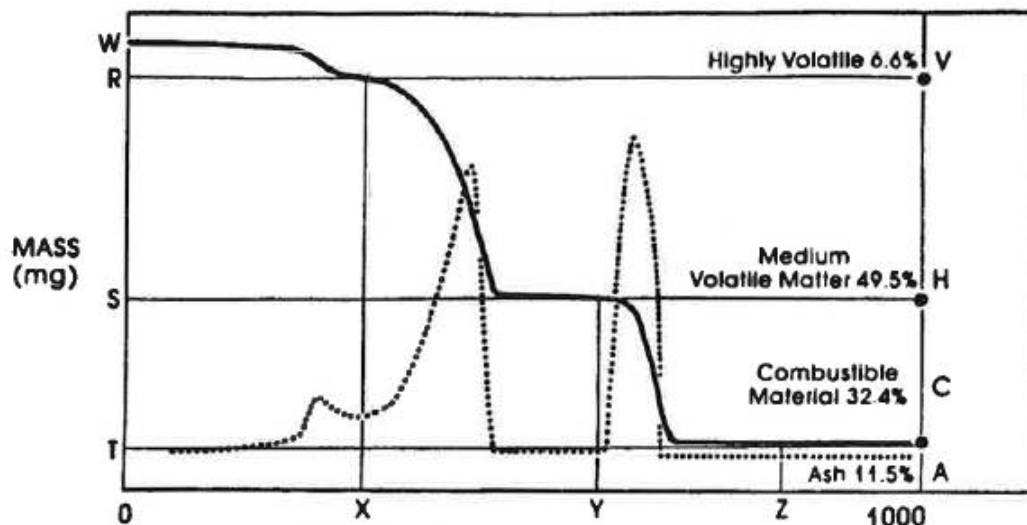


FIG. 1 Sample Thermogravimetric Curve

DSC is a technique upon which the heat-flow to or from a sample specimen is measured as a function of temperature or time as the sample is subjected to a controlled temperature program in a controlled atmosphere.

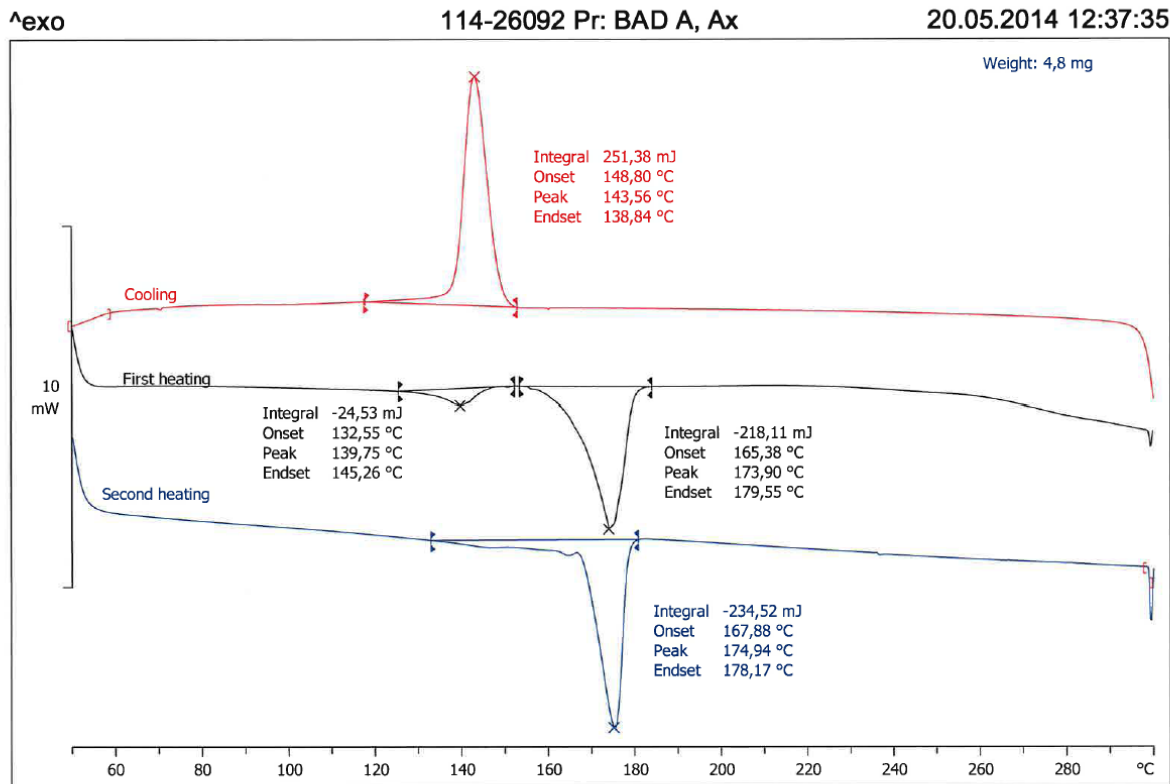
Used to determine e.g.

- The glass transition temperature (T_g)
- Melting temperature (T_m)
- The crystallization temperature during cooling (T_c)
- Oxidative induction time (OIT) – determination of antioxidant level
- Degree of curing

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Enclosure A



From first heating:

Sample	T _{m1} (°C)	T _{m2} (°C)
BAD A	139.4 (±0.6)	173.7 (±0.3)
BAD B	141.3 (±1.4)	174.8 (±0.9)
BAD C	140.2 (±1.4)	174.0 (±0.4)
BAD D	140.2 (±1.2)	174.7 (±0.2)
BAD E	139.3 (±0.2)	173.3 (±0.8)
GOOD A	131.4 (±2.3)	174.0 (±0)
GOOD B	133.2 (±1.4)	174.2 (±0.6)

- Chemical resistance
- Solubility
- Hansen solubility parameters HSP
- MFI/MVR
- Environmental Stress Cracking (ESC)
- Determination of additives (GC-MS)
- Size exclusion chromatography – molecular weight/molecular weight distribution

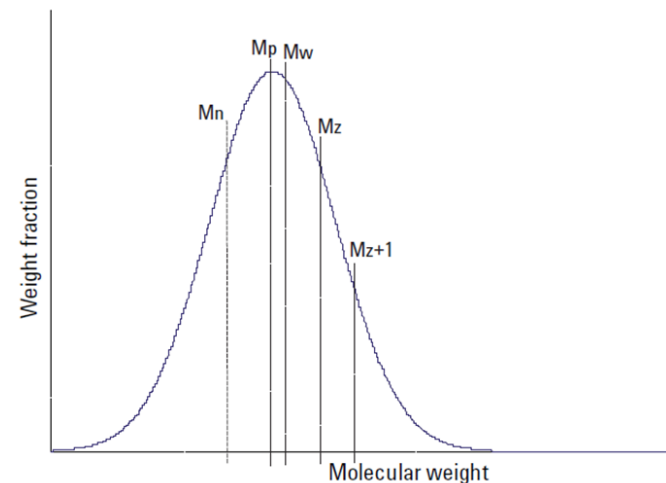


Figure 3. The average molecular weights of a mono-modal polymer – in this case the distribution is nearly symmetrical

Rubber

- Hardness measurements (Shore A, Shore D)
- Compression set
- Compatibility
- Solubility
- Chemical resistance
- Swelling
- HSP Hansen solubility parameters



Why?:

- Unknown composition of environment or polymers
- High complexity due to high number of additives – plasticizers – fillers – antioxidants - UV stabilisers etc.
- Combinatory effects
- Extreme pressure and temperature

- Task:
 - Replacement of a polyester filter due to degradation
 - A cotton filter or a PPS filter was chosen as replacement
- Test conditions:
 - Temperature: $150 \pm 3^{\circ}\text{C}$ (PPS)/ $135 \pm 3^{\circ}\text{C}$ (cotton)
 - Pressure: 25 ± 1 Bar
 - Time: 7 days
 - Testmedia: Ammonia solution
 - pH: 9.9

Evaluation filter material



- Visual evaluation – cotton filter showed color change
- Tensile strength
- Elongation at break

Special testing – Chemical resistance of coatings

Exposure testing to determine and qualify coating resistance to chemicals, temperature, pressure and exposure time.

Coatings are evaluated with respect to:

- Appearance and mechanical properties:
 - Swelling
 - Blistering
 - Color
 - Corrosion
 - Adhesion
 - Hardness
 - Impact resistance
 - Flexibility

