Recycling PVC Medical Tubing in Practice

Tobias Johnsen

Medical Tubing & Catheters

2 April 2025, Düsseldorf

vinyl plus healthcare

COMMITTED TO SUSTAINABILITY IN MEDICAL APPLICATIONS

Agenda

- About VinylPlus Healthcare
- The Challenge of Single-Use Plastics
- From Single-Use to Durable Hospital Wall Covering
- Quantifying Climate Benefits
- PVC Loop: Recyclability Study on Flexible PVC

About VinylPlus Healthcare

About VinylPlus Healthcare

- Launched 1 April 2025
- Organised under VinylPlus®, the European PVC industry's Commitment to sustainable development
- Brings together activities of
  - PVCMed Alliance (now discontinued as separate platform)
  - VinylPlus® Med for medical device recycling
  - VinylPlus® PharmPack for pharmaceutical blister packaging recycling

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COMMITTED TO CIRCULARITY IN PHARMA PACKAGING

Where is Vinyl Used in Healthcare?

Why a New Platform?

- A Changing Landscape
- Fragmented Efforts
- Regulatory Momentum
- Need for Trusted Data & Expertise
- Unlocking Circular Solutions
- Amplifying the Industry's Voice

VinylPlus Healthcare was created to connect the dots – and lead the way!

Our Activities

- Scientific Research and Studies
- Webinars and Events
- Conference Participation and Industry Engagement
- Stakeholder Meetings and Non-Industry Engagement
- Policy and Advocacy Efforts
- Online Communication and Resources

Partners shape our activities!

Ole Grøndahl Hansen, Project Leader, and Tobias Johnsen, Consultant

Join Us!

- VinylPlus Healthcare is open to partners across the value chain
  - Manufacturers and Suppliers
  - Medical Device and Diagnostic Equipment Manufacturers
  - Recyclers and Waste Management Companies
  - Healthcare Institutions and Professionals
  - Associations and Industry Groups
  - Academia and Technical Institutes
  - Pharmaceutical Companies
  - Machinery Producers

By joining VinylPlus Healthcare, you also become part of the broader VinylPlus family – Europe's platform for sustainable development of the vinyl industry!

Get involved today. Contact us to explore partnership opportunities: info@vinylplushealthcare.eu

Discover More

Pick up a leaflet and
connect with us online

vinylplushealthcare.eu

info@vinylplushealthcare.eu

The Challenge of Single-Use Plastics

The Challenge of Single-Use Plastics

- European healthcare systems contribute 5–10% of national carbon footprints
- Medical devices and pharmaceuticals accounting for nearly half
- Vinyl is the single most widely used plastic in single-use medical devices, including oxygen masks, tubing, and various bags
- Suitable for mechanical recycling
  - High recycling potential due to large volume
  - Mono-material PVC is easier to sort and recycle than multi-material non-PVC products
- Compatible with advanced recycling where needed – such as dissolution and pyrolysis

From Single-Use to Durable Hospital Wall Covering

From Single-Use to Durable Hospital Wall Covering

- VinylPlus® Med launched in 2022 to help solve the single-use challenge
- Collects non-contaminated, REACH-compliant, DEHP-free medical devices at 25 Belgian hospital sites
  - VinylPlus-developed scanner to detect PVC and DEHP ensures correct sorting
- Main products:
  - Tubing
  - Bags
  - Face masks
- The recycled PVC is used as backing material for hospital wall covering, manufactured by Vescom in the Netherlands
  - Flooring being tested

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From Single-Use to Durable Hospital Wall Covering

- Partners

VEOLIA — Logistics

DE LOODS — Waste Dismantling Hub

RAFF PLASTICS — Plastic Recycler

- Synergies: Veolia and De Loods already work together on other plastic recycling schemes (PP blue wraps, PS serology trays)
- Expansion to France underway

Step-by-Step: The VinylPlus Med Recycling Process

USE OF MEDICAL DEVICE

The medical device is used by patients for elective surgery and other treatments where the waste remains non-contaminated.

COLLECTION

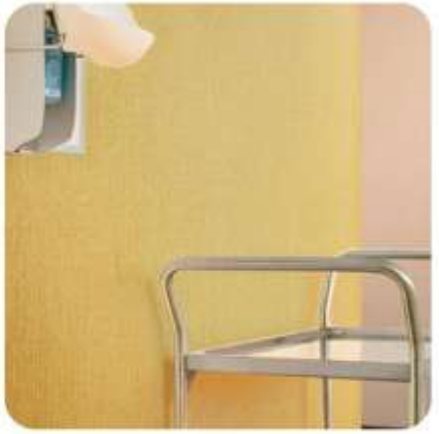
Filled bins provided by VinylPlus Med are collected by waste management companies.

DISMANTLING

Our social partner, De Loods Nekker, dismantles the devices, removing non-vinyl parts.

RECYCLING

Our recycling partner, Raff Plastics, processes the waste.



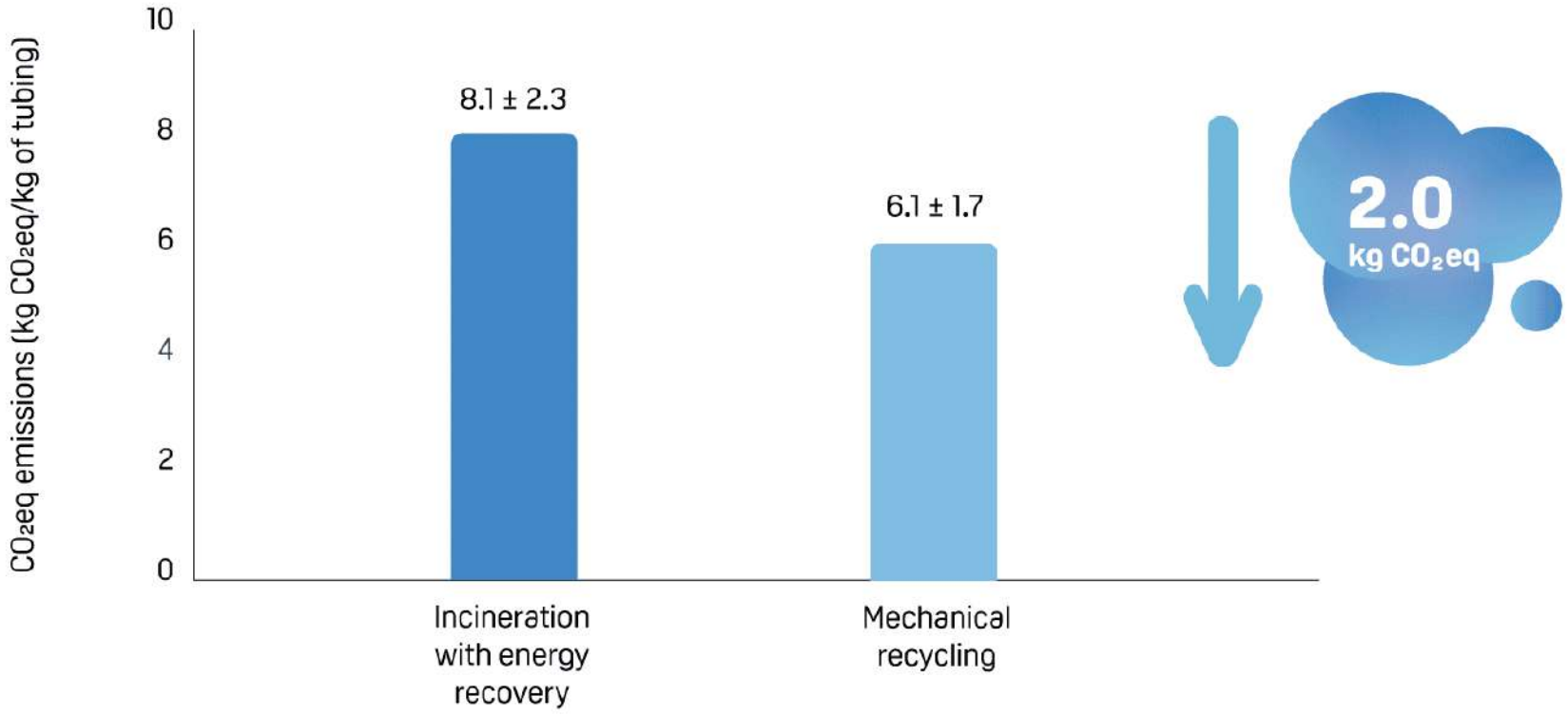
USE OF RECYCLED VINYL

The recycled vinyl is used for wall covering and other durable products for the healthcare sector.

Quantifying Climate Benefits

3rd Party LCA Confirms Significant Carbon Savings

CRADLE-TO-GRAVE CARBON FOOTPRINT OF MEDICAL VINYL TUBING: RECYCLING VS. INCINERATION



Source: Ecovamed. (2024, January). Life Cycle Assessment: Recycling PVC medical tubing cuts greenhouse gas emissions by 25% compared to incineration.

PVC Loop: Recyclability Study on Flexible PVC

Why the Study?

- Rigid PVC is well-documented to withstand several mechanical recycling cycles without significant loss of performance
  - 8-10x successful cycles achieved in experimental works
- Scientific literature offers limited insight into the recyclability of flexible (soft) PVC
- PVCMed Alliance initiated a study to close this knowledge gap
- Spanish institute AIMPLAS was commissioned to test how many times flexible PVC medical tubing can be recycled

PVC Loop at a Glance

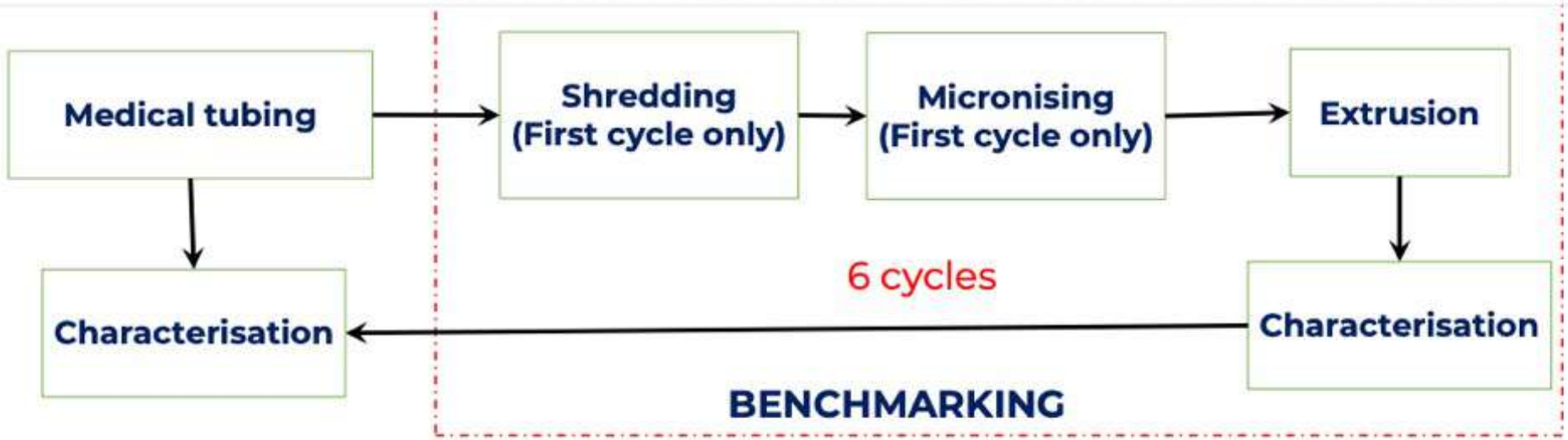
PVC LOOP AT A GLANCE

OBJECTIVES		
Address recyclability with no re-stabilization	Evaluate mechanical recycling for market suitability	Assess impact of multicycle recycling on the performance of flexible PVC

PVC Loop at a Glance

TARGET: MEDICAL TUBING

- Application: IV solutions, blood and dialysis systems
- European Pharmacopoeia grade
- 6 complete recycling cycles: grinding, extrusion, injection moulding

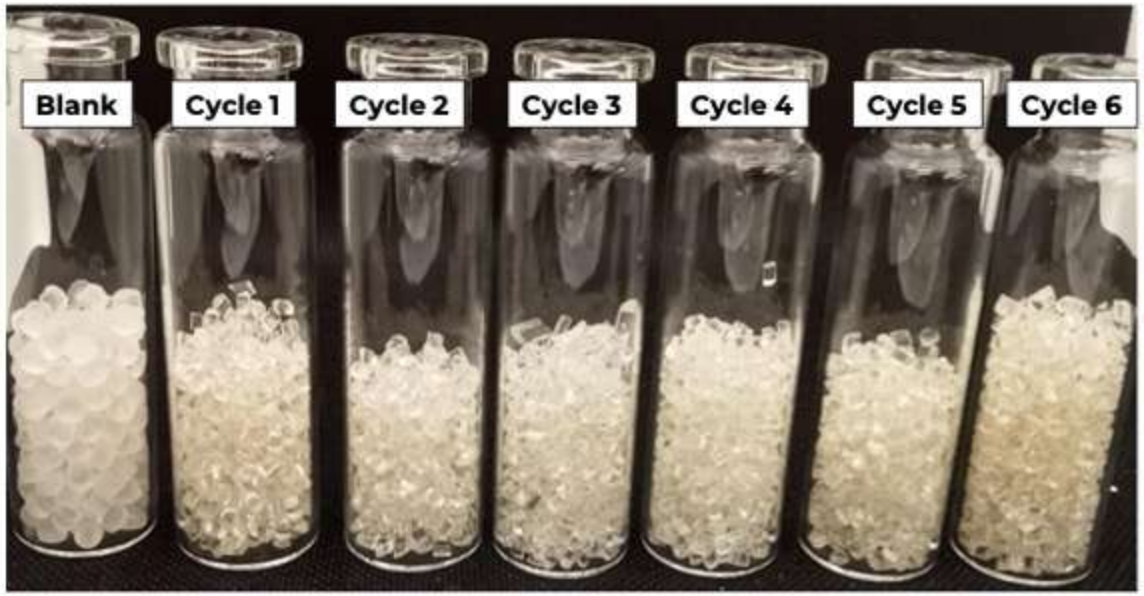


Processing

PROCESSING

Extrusion

Pellets production in a pilot-plant Bausano D30 counter-rotating twin-screw extruder was used, aimed at a maximum melt temperature of 175 °C.



Processing

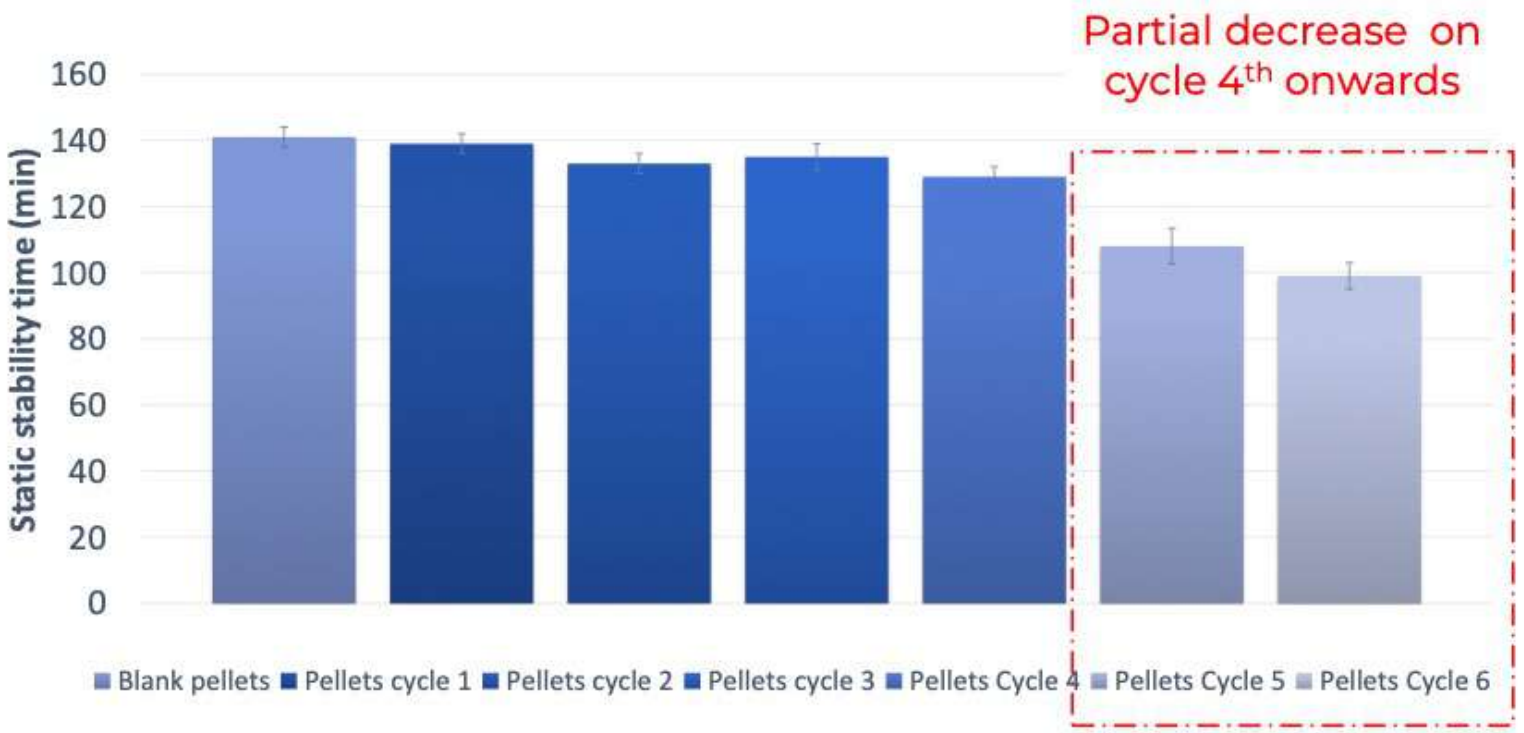
Injection moulding

Test bars injected in an Engel VC 200/50 Tech injection moulding machine, into ISO 1A test specimens (dog-bone).

Thermostability

THERMOSTABILITY

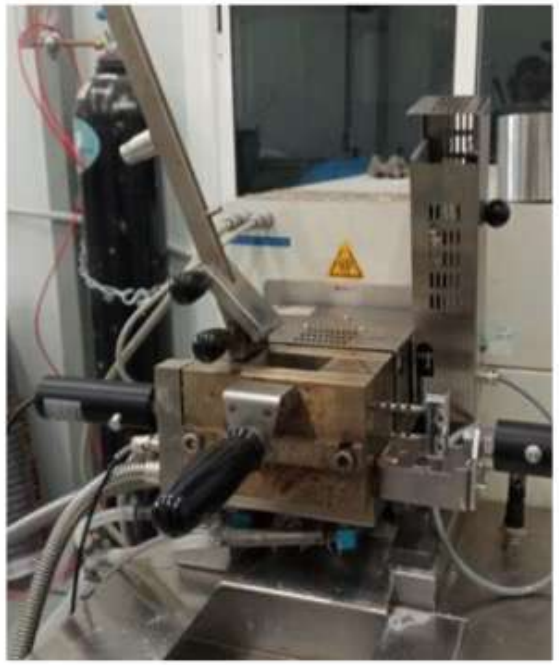
Static stability
Congo red test at 180 °C, in accordance with S/N ISO 182-1



Thermostability

Dynamic stability

Continuous stress in plastograph at a given temperature: 180°C, 185 °C and 190 °C

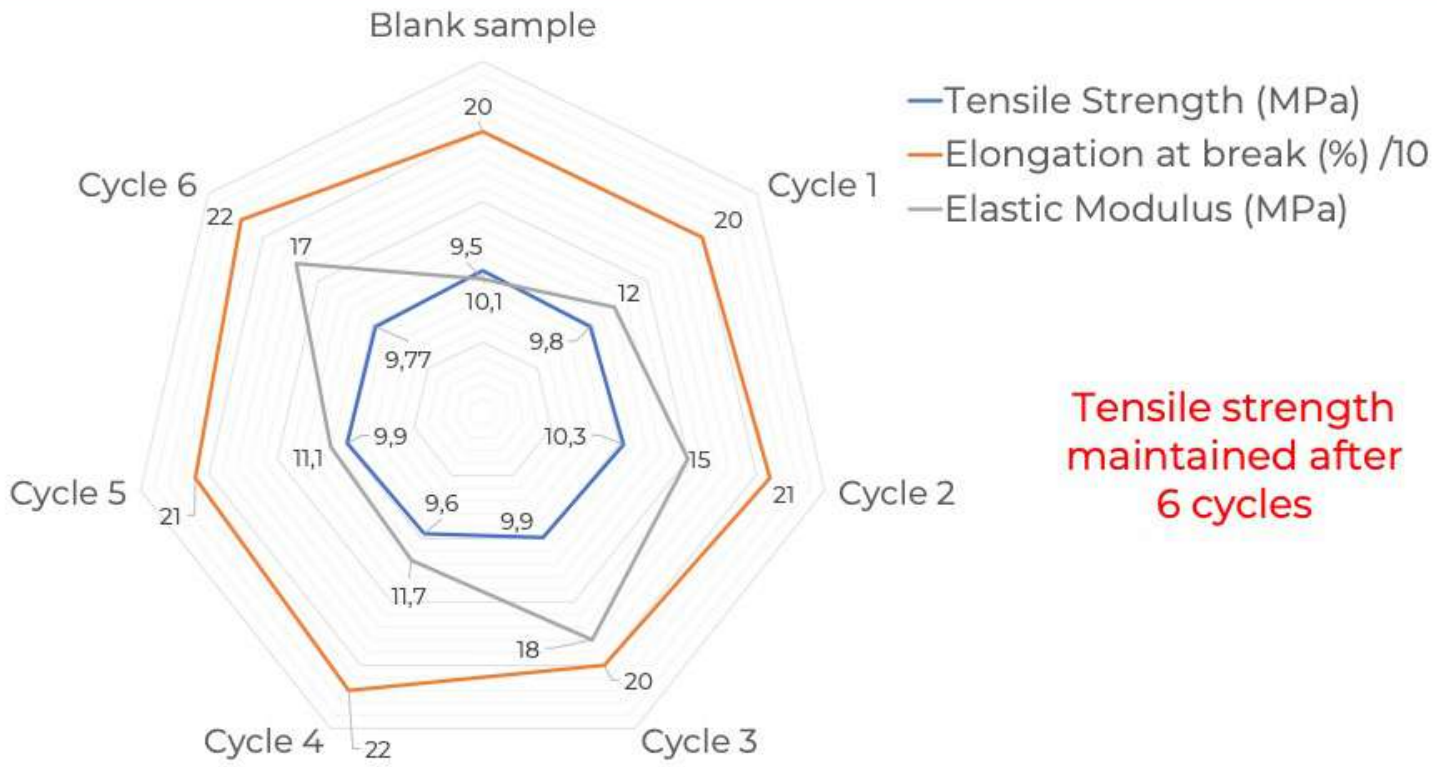


Stable up to 6 cycles

Description	Heat & shear stability time (minutes)			Heat & shear stability time (minutes) – Fusion time omitted		
	180 °C	185 °C	190 °C	180 °C	185 °C	190 °C
Blank	47 ± 2	44 ± 2	36 ± 2	37 ± 2	36 ± 2	27 ± 2
Cycle 1	46 ± 2	38 ± 2	26 ± 2	36 ± 2	32 ± 2	21 ± 2
Cycle 2	45 ± 2	33 ± 2	31 ± 2	29 ± 2	28 ± 2	26 ± 2
Cycle 3	46 ± 2	40 ± 2	34 ± 2	34 ± 2	29 ± 2	26 ± 2
Cycle 4	45 ± 2	39 ± 2	35 ± 2	35 ± 2	28 ± 2	26 ± 2
Cycle 5	44 ± 2	38 ± 2	36 ± 2	31 ± 2	27 ± 2	26 ± 2
Cycle 6	43 ± 2	36 ± 2	29 ± 2	33 ± 2	26 ± 2	24 ± 2

Performance

Mechanical properties
Tensile properties according to UNE:EN ISO 527

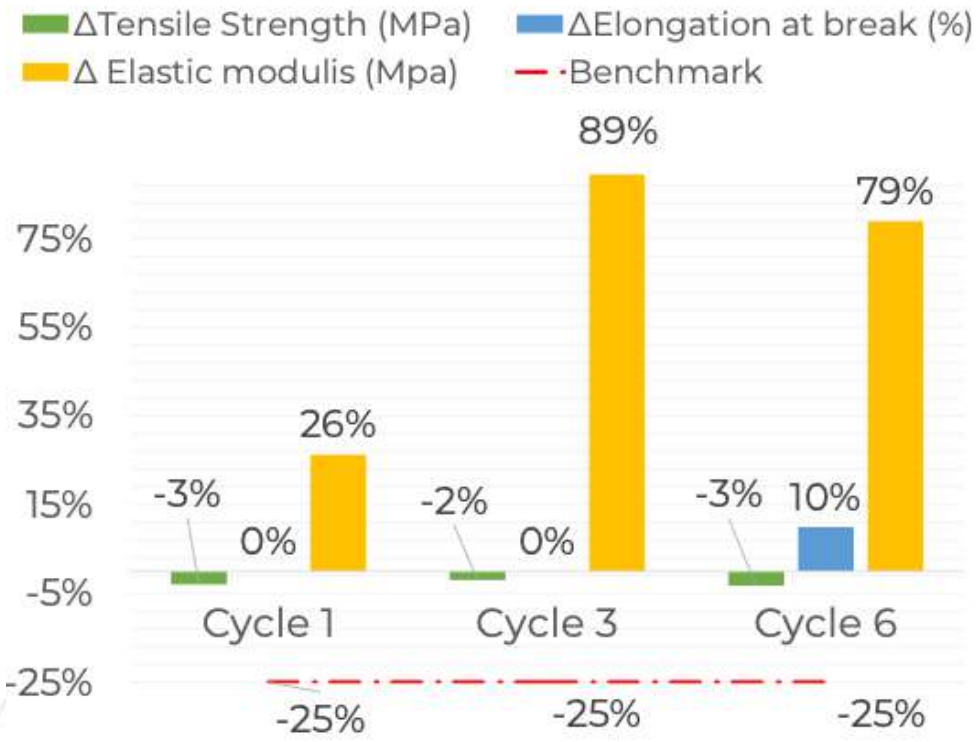


Tensile strength maintained after 6 cycles

Colour evaluation
Determination of L*, a* & b* coordinates according to UNE-EN ISO 11664-4:2020

Performance

Mechanical properties
Tensile properties benchmarking



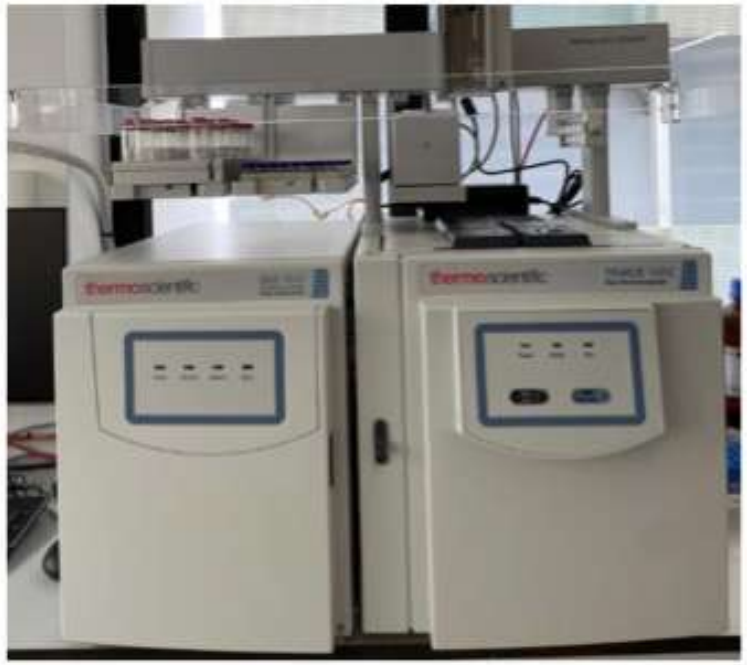
Superior benchmarking:
No more than a 25% Δ drop to the blank

	Δ Tensile Strength (MPa)	Δ Elongation at break (%)	Δ Elastic modulus (MPa)
Cycle 1	-3 %	0 %	26 %
Cycle 3	-2 %	0 %	89 %
Cycle 6	-3 %	10 %	79 %

Performance

Plasticiser content

Determination of plasticiser content by solvent extraction and GC(-MS)



Plasticiser content remains stable across 6 recycling cycles

Sample	Plasticiser content %
Blank	36
Cycle 1	36
Cycle 3	36
Cycle 6	36

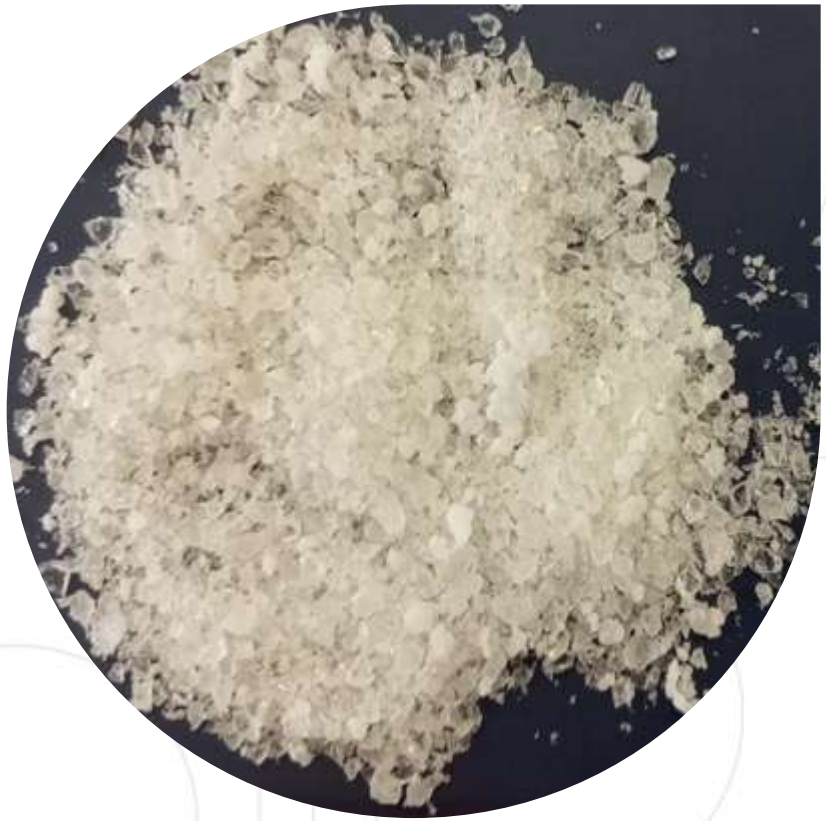
Performance

Colour evaluation
Determination of L*, a* & b* coordinates according to UNE-EN ISO 11664-4:2020

Light yellowing observed after 6 cycles

Sample	Colour coordinate			Delta values			
	L*	a*	b*	DL	Da	Db	DE
Blank	95,61	-0,39	3,72	-	-	-	
Cycle 1	94,49	-0,72	5,81	-1,12	-0,33	2,09	2,39
Cycle 2	94,94	-0,92	5,97	-0,67	-0,53	2,25	2,41
Cycle 3	94,56	-0,67	5,72	-1,05	-0,28	2,00	2,28
Cycle 4	94,33	-1,14	6,99	-1,28	-0,75	3,27	3,59
Cycle 5	93,15	-0,77	7,42	-2,46	-0,38	3,70	4,46
Cycle 6	92,74	-0,90	10,33	-2,87	-0,51	6,61	7,22

Key Findings



- Tensile strength and plasticiser content remained stable
- Only minor degradation in static thermostability after cycle 4
- Dynamic thermal stability confirmed material durability
- Slight yellowing observed after cycle 6 (aesthetic, not functional)

Complementary BASF Study

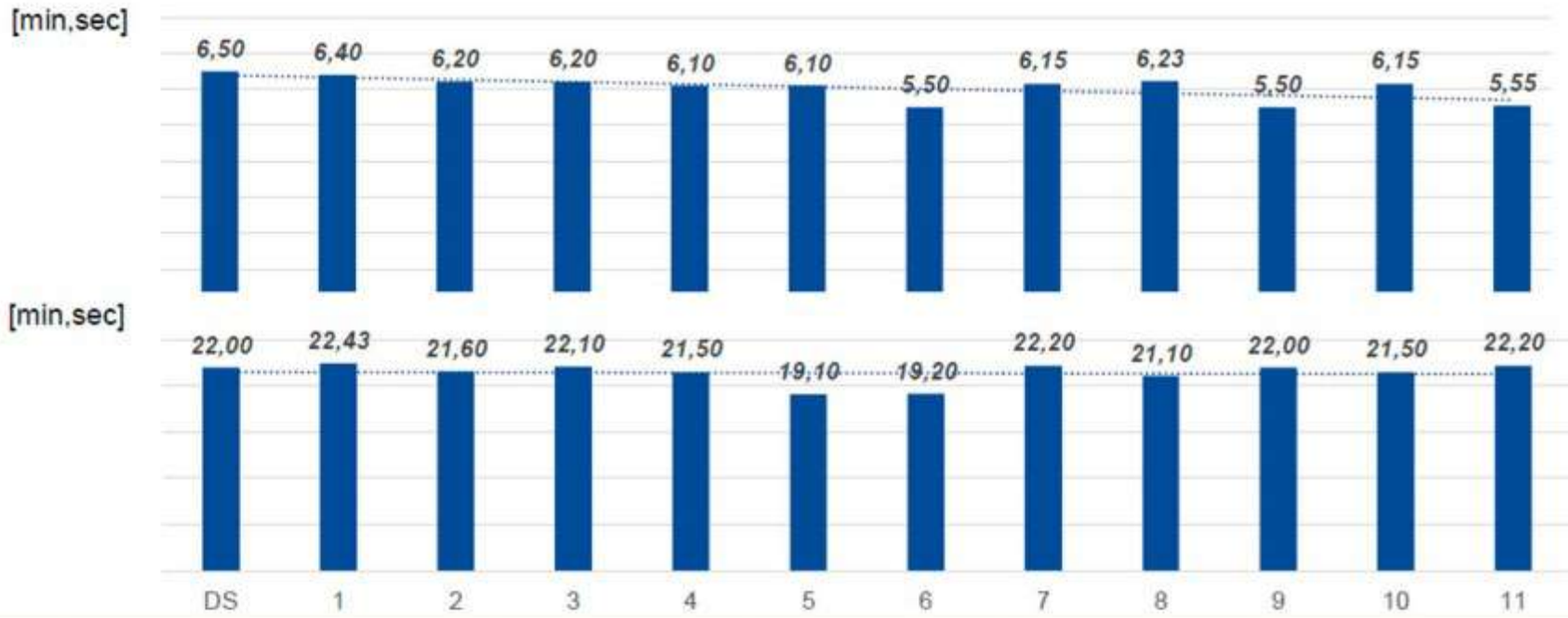
Recyclability assessment on PVC-P
Performed up to 11 extrusion cycles

- Transparent formulation
  - 100 phr PVC Inovyn 271 PC
  - 60 phr Palatinol® 10-P DPHP
  - 1,2 phr Ca-Stearate
  - 0,6 phr Zn-Stearate
- Compounding on double screw extruder
- 11 extrusion cycles single screw extruder

- Characterization
  - Thermostability (Congo Red, PVC Thermomat)
  - Colour
  - Mechanical data (Elongation at break, 100% Modulus, etc.)
  - Plasticiser extraction

Complementary BASF Study

Thermostability (Congo red, PVC Thermomat HCl-Stability [min, sec]
VDE 0473 Part 811-3-2 and Metrohm Thermomat stability time at 200°C with 50µS as endpoint



No changes in material thermostability after 11 extrusion cycles

Complementary BASF Study

Colour evaluation – Pressed plates at 170 °C

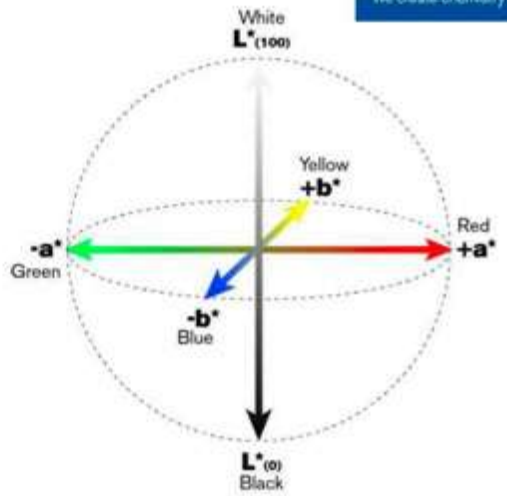
Determination of colour coordinates L*, a* and b* according to UNE-EN ISO 11664-4:2020
Yellowness Index is a number calculated from spectrophotometric

BASF
We create chemistry

Light yellowing observed after 6 extrusions; constant up to 11 extrusions

Sample	L	a	b	Yellowness index	DL	Da	Db	DE
1 X (DS)	88,97	-0,36	3,89	7,80	0,00	0,00	**0,00**	**0,00**
6 X (ES)	88,36	-0,66	4,78	9,50	-0,61	-0,30	**-0,89**	**1,12**
11 X (ES)	88,40	-0,72	4,93	9,54	-0,57	0,36	**1,04**	**1,24**

DS = Double screw extrusion; ES = Single screw extrusion



Complementary BASF Study

Mechanical properties
Tensile properties after 6 and 11 extrusions (11 samples)

Mechanical performance maintained after 11 extrusions

Run	Breaking strength (MPa)	Elongation at break (%)	100% Modulus (MPa)
0 (DS)	18,2 / 18,7	310 / 332	8,9 / 8,7
6 (ES)	18,3 / 18,2	314 / 326	9,0 / 8,6
11 (ES)	20,2 / 18,4	350 / 317	9,0 / 8,9

DS = Double screw extrusion; ES = Single screw extrusion

Plasticiser content %
Theorical value 37 %

Plasticiser content stable

Run	Plasticiser content (%)
0 (DS)	37
6 (ES)	37
11 (ES)	37

Factsheet Available at vinylplushealthcare.eu

AIMPLAS

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PVC LOOP: RECYCLABILITY STUDY ON FLEXIBLE PVC

Unlocking recycling potential for flexible PVC from medical applications

SUMMARY

The PVC Loop project examined the mechanical recyclability of flexible PVC (PVC-P) from medical applications. The study focused on medical tubing used in IV solutions, blood, and dialysis systems, completing six full recycling cycles, including grinding, extrusion, and injection moulding steps, with no additivation carried out between the cycles.

Findings show that mechanical properties, including tensile strength and plasticiser content, remain stable across six cycles, with only minor degradation observed for the static thermostability after the fourth cycle. The dynamic thermal stability tests confirmed the material's durability under processing conditions. However, slight yellowing was observed after the sixth cycle, indicating aesthetic limitations after many recycling cycles.

A complementary BASF study demonstrated that another PVC-P composition can endure up to 11 extrusion cycles with maintained thermostability, though light yellowing was noticeable after the sixth cycle.

Overall, the study confirms that, as rigid PVC, flexible PVC from medical products retains its functional properties through multiple recycling cycles, supporting its potential for sustainable recycling in the healthcare sector and contributing to a circular economy.

PVC LOOP AT A GLANCE

OBJECTIVES

- Address recyclability with no re-stabilization
- Evaluate mechanical recycling for market suitability
- Assess impact of multicycle recycling on the performance of flexible PVC

TARGET: MEDICAL TUBING

- Application: IV solutions, blood and dialysis systems
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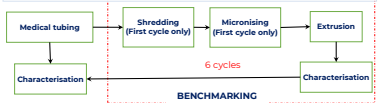

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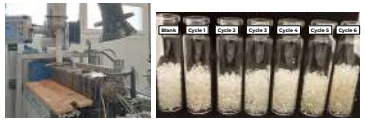

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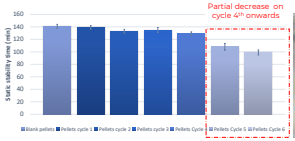

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Date of publication February 2025
Study performed at AIMPLAS-Mechanical Recycling group
Contact abarbas@aimplas.es

AIMPLAS

vinyl plus healthcare

PVC LOOP: RECYCLABILITY STUDY ON FLEXIBLE PVC

Unlocking recycling potential for flexible PVC from medical applications

Realistic Impact of Recycled PVC

- Flexible PVC can be recycled mechanically 6 (or up to 11) times without adding virgin PVC or additives, retaining key functional properties
- Critics argue might that this is “not much” – but context matters:
  - Medical products often have <1-year lifespans
  - Wall covering, flooring and roofing membranes last 20–40 years per cycle
- Examples of long-term use
  - PVC wall covering & flooring
    - Containing virgin PVC and recyclate (various ratios)
    - Typical lifetime: 20 years
    - Recycled 6 times → material remains in use for up to 120 years
  - PVC Roofing Membranes
    - Product lifetime: 40 years
    - With recyclate and virgin PVC through 6 cycles → material stays in use for up to 240 years

Broader Circularity Potential

- Safe collection and recycling of medical PVC demonstrated in Europe, e.g. VinylPlus Med
- Flexible and rigid PVC can also be recycled through advanced technologies, offering complementary end-of-life solutions
  - Dissolution treatment of PVC-based pharma blister packaging yields purified PVC, now being tested for new rigid film
  - Pyrolysis of plastic waste containing 10% PVC produces pyrolysis oil suitable for steam cracking

Conclusion

- Flexible PVC has proven recyclability in medical applications
- Enables long-term material use in products with decades-long service lives
- Infrastructure and innovation are in place to support circular models across healthcare
- Flexible and rigid PVC fit into both mechanical and advanced recycling streams, contributing to decarbonisation and resource efficiency

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