Medical Plastics – a Technical Review

F. Cotin, Ph. De Groote - Certech



With the support of:

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Certech
R&D partner in chemistry

R&D partner and supplier of analytical and technological services for companies involved in activities related to chemicals, plastics & life science

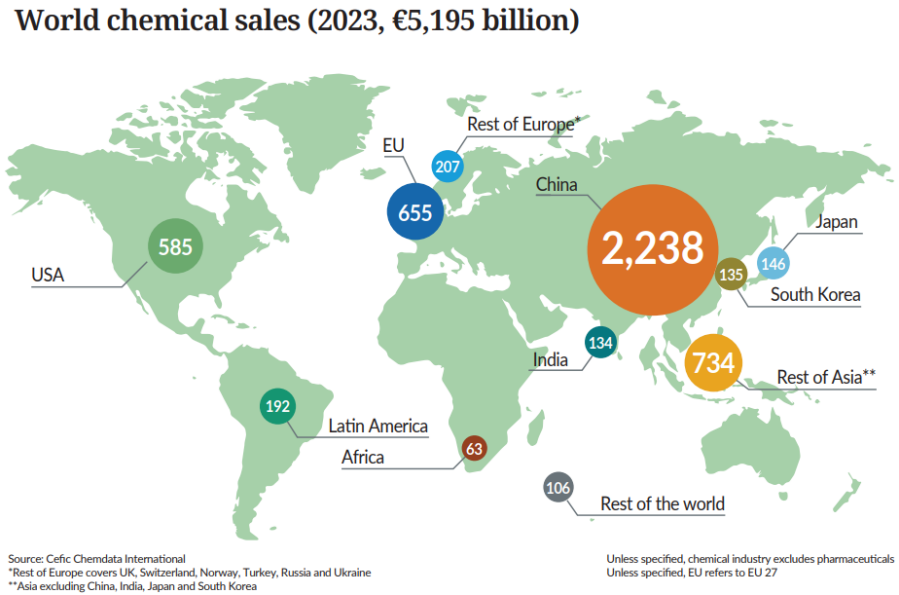
Belgium (2024)
74,9 billion € turnover
99.017 direct jobs
33,3% of Belgian exports
6,8 billion € in R&D investments



Wallonia (2024)
13 billion € turnover (25%)
24% industrial employment
30.367 direct jobs
and 75.000 indirect jobs
3,5 billion € in R&D investments
47% of Walloon exports

Source: essenscia

Europe (2023)
655 billion € turnover
2nd largest chemicals producer



Source: Cefic

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Certech
R&D partner in chemistry

420 industrial contracts in 2025

33 employees

1830 industrial collaborations since 2000

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Certech – Life Science Activities

Certech supports companies from early product development to technology transfer.

Process Intensification / Factory of the Future

- Continuous-flow and micro/mesofluidic technologies
- Medicinal and immunochemistry
- Biobased synthesis, mRNA-related processes, purification



Corning® Low Flow reactor



Flow reactor prototype for mRNA synthesis

Medical Device & Biomaterials Development

- Formulation and encapsulation of active ingredients
- Polymer and composite medical devices
- Controlled-release systems and biomaterials
- Applications: vascular, ophthalmic, women's health, veterinary, resorbable implants, 3D printing, pharma/biotech equipment



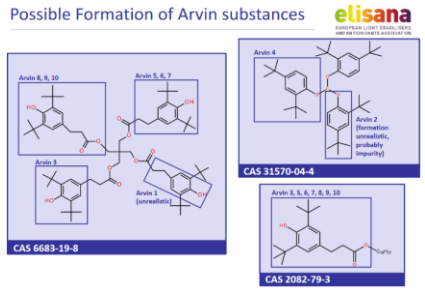
Spray dryer at Certech



New product developed for company Sil'Innov



Development of implants for women's health (company Mithra)



Example of NIAS from additive degradation

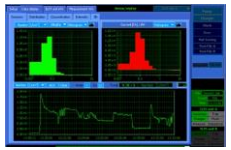
Material & Process Characterization

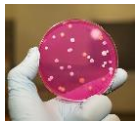
- Conformity testing (incl. Ph. Eur. standards)
- Contaminants, NIAS, migration/extractables, nanoparticles
- Structure–property relationships, composition analysis, odour science

HSE & Environmental Expertise

- Risk assessment, exposure measurements, PPE evaluation
- Ambient air and atmospheric pollution analysis







HSE expertise

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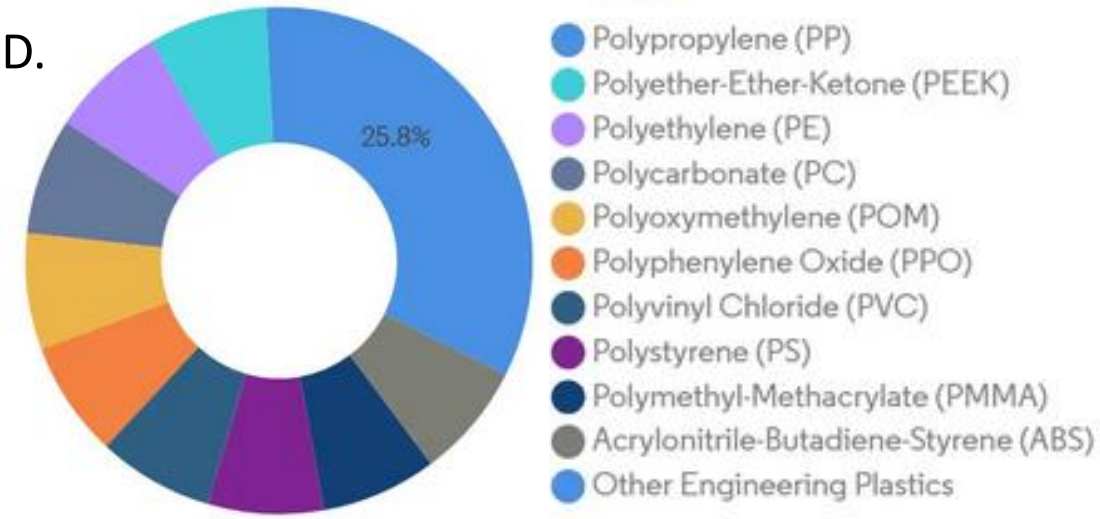
Medical Plastics – a Technical Review

- Market Data & Key Materials
- Innovations
- Recycling of Medical Plastics
- Trends & outlook

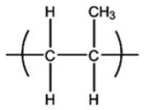
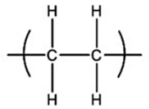
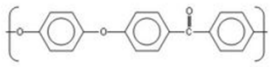
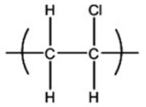
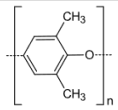
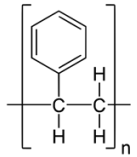
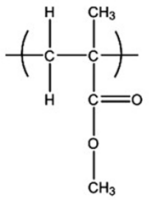
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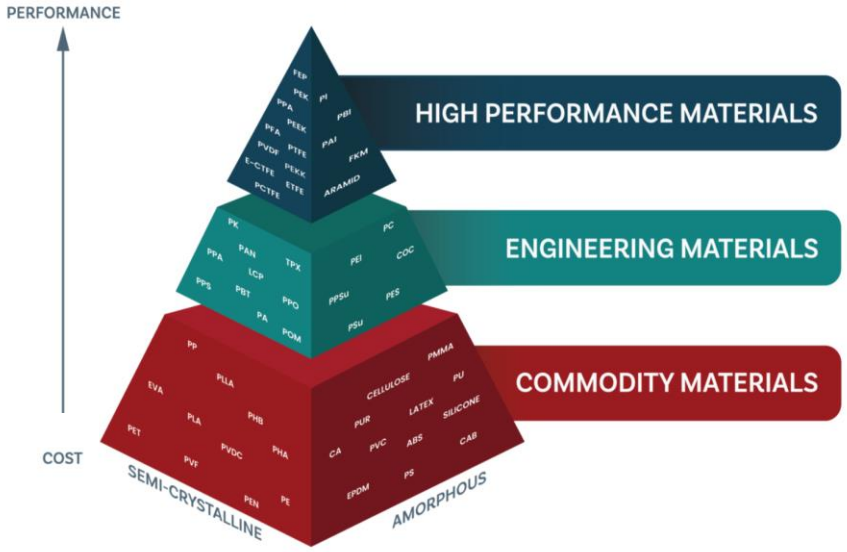
Market Data & Key Materials (1/3)

- 2025 Market Value: estimates vary from 33.68b to 61.35b USD.
- Projected Growth 2025-2035 : 5.3% to 10.2% CAGR
- Major Drivers:
  - Increasing need for sterilization,
  - rising healthcare expenditures,
  - and the adoption of advanced, lightweight materials
- North America highest market share (approx. 33–36%),
- Asia-Pacific region fastest growth



https://www.mordorintelligence.com/industry-reports/medical-plastics-market

Polypropylene (PP)		Polyoxomethylene (POM)	
Polyethylene (PE)		Polyether-Ether-Ketone (PEEK)	
Polyvinyl chloride (PVC)		Polyphenylene oxide (PPO)	
Polystyrene (PS)		Polymethyl-Methacrylate (PMMA)	

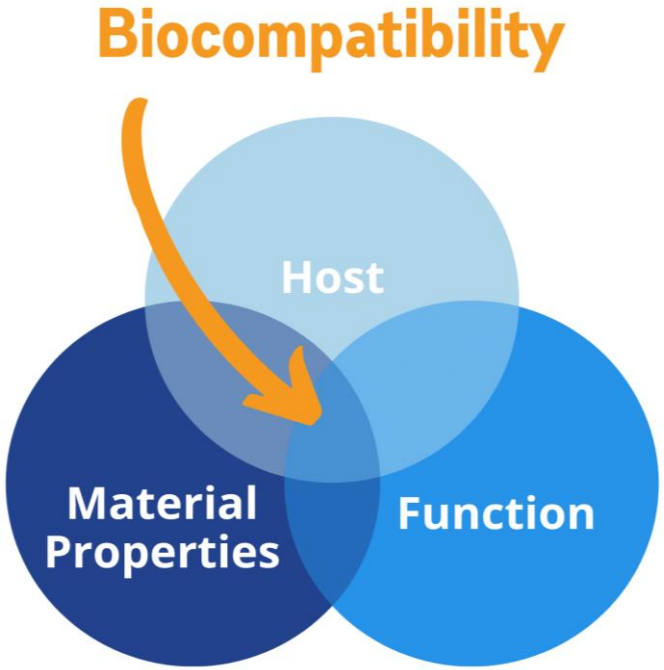


https://www.goodfellow.com/global/resources/the-polymer-pyramid-a-selection-guide-to-plastic-materials

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Market Data & Key Materials (2/3)

Key Characteristics expected from Medical Plastics



Source: www.cascobaymolding.com/biocompatibility

- **Biocompatibility:** Inert and non-toxic, safe for contact with human tissue and fluids.
- **Sterilization Resistance:** Can withstand steam, gamma radiation, or ethylene oxide (EtO) gas without degrading.
- **Chemical Resistance:** Stable in harsh medical environments and resistant to chemicals.
- **Durability:** Strong, lightweight, and resistant to wear and tear.
- **Versatility:** Can be molded into complex shapes for various applications

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Market Data & Key Materials (3/3)

Applications and Key Features of Polymers Used in the Medical Industry





Applications	Common Polymers	Key Properties
Medical Packaging	PE, PP, PVC	Non-permeability, resistance to sterilization
Surgical Instruments	PP, PC, ABS	Biocompatibility, durability, resistance to sterilization
Implants	PE, PC, ABS, PEEK	Biocompatibility, lightweightness, durability
Drug Delivery Systems	PVC, PP, PC	Non-permeability, compatibility with pharmaceuticals
Diagnostic Components	PS, PC, ABS	Transparency, durability
Dental Devices	PMMA, PC	Biocompatibility, transparency, resistance to sterilization
Wearable Medical Devices	PE, PC, ABS	Lightweightness, durability, biocompatibility
Transparent Components	PMP (polymethylpentene)	Transparency, low density, chemical resistance
High-temperature Applications	PEEK	High-temperature resistance, chemical resistance, strength





https://www.specialchem.com/plastics/guide/medical-grade-plastics

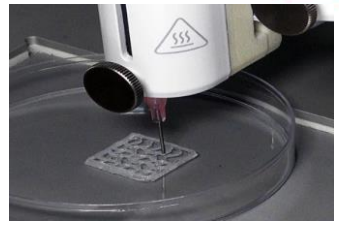
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Innovations (1/2)

Key Areas of Innovation:

Biodegradable & Smart Materials:

- 3D printed scaffolds for tissue engineering that gradually degrade in the body
- "self-healing" polymers
- conductive skin for prosthetics.



3D model printing with encapsuled cells
Source : www.viscofan-bioengineering.com/

Sustainable Alternatives:

- Shift → bio-based and recyclable materials (incl. mono-) → reduced environmental impact
- Non-phthalate plasticizers replacing DEHP in flexible medical products (tubing and blood bags).



polypropylene
(PP)-based tablet blister
Source: www.suedpack.com

Advanced Manufacturing (AM) & Precision:

- **3D Printing/AM**→ patient-specific implants, prosthetics, and anatomical models
- **Multi-shot & micro-molding** → complex, high-precision, and miniaturized components.
- **Laser Welding** → assembling plastic parts with high precision.



cranial implant made from PEEK
source: www.3dnatives.com

Enhanced Performance & Safety

- materials with superior fatigue strength & improved resistance to sterilization
- antimicrobial additives to reduce infection risks.

Digital Integration → "smart plastics" incorporating sensors for real-time monitoring



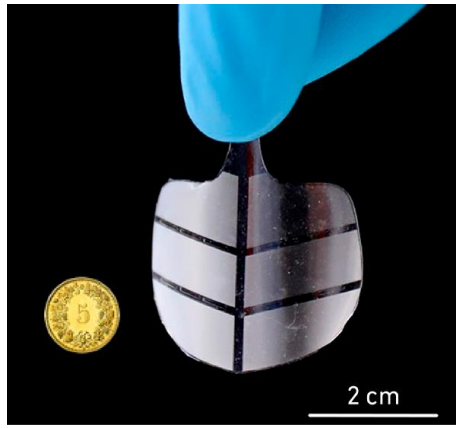
Thermoformed petri dish with printed sensor systems
Source: www.plasticstoday.com

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Innovations (2/2)

Medical/Health polymer innovations presented at K2025

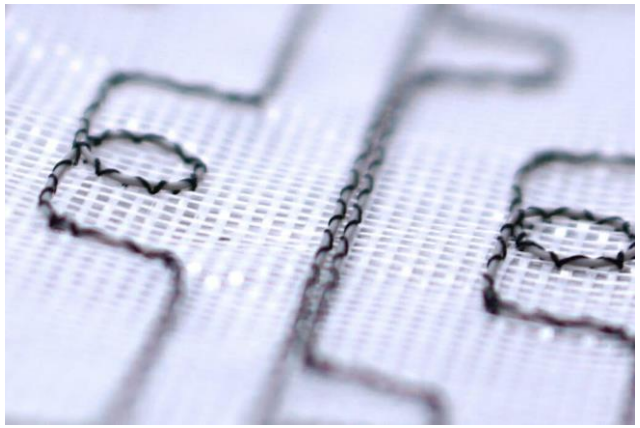
- artificial muscles (dielectric elastic actuators) produced from **silicone-based materials** using 3D printing
- sensory fabrics (detecting pressure, moisture and temperature) with **textile sensors made of polymer optical fiber**
- mattress for premature babies with a **flexible polymer membrane** which reduces the contact pressure by up to 40%
- artificial cornea, made of **hydrophilic (poly)acrylate** → no rejection reaction
- replacement tissue from **biodegradable plastic** : 3D printed porous microspheres that are colonized with cells.



Artificial muscles made from silicone
Source : https://ethz.ch/en/news-and-events



Artificial cornea made of acrylic polymer
Source : https://eye-yon.com/endoart/



Highly flexible textile sensors
Source: www.tfp-tech.com



Prototypes directly 3D printed with Silicone 40A Resin
Source : www.formlabs.com

Key developments → silicone 3D printing; smart textiles; flexible polymers, improved biocompatibility; tissue engineering

https://www.k-online.com/en/media_news/k-mag/plastics-in-practice/plastics-in-daily-life/medical-technology-innovations

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Recycling of Medical Plastics (1/3) - context

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Numbers

- ~7.2 Mt global healthcare plastic waste; ~40% PVC
- Recycling remains very low (~5% in NA & EU)
- EU healthcare plastics <1 Mt/year vs >15 Mt/year packaging
- Healthcare waste = only ~1–2% of global urban waste (85% non-hazardous)



Source: www.shutterstock.com

Challenges

- Body-contact devices vs non-contact items
- Contamination, sterility, and biohazard disposal rules
- High costs, logistics, and strict quality requirements
- Used medical plastics require very high safety standards



Source: www.shutterstock.com

Recycling pitfalls

- **Recyclable vs recycled !**
- **Upcycling vs downcycling !**
- **Volume vs economics : collection, transport, massification …**

Solutions

- Advanced sorting and controlled disassembly
- Design for recycling (single-use devices)
- Improved chemical decontamination
- Emerging process and technology innovations



Source : https://envetec.com/generations/



https://www.ecosteryl.com/chu-rennes-desinfection-tri-dasri-automatise/

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Recycling of Medical Plastics (2/3) - examples

PVC/Aluminum Blister Recycling by Vinyl Plus® (https://vinylplushealthcare.eu/)

- **Technology:** Creasolv® solvent-based dissolution (Fraunhofer IVV).
- **Objective:** Develop recycling of PVC/alu blisters to recover high-purity PVC and aluminum
- **Status:** Pharma-grade blisters with 30% rPVC successfully produced in R&D trials

→ Upcycling (high added-value application) ☑



Source : www.shutterstock.com

Recycling of Medical PVC by Vinyl Plus® (https://vinylplushealthcare.eu/)

- **Technology:** Mechanical recycling (shredding, extrusion, shaping).
- **Objective:** Collect and recycle non-contaminated PVC medical devices.
- **Status:** Recyclate currently tested for hospital flooring

→ Downcycling ? (low added-value application) ☑



Source : www.vinylplushealthcare.eu

Chemical Recycling of Medical Plastics by SABIC–Zuyderland (www.recyclingtoday.com)

- **Technology:** Pyrolysis converting non-contaminated medical plastic scrap into certified circular PE for new medical packaging and devices.
- **Objective:** Divert medical plastics from incineration through chemical recycling.
- **Note:** Pyrolysis-oil cracking typically relies on mass-balance accounting

→ Truly “closed loop” ? ☑



Source : www.shutterstock.com

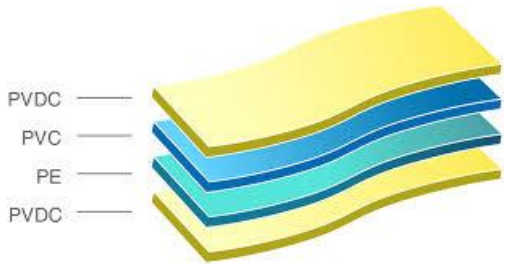
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Recycling of Medical Plastics (3/3) - examples

Recyclable blister concept (www.suedpack.com)

- **Technology:** Blister based on polypropylene (PP) for hard pharmaceutical products or nutraceuticals.
- **Objective:** Reduced carbon footprint, energy and water consumption *vs* conventional blister (PVC/PVdC + aluminium.)
- **Status**: Commercialy available ☑





PV/PVdC laminated foil for pharmaceutical packaging
www.bilcare.com



polypropylene (PP)-based tablet blister
Source: www.suedpack.com



Design for Recycling

Case study - mechanical recycling of blood tubes (www.syddansksundhedsinnovation.dk)

- **Scope:** Danish initiative for recycling PET material from blood collection tubes used in a healthcare setting.
- **Conclusions:** Cleaning with detergents lowered the microbial levels, but not sufficiently. ⊗
  Heat treatment reduced microbial burden to under detection limit. ☑



Single-use medical plastics : not always bad… (https://creativeecotech.com/)

- During COVID-19 pandemics disposable medical products saved lives (PPE kits in hospitals, etc.)
- Future : smarter plastic use, safer alternatives, and better waste systems.



→ → **responsible use is the real solution!**

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Trends & outlook



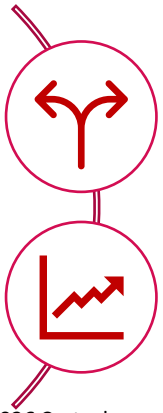
Miniaturization: Smaller, more precise devices driving innovation in plastic formulation..

Sustainability: Growing focus on recyclable and bio-based plastics

Customization: 3D printing and patient-specific implants using advanced polymers.

Regulatory Impact: Evolving policies affecting plastic usage and safety

Challenges



Competition from metals, ceramics, and natural materials.

Regulatory hurdles and potential economic volatility

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Bridging Day 1 and Day 2

DAY 1 – Sustainability, Sterilization & IA

Where day 1 leaves us ?

- Healthcare polymers are evolving under pressure from sustainability, regulation, and performance demands.
- New opportunities emerge in connected health, customization and advanced manufacturing.



DAY 2 – Innovative & PFAS-free materials

What to Expect Tomorrow Morning ?

- A technical deep dive into innovative materials, medical plastics, and their applications.
- Case studies and insights from experts shaping the next generation of medical devices and healthcare materials.

Medical plastics

- Enable implantable, diagnostics, drug-delivery systems, and next-gen packaging.
- Must meet stringent quality, biocompatibility, and regulatory expectations.
  → central to tomorrow's personalized and connected healthcare solutions

Any question ? See you tomorrow for an enriching day !

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