



# INNOVATION IN BIOPOLYMERS

## A PATENT LANDSCAPE ANALYSIS

Jakob Hoffmann | TransitionLab Insights Session | July 15, 2022

**BIOTEXFUTURE**<sup>7</sup>

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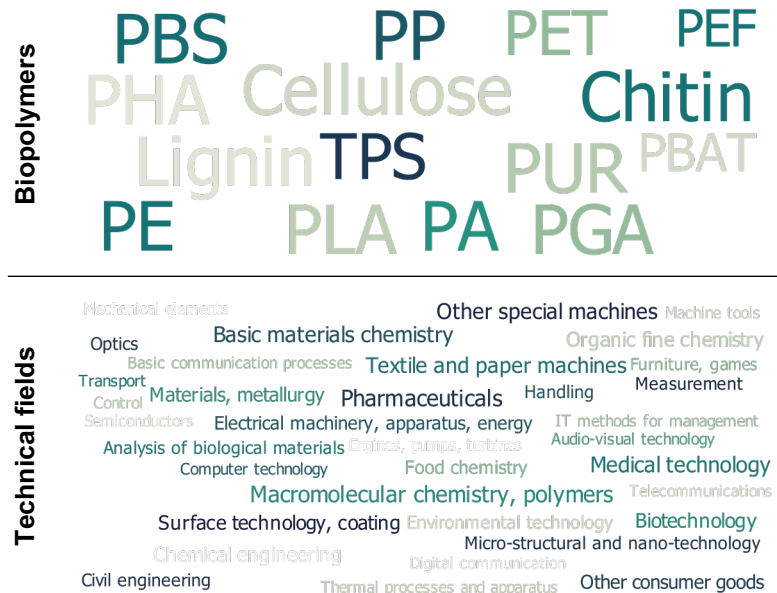
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# A BIOPOLYMER PATENT LANDSCAPE

## Goals, scope and approach



- Biopolymers are increasingly explored as alternatives to petrochemical polymers not only for niche use cases but also for large-scale industrial production.
- **Goal:** The goal of this report is to explore innovation trends in biopolymers across different industries, markets and organizations.
- **Approach:** The report uses patent landscaping, a method for investigating large-scale technology trends based on patent data as a measure of innovation activity.
- **Scope:** The report builds on a database of 174,813 patent families\* related to the development and use of at least one of 15 biopolymers, which are cross-classified with a list of 35 technological fields identified by WIPO.

# BIOPOLYMER APPLICATIONS



Sergiy Zhov - stock.adobe.com

**Packaging**



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**Automotive**



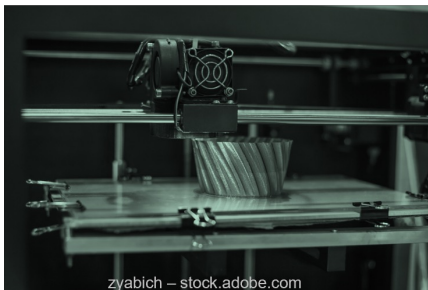
VIT Studio - stock.adobe.com

**Consumer appliances**



Alfredo - stock.adobe.com

**Agriculture**



zyabich - stock.adobe.com

**Additive manufacturing**



znstik - stock.adobe.com

**Textiles**



mario beauregard - stock.adobe.com

**Medical applications**

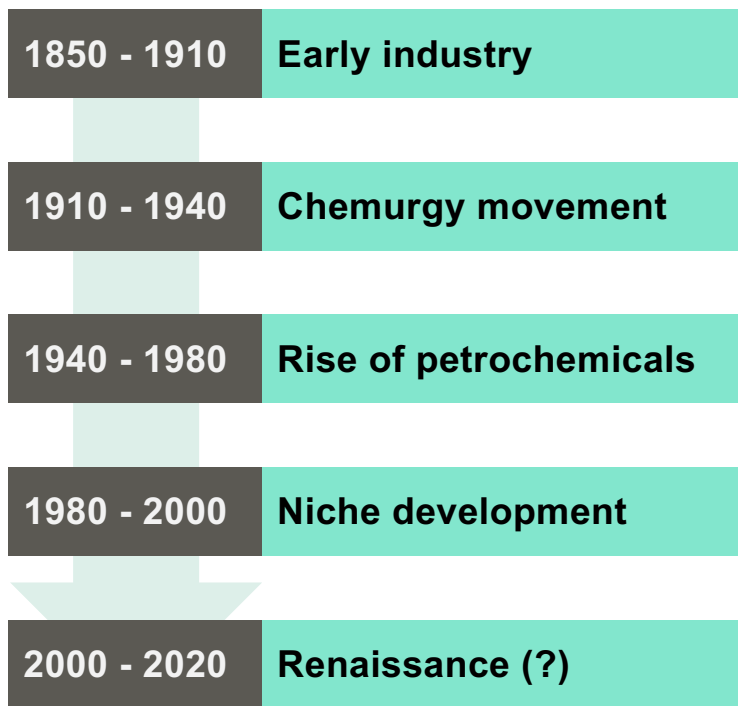


Herman - stock.adobe.com

**Building & construction**

# BIOPOLYMERS: A BRIEF HISTORY

The rise, downfall and renaissance of biopolymers

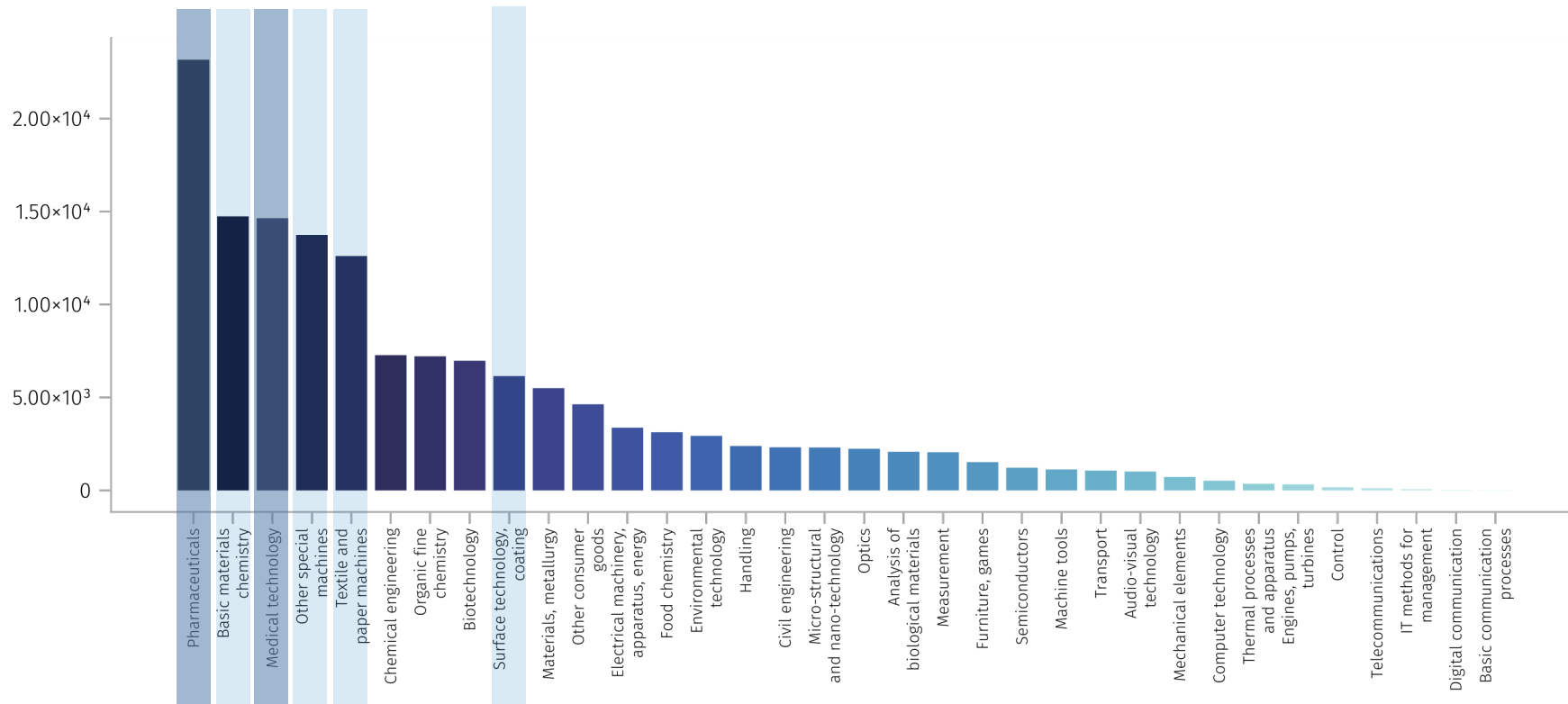


- In the 18<sup>th</sup> century, discovery of biopolymer materials (e.g. celluloid, casein) drove a shift from rare natural materials (e.g. ivory) to synthetic materials. This development cumulated in the chemurgy movement in the 1930s, with prominent representatives such as Henry Ford pushing the use of soy-based biopolymers in the automotive industry.
- WWII triggered a wave of innovation in petrochemistry which combined with cheap oil prices herald the end of the early bioplastic era.
- Starting in the 1980s, development of biopolymer materials resumed but was primarily confined to niche use cases (especially medical and pharmaceutical applications).
- With increasing awareness of the environmental impacts of plastic wastes, bioplastic are now again explored as solutions to large scale industrial applications, with both classical biopolymers (cellulose, PHA) and new solutions (PEF) being under consideration.

# TECHNOLOGIES & INDUSTRIES

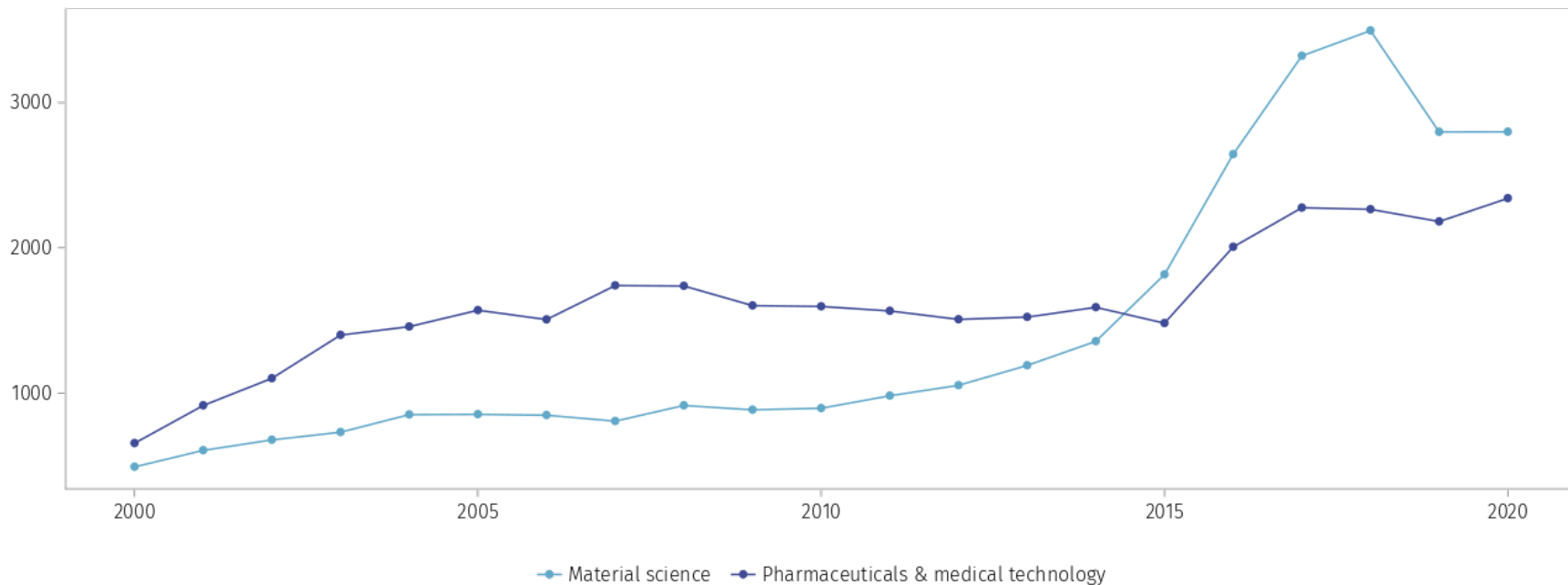
# TECHNOLOGIES AND INDUSTRIES

Biopolymer patents across 35 WIPO technology fields, 1990 – 2020



# BIOPOLYMER PATENTS: MEDICAL LEGACY

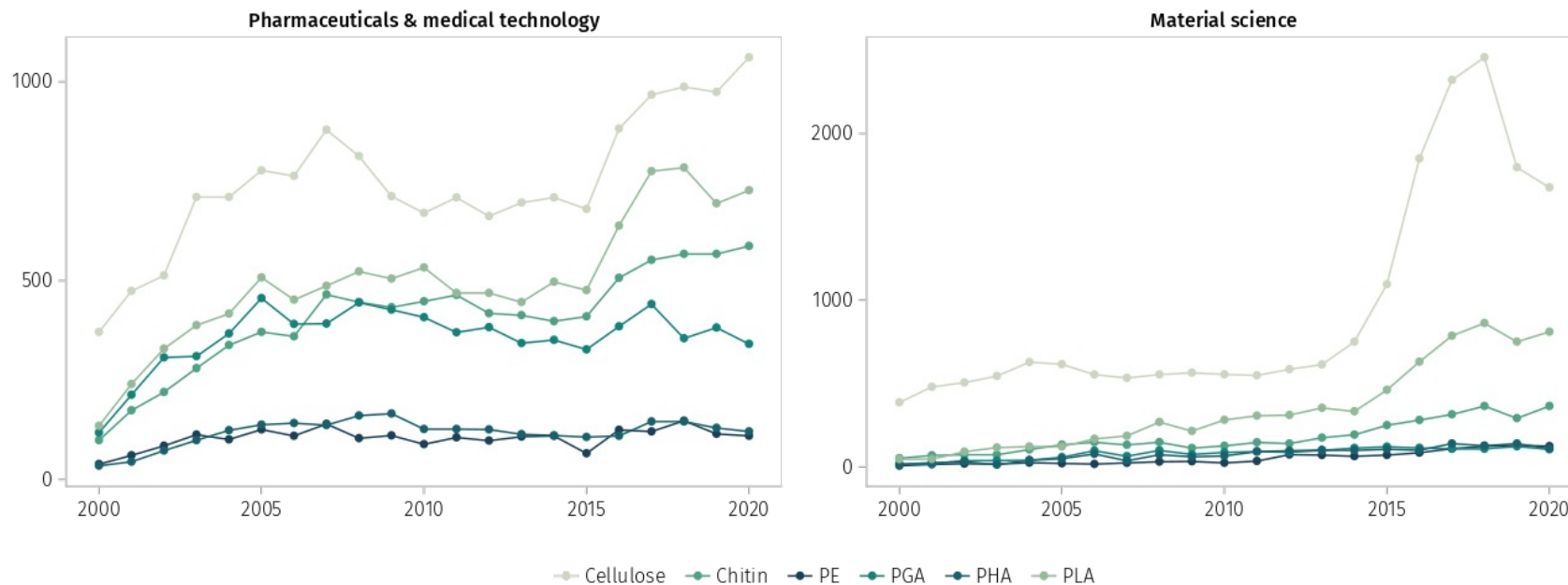
Patenting for non-medical use cases has overtaken medical and pharma applications





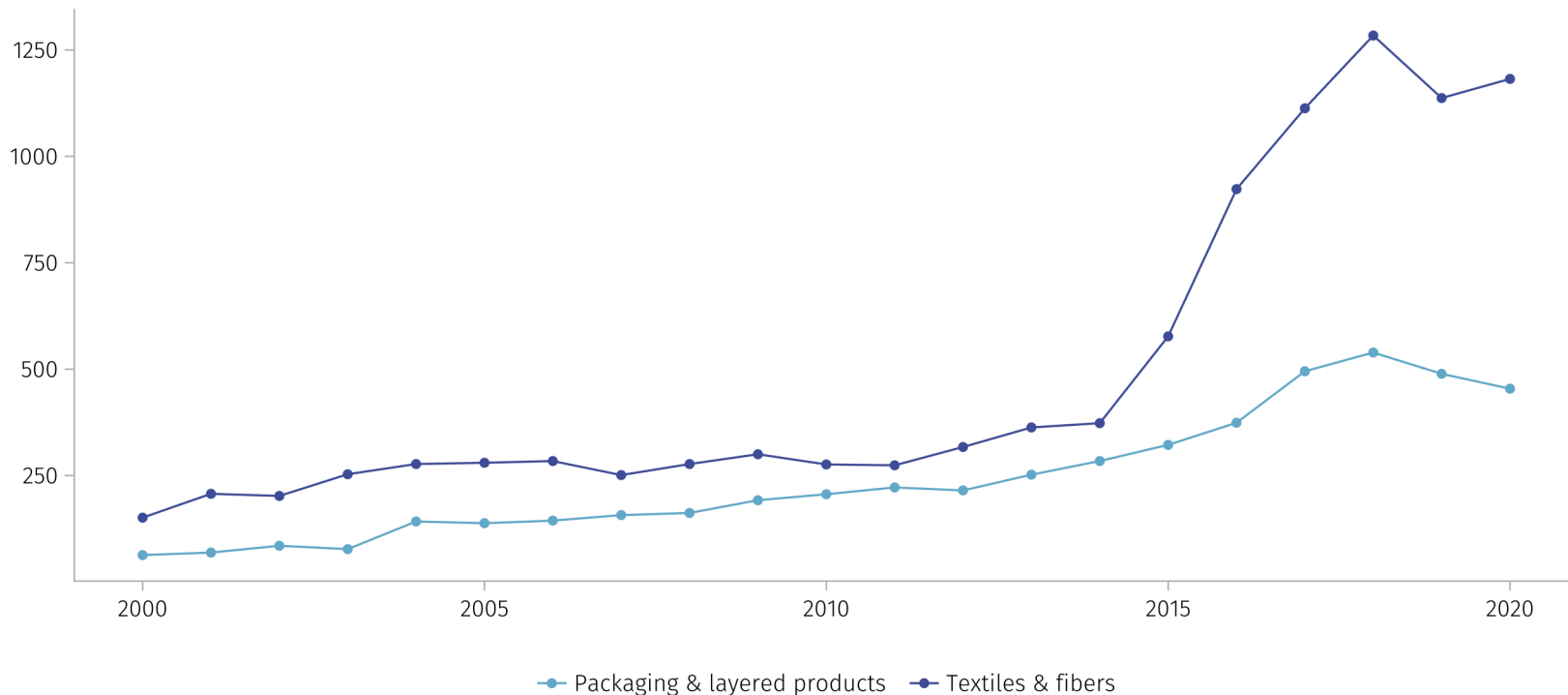
# BIOPOLYMER PATENTS: MEDICAL LEGACY

Medical applications are more diverse in terms of biopolymer variety



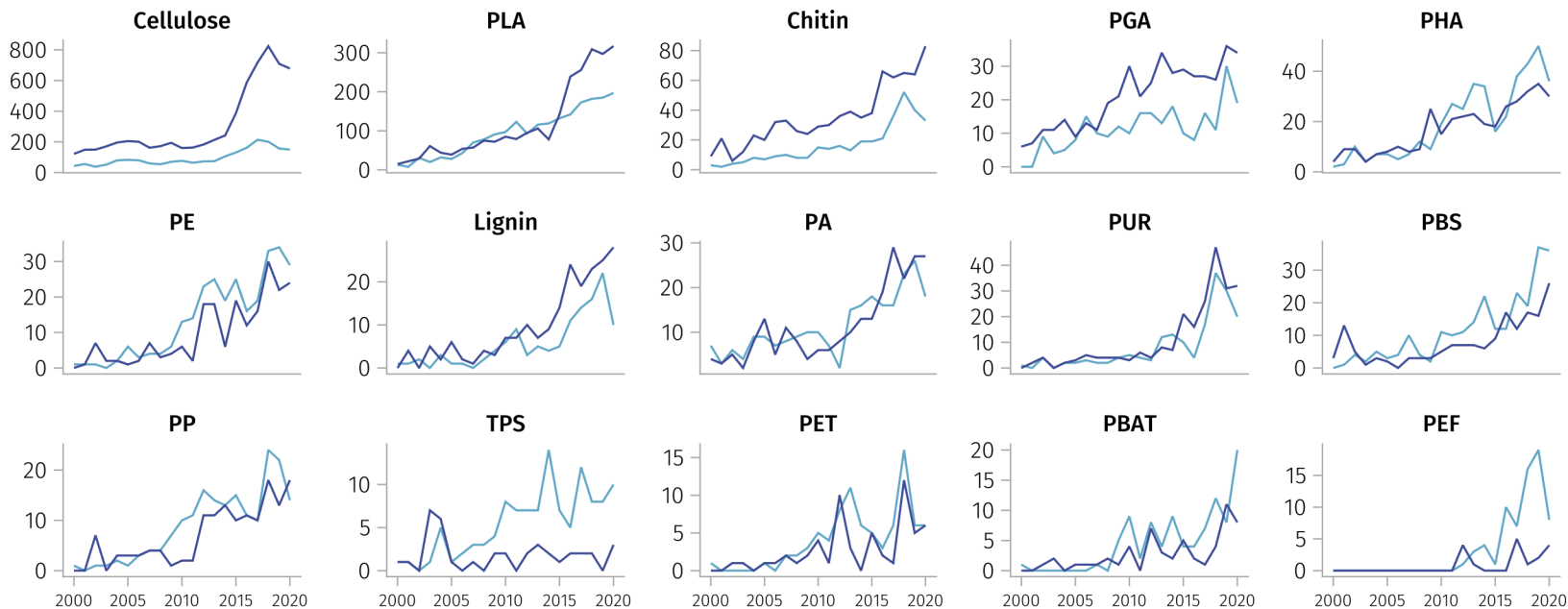
# BIOPOLYMERS IN PACKAGING AND TEXTILES

Patenting activity in fibers and textiles has increased strongly over the past 5-10 years



# BIOPOLYMERS IN PACKAGING AND TEXTILES

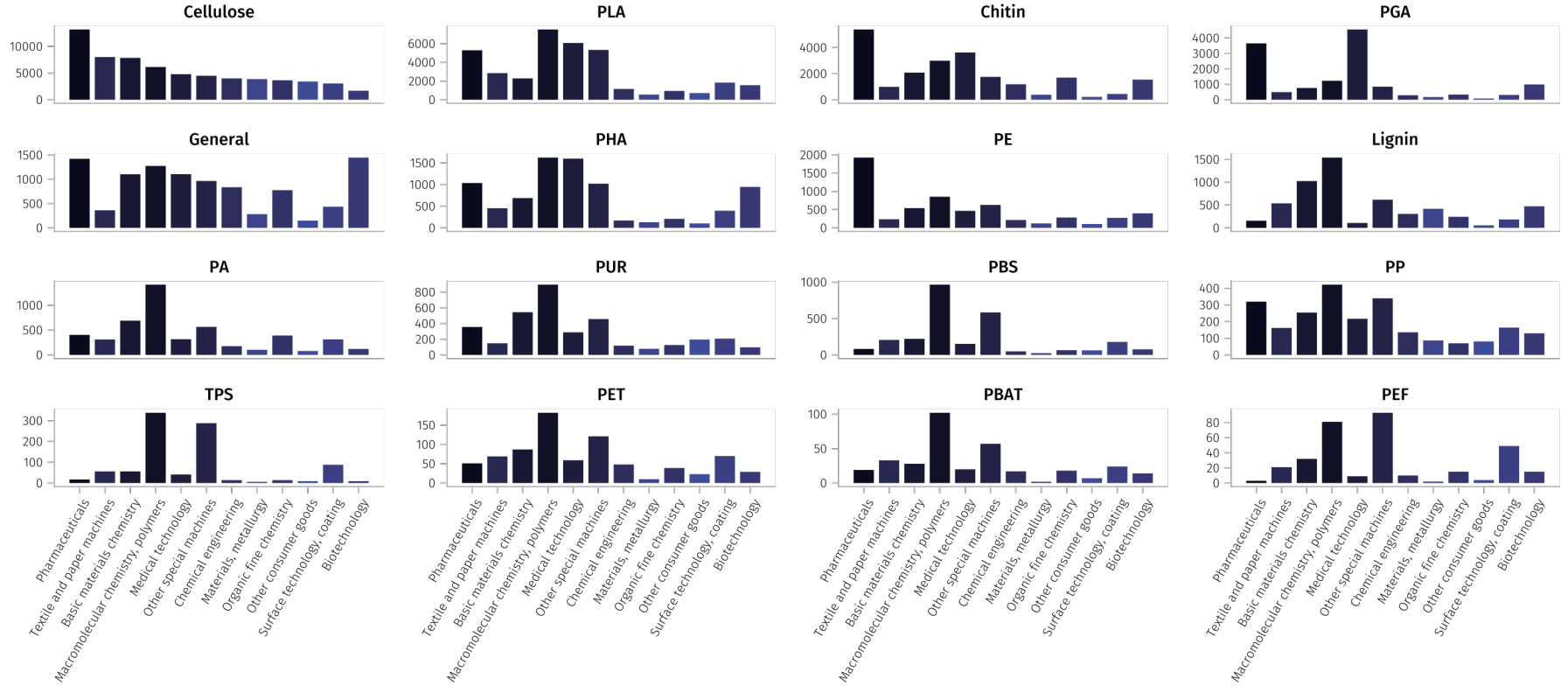
Cellulose and PLA are main drivers of fibers and textiles patenting



— Packaging & layered products — Textiles & fibers

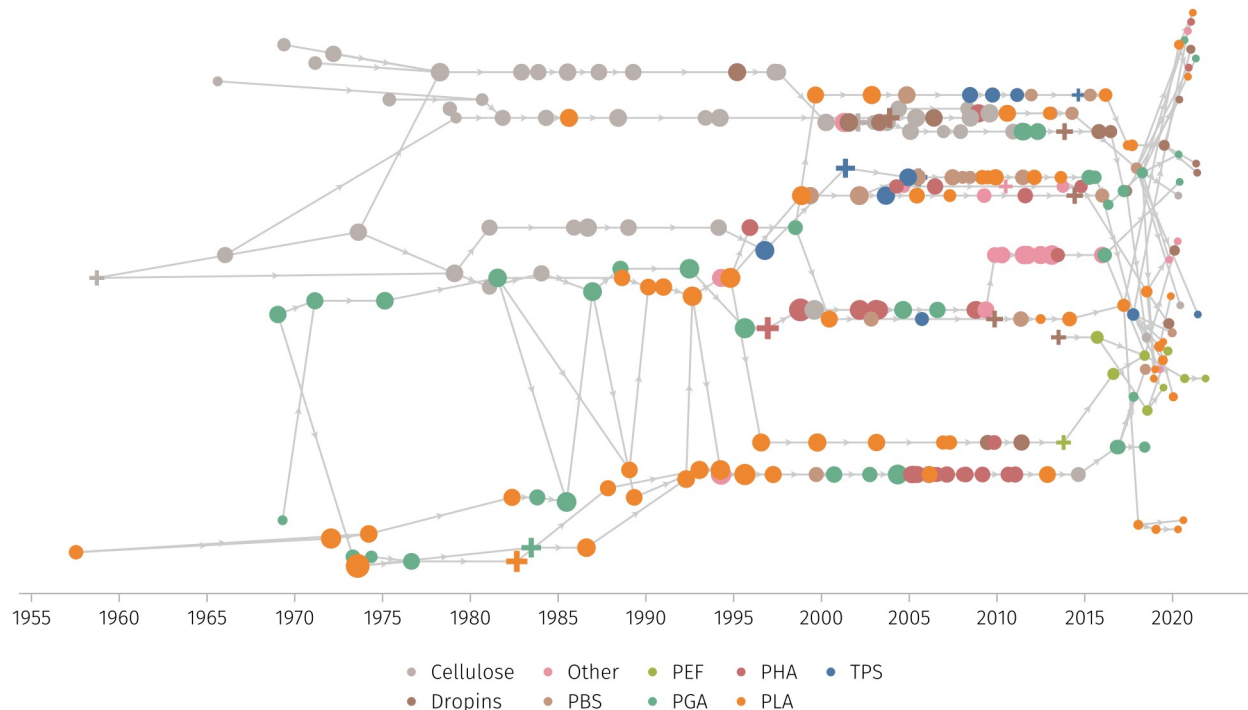
# BIOPOLYMERS AND TECHNOLOGY FIELDS

Biopolymers vary in terms of their use case specialization



# BIOPOLYMER INNOVATION PATHWAYS

Patent-based history of technology development since the 1950s



- Main path analysis aims to algorithmically uncover the main technological trajectories in a technological field by use of patent citations (Verspagen 2007): points represent patents and ties citations between them.
- Early development until the 1990s was focused on two major streams: Cellulose and PLA/PGA.
- The two streams diversified into innovations in PHA, PBS or drop-ins, amongst others, at the end of the 1990s.
- More recently, clusters relating to new developments (e.g., PEF) have emerged.

# MARKETS & ORGANIZATIONS

# MARKETS

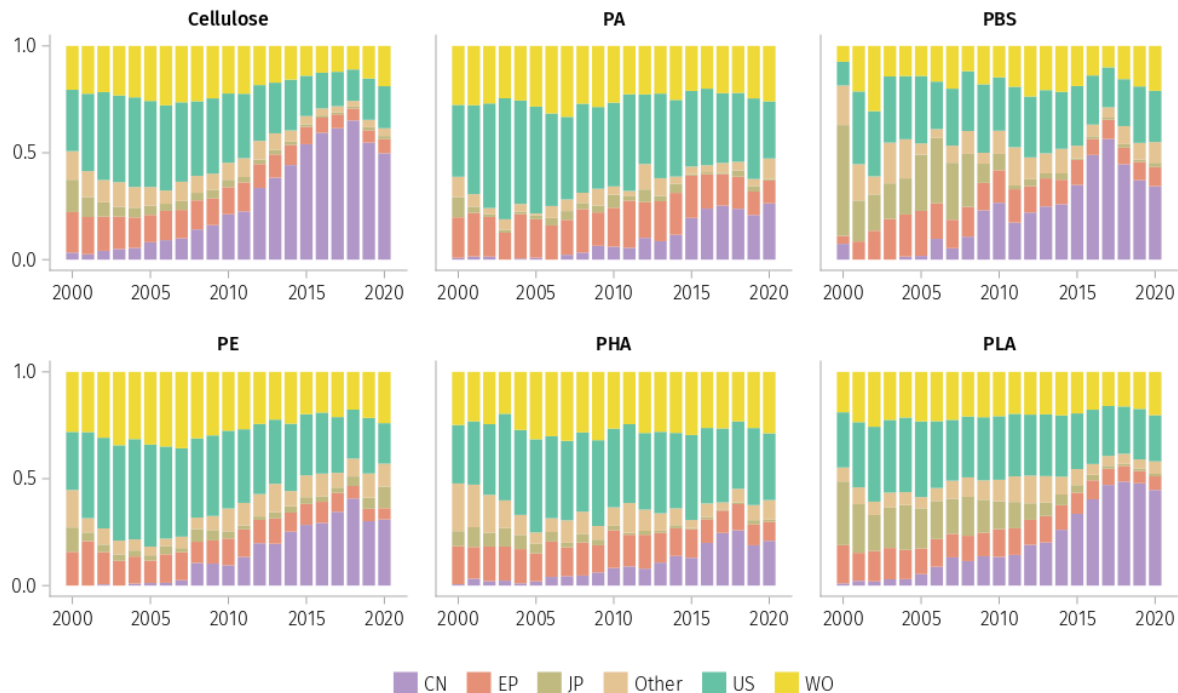
Global innovation growth and relative shifts over the past 20 years



- Biopolymer patent applications per year are mostly steady in Europe (EP), the US and Korea (KR).
- There are signs of decline in Japan, with new applications especially for PLA decreasing over the last 10 years.
- China shows exponential growth in patent applications over the last 20 years and has now overtaken Europe and the US.
- This is especially the case for PLA and Cellulose, where around 50% of all patents are now filed in China.

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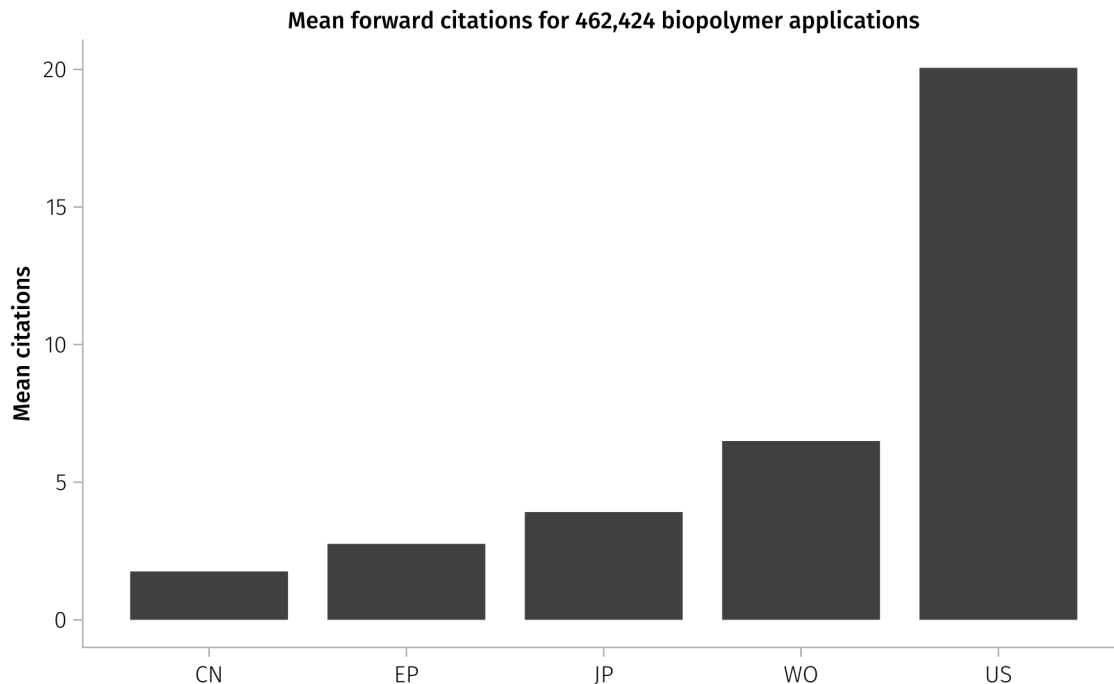


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# MARKETS

## Global differences in patent impact

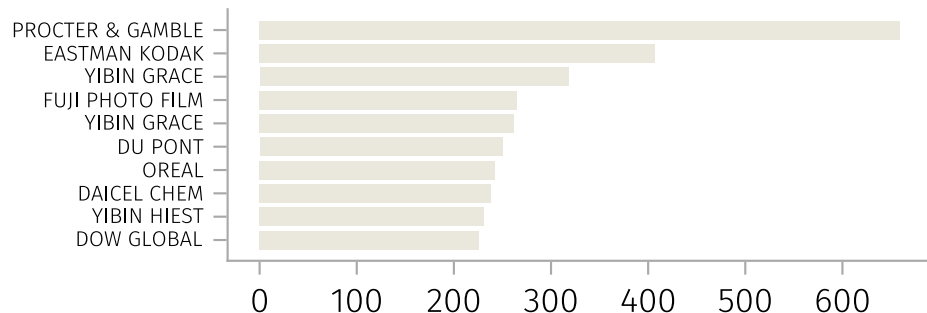


- While China shows explosive growth in terms of patent applications, Chinese patents usually have less reach and impact on global technology development than their US, EU or Japanese counterparts.
- Mean forward citations are lower for Chinese patents than for the EU, US and Japan (although legislative and recency bias can make comparisons difficult).
- Citations are also less international: Families with an American application are cited by patents from an average of 3 different jurisdictions, compared to 0.7 for Chinese applications.
- Only 5.1% of families with an application in China also have applications elsewhere, compared to 57.4% of families with a US application and 80.1% of families with an EP application.

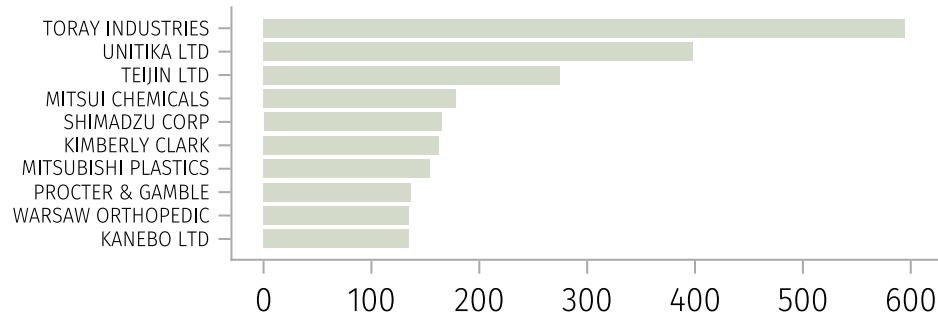
# ORGANIZATIONS

## Key applicants for selected polymers

### Cellulose



### PLA

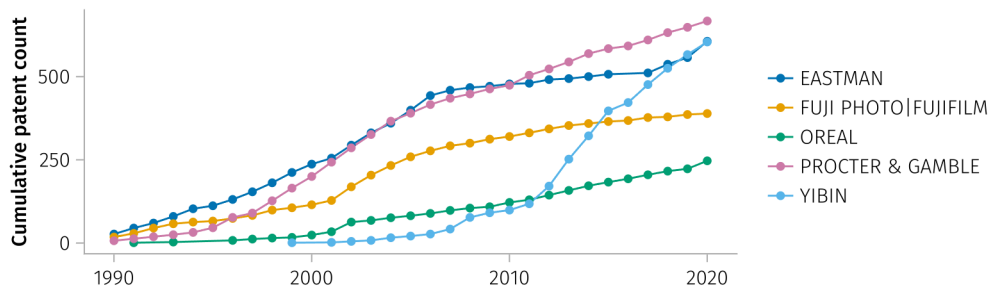


- The top 10 patent applicants for cellulose are mostly large American corporations (P&G, DuPont, Dow), historical incumbents (Eastman Kodak, Fuji Film) and strong newcomers from new markets (Yibin Grace).
- IP in PLA is dominated by large Japanese chemistry corporations, for which new applications have however stalled recently. Some important market participants are missing from the top 10 patent holders, e.g., Corbion or NatureWorks.
- Large American corporations feature prominently also in more niche biopolymers (e.g. PBS, PEF), indicating diversified portfolios or highly general applications.
- More recent technologies, such as PEF, showcase the influence of specific research cooperations, such as the (cancelled) collaboration effort of BASF and Avantium (of which Furanix and Synvina are subsidiaries) as well as the influence of specific applications (packaging; Coca Cola, Tetra).

# ORGANIZATIONS

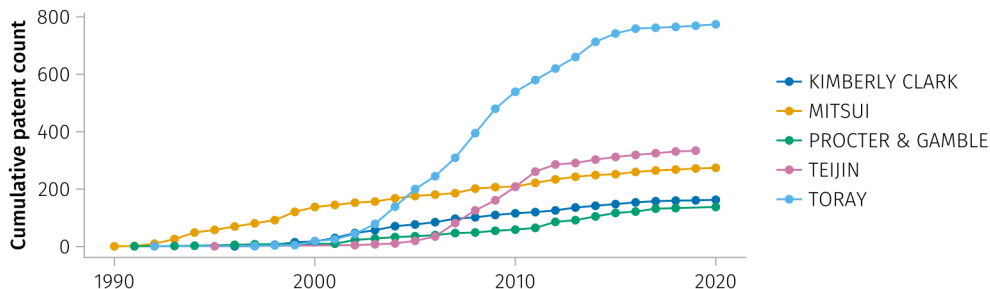
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### PLA

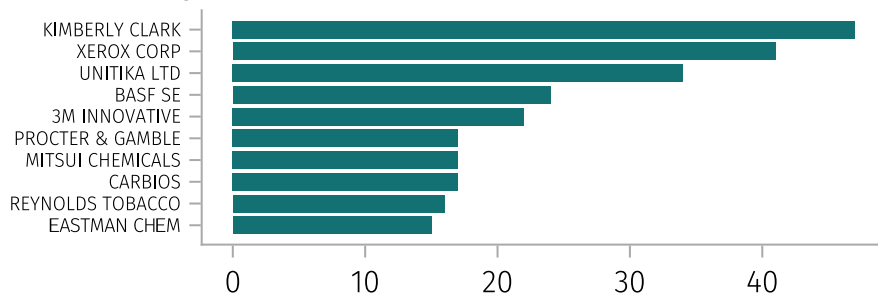


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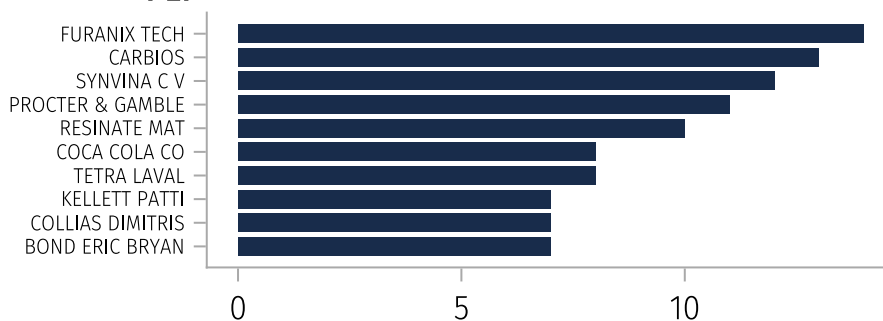
# ORGANIZATIONS

## Key applicants for selected polymers

### PBS



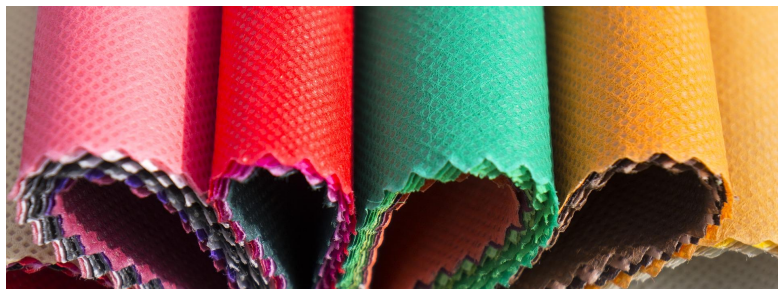
### PEF



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# CONCLUSIONS AND OUTLOOK

## Global patenting trends in biopolymers



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- While pharmaceuticals and medical applications are still major innovation contexts for biopolymers, the last 5-10 years have shown an emancipation from this niche, as indicated by an increasing number of patents related to material science and related fields, such as textiles & packaging.
- These trends are highly polymer-specific: While the medical sector is generally more diversified in terms of biopolymer variety, growth in material applications and especially fibrous materials and textiles is for now mainly due to strong growth in Cellulose and PLA.
- Patenting also exhibits strong regional variation: Most strikingly, and triggered at least in part by strong governmental incentives, China shows exponential growth in patent applications, accompanied however by negative consequences for patent quality (Sun et al. 2021).
- Questions for future research concern, e.g., the transfer of basic research into industrial applications or the impact of societal discourse and regulatory pushes on the direction of technology development.

## **INSIGHT 22-07**

Please reach out for full report,  
feedback and questions to

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