TORAY
Innovation by Chemistry

TORAY IR Day

Medium-Term Management Program Project AP-G 2025

Toray Group's R&D Strategies

June 5, 2023

Satoru Hagiwara
Executive Vice President and Representative Member of the Board,
CTO, Toray Industries, Inc.




Contents

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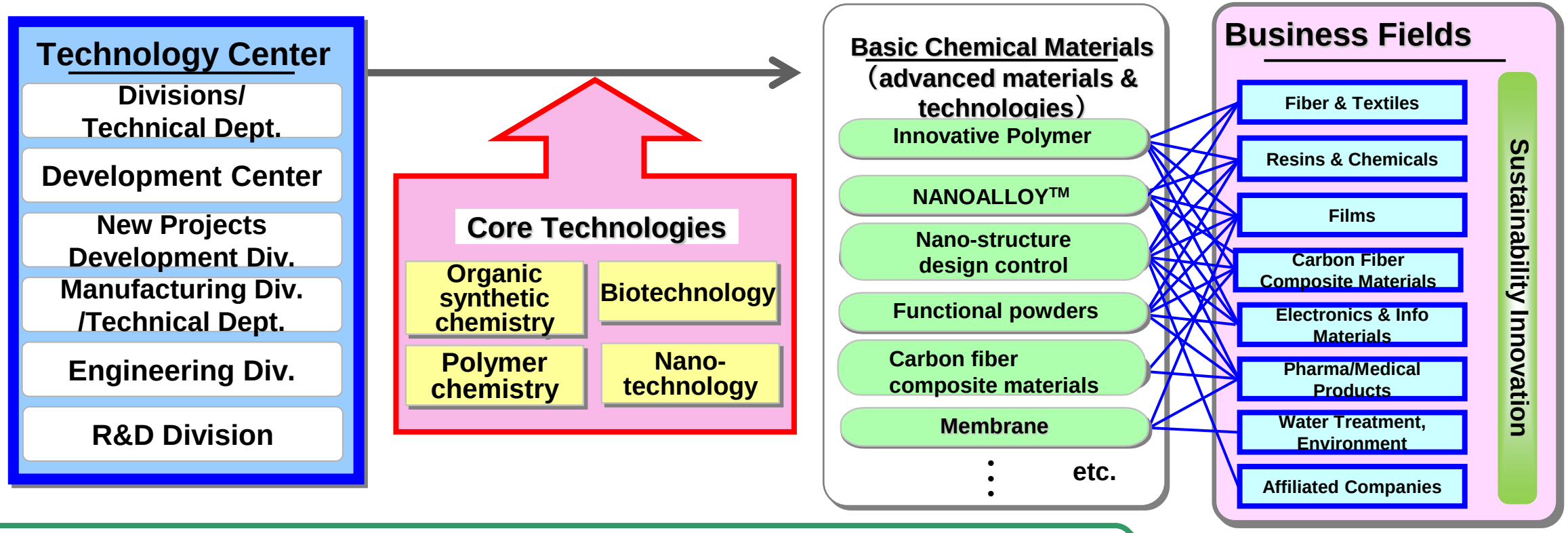
Characteristics of Toray Group's R&D

Characteristics of Toray Group's R&D: Undivided R&D Organization



- Experts in individual areas are gathered in Technology Center: Creation of new technology by fusion & integration of existing technologies
- Various advanced materials and technologies contribute to a wide range of business fields
- Integrated strengths: Utilize a wide range of technologies and knowledge in different fields to solve problems in an individual business field

Utilization of Combined Strengths

Fusion of 4 core technologies, chemical engineering process, engineering, and high analysis and evaluation technologies

Characteristics of Toray Group's R&D: Utilization of Collective Strengths

Core Technologies

- Organic Synthetic Chemistry
- Polymer Chemistry
- Biotechnology
- Nanotechnology

→ Enhancement of Development for Key Themes

Chemical Engineering Process

(Chemical Engineering Dept.)

Chemical engineering process technology

- Process design
- Basic industrialization technology
- Disaster prevention and environmental design

Creating safe and cost-competitive processes from research results (also serves as a last resort in challenging times)

Supporting group-wide themes from the perspective of the chemical engineering process

Engineering

(Engineering Development Center)

Elemental technologies of Engineering

- Molding
- CAE analysis
- Micro-precision processing
- Coatings
- Surface treatments
- AI

Realizing equipment that is highly competitive (on quality and cost)

Realizing innovative process and equipment development, executing demonstrations

Analysis

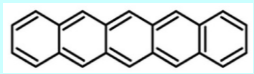
(Research Centers, Toray Research Center, Inc.)

Analysis Technology

- Physical property evaluation
- Structural analysis
- Composition analysis
- Morpho-logical observation

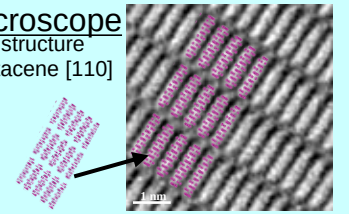
Latest Examples

Chemical structure of pentacene



Direct molecular observation using high-end electron microscope

Crystal structure of pentacene [110]



Supporting problem solving in R&D and manufacturing with cutting-edge analytical technologies

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Medium-Term Management Program, Project AP-G 2025

— Achieving Sustainable Growth

Achieving Sustainable Growth

- **Expansion of Sustainability Innovation (SI) and Digital Innovation (DI) businesses** SI & DI Project **New**
- **Target: Expanding revenues from businesses related to these areas to about 60% of total by 2025**

SI&DI Projects

Growth Business Fields under AP-G 2022

GR Business

LI Business

New

Growth Business Fields under AP-G 2025

SI Business Sustainability Innovation Business (*1)

1. **Products that accelerate measures to counter climate change**
2. **Products that facilitate sustainable, recycling-based use of resources and production**
3. **Products that help provide clean water and air and reduce environmental impact**
4. **Products that help deliver better medical care and hygiene for people worldwide**

DI Business Digital Innovation Business

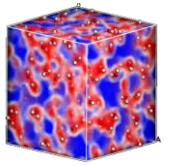
Materials, equipment, technologies, and services that help improve convenience and productivity by supporting the widespread adoption of digital technology

Carbon fibers for aircrafts

Electrolyte membranes for production of H2

Bioprocess using membranes

Chemical recycling using subcritical water

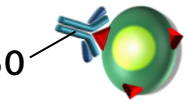


RO membranes for seawater desalination

Environmentally friendly offset plate

Protective clothing

Cancer Antibody Drug TRK-950



Polyimides

Semiconductor manufacturing and inspection equipment

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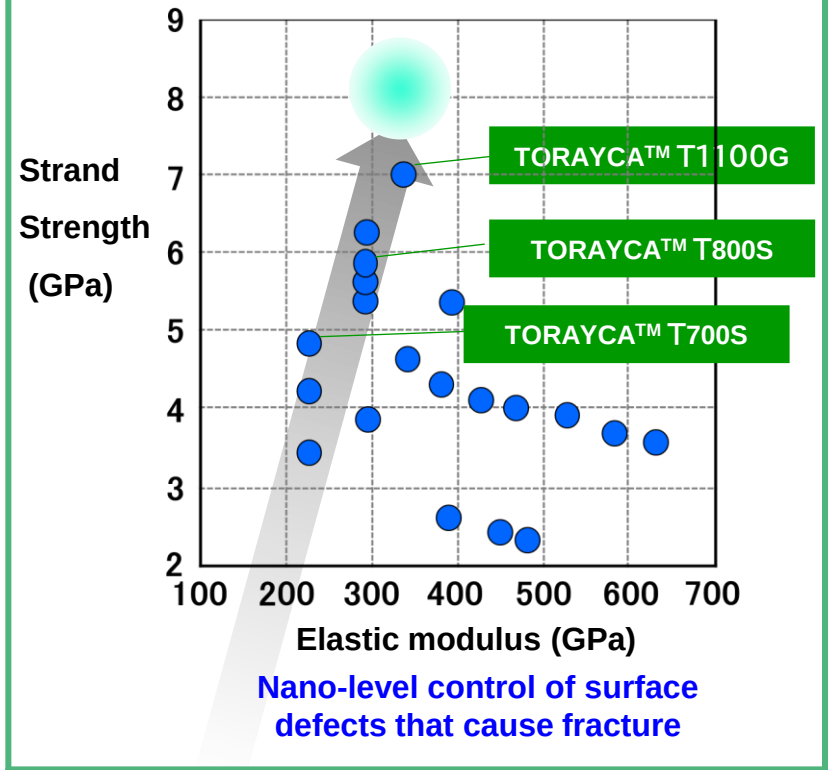
Expanding the Carbon Fiber Composite Materials Business

Basic Strategy 1 Sustainable Growth

Higher Strength Carbon Fiber

Continuously pursue the basic performance of carbon fibers, which are “lightweight and high strength”



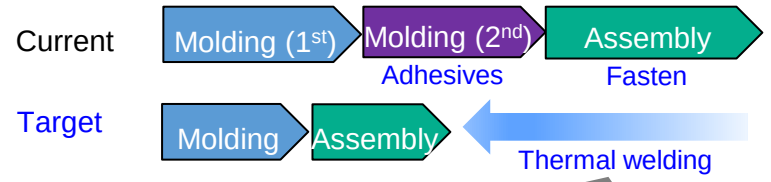
Nano-level control of surface defects that cause fracture

Pursuing ultimate performance that is required in aircraft, pressure vessels, and high-end sports applications

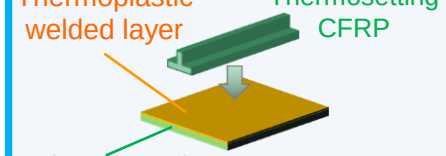
Expansion of CFRP for aircraft components

Realizing high-rate production equivalent to or higher than metal to meet increase in demand for small aircrafts

＜Production lead-time for CFRP aircraft components＞



High-Speed Thermal Welding Technology



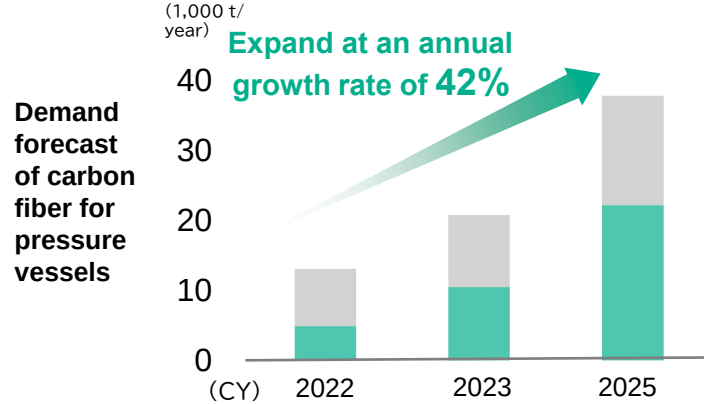
Model part

Joint strength equivalent to conventional products at a high rate equivalent to or higher than metal

Goal: Practical application by 2030
(Part of a technology development partnership with Company B)

Expansion of demand for carbon fibers for high-pressure gas tanks

Significant increase in demand for gas tanks for compressed natural gas (CNG) and fuel cell vehicles



Stable Strength

High-grade (Ease of use)

Stable supply

Photo courtesy of Toyota Motor Corporation

Maintaining the world’s top market share by R&D that meets customers’ requirements

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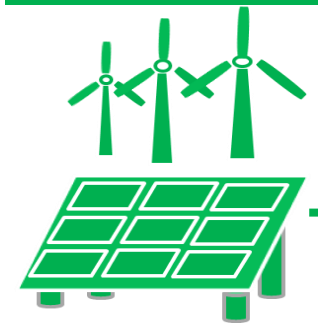
Initiatives for the Realization of a Hydrogen Society

Develop a wide range of key materials for all stages of hydrogen-related Production, transportation and storage, and use

Production → Transportation, Storage → Use

Electricity from renewable energy



Power to Gas

Water electrolyzer

Komekurayama, Yamanashi Pref.

Green Hydrogen

-Carbon fiber for tanks
-Plastic liner
-Electrolyte membranes, CCM, MEA

Power to X

Industrial sector

Heat demand

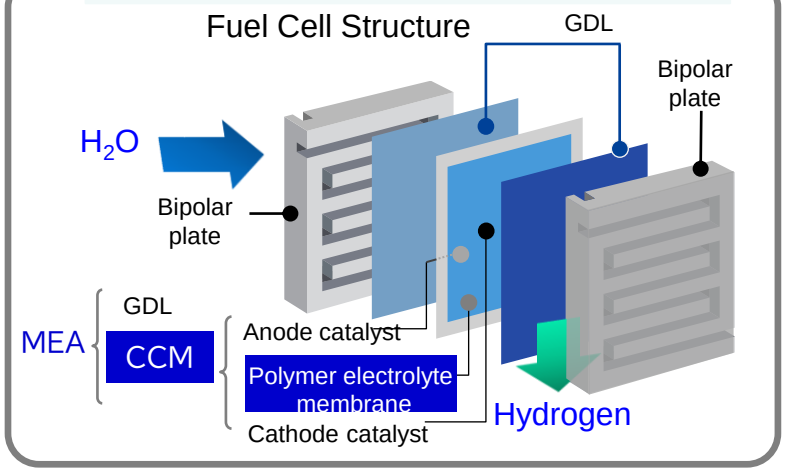
Iron manufacturers

Fuel cell, etc.

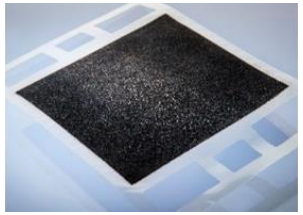
Transportation sector

-Electrolyte membranes, CCM, MEA
-CP, GDL

Proton exchange membrane(PEM) water electrolyzer



CCM/MEA



Greenerity GmbH
2023
start operation of 2nd plant for fuel cells
2024
start operation of 2nd plant for electrolyte membranes

Hydocarbon electrolyte membrane

Plan to start production in 2024

Features of Hydrocarbon (HC) electrolyte membranes

Requirements		Alkaline water electrolysis	PEM water electrolysis		
			Standard: Fluorine membrane	Toray: HC electrolyte membrane	
Efficiency	%	80	76	87	High efficiency
High current density	A/cm²	0.3	1	2	Reduced stacks
Low gas permeability	a.u.	High	1	1/3	Safety and high availability

Target: Practical application for water electrolysis by 2025

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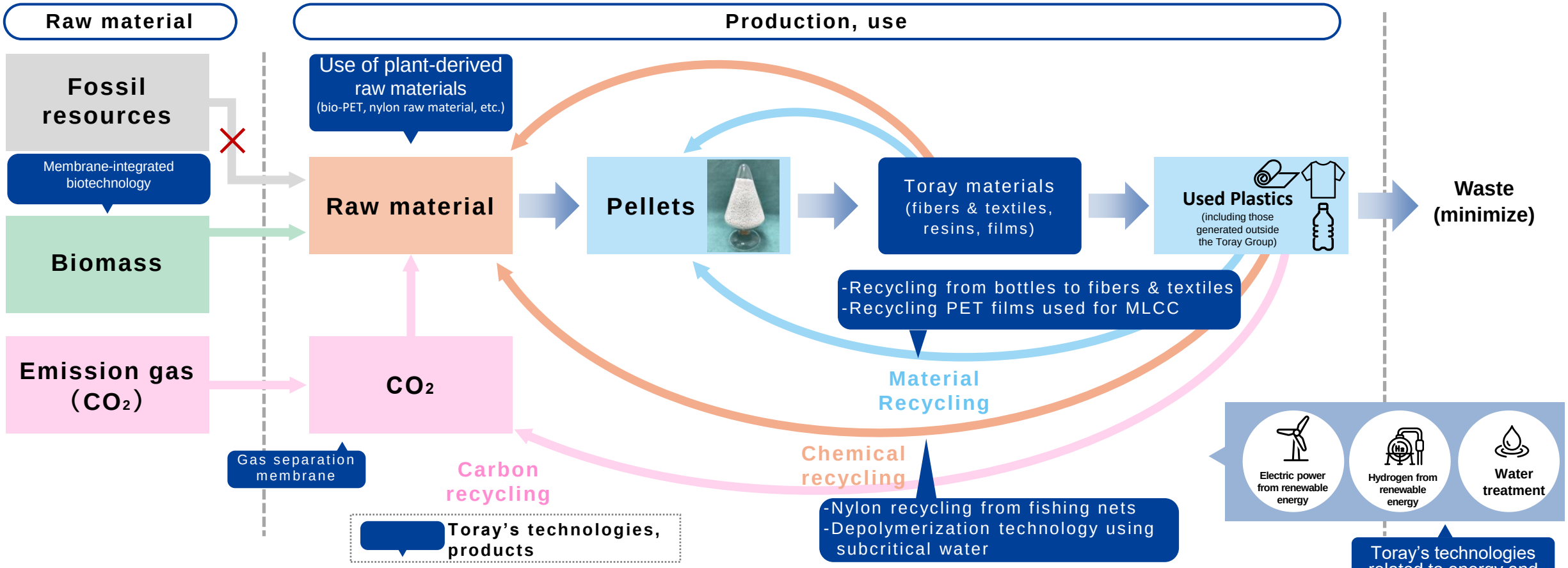
Initiatives for a Circular Economy

Accelerate initiatives including biomass plastics, material and chemical recycling

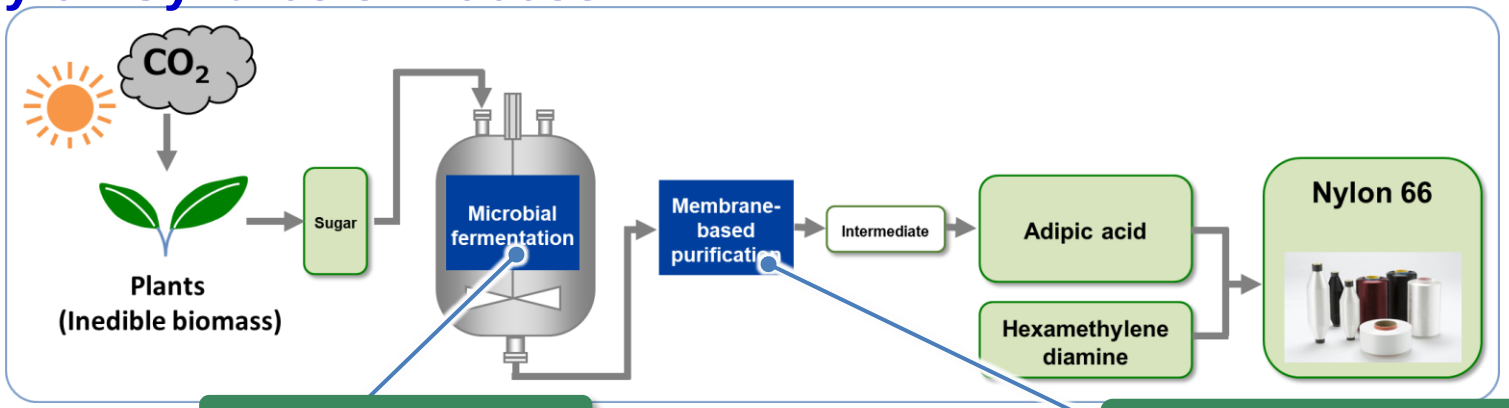


- Revenue target for products that facilitate sustainable, recycling-based use of resources and production in the SI Business in FY 2030
  400 billion yen
- Target for percentage of raw materials sourced from recycling, derived from biomass, or produced with CO_2 recycling used in Toray core polymers (*1) in FY 2030 **20%**

*1 PET and nylon polymers

Bio-Manufacturing: Creation of Nylon Raw Materials from Inedible Biomass

New Nylon Synthesis Process



Applications

- Fibers and textiles (apparel, airbag)
- Automotive parts

Microbial fermentation

1. Discovery of microorganisms (world's first)

Intermediate generation amount: 1

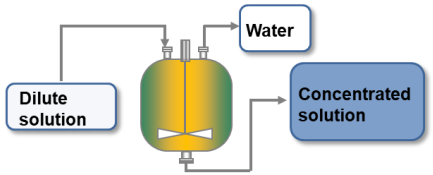
Genetic recombination

2. Dramatic increase in generation amount

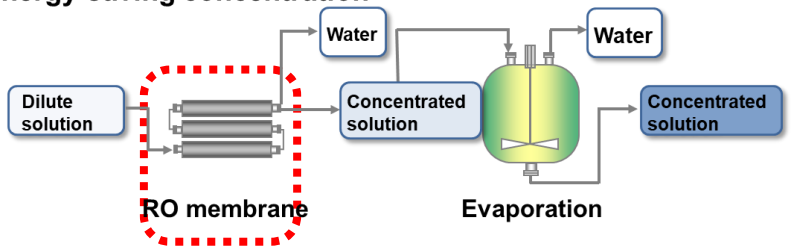
Intermediate generation amount >1000

Membrane-based purification technology

Conventional concentration



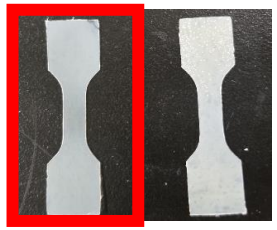
Energy-saving concentration



Energy consumption reduced by RO membrane concentration

World's first success in obtaining high-purity adipic acid from sugars derived from inedible biomass (lab scale)

Intermediate



Bio-based Petroleum-based

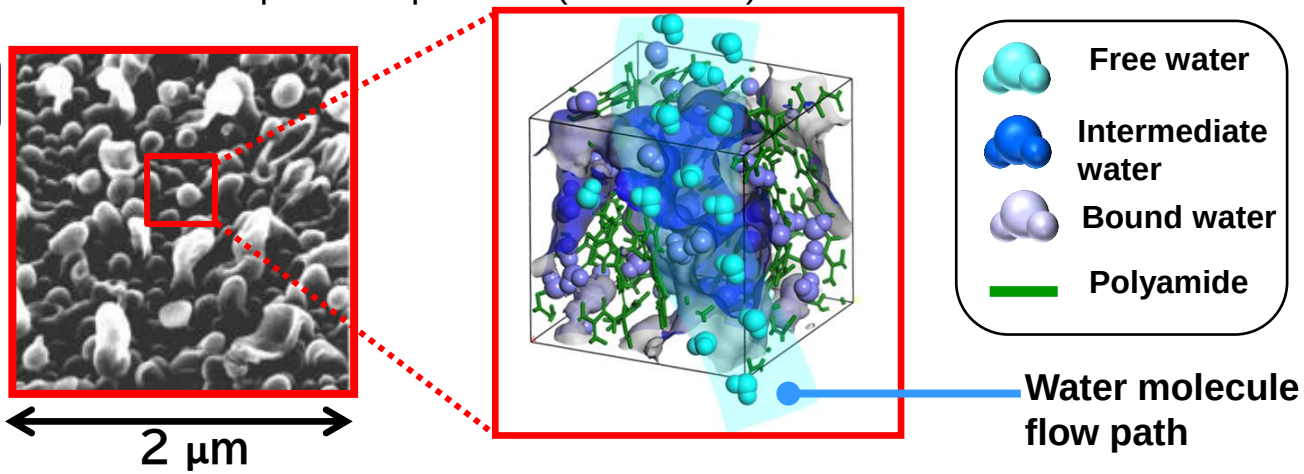
Target: Commercialization around 2030

Unrivaled Products:
Expansion of the Water Treatment Membrane Business

In addition to seawater desalination, wastewater reuse is gaining momentum, and RO, UF, and MBR membrane technologies are all contributing to meeting pressing water demand.

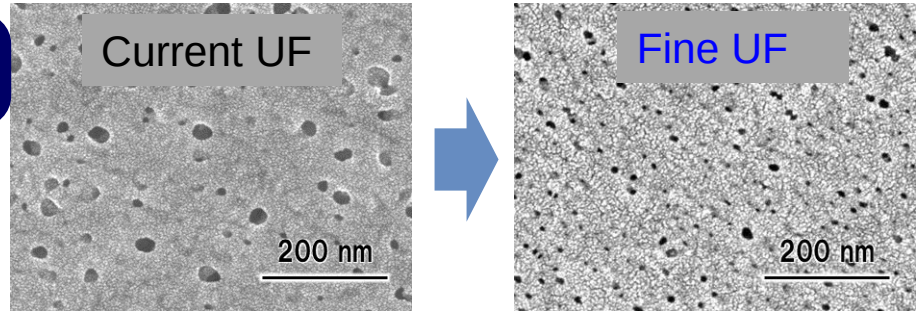
Technology Features: Precise control of membrane pore size distribution by deepening interfacial polycondensation (RO) and phase separation (UF & MBR)

RO membrane



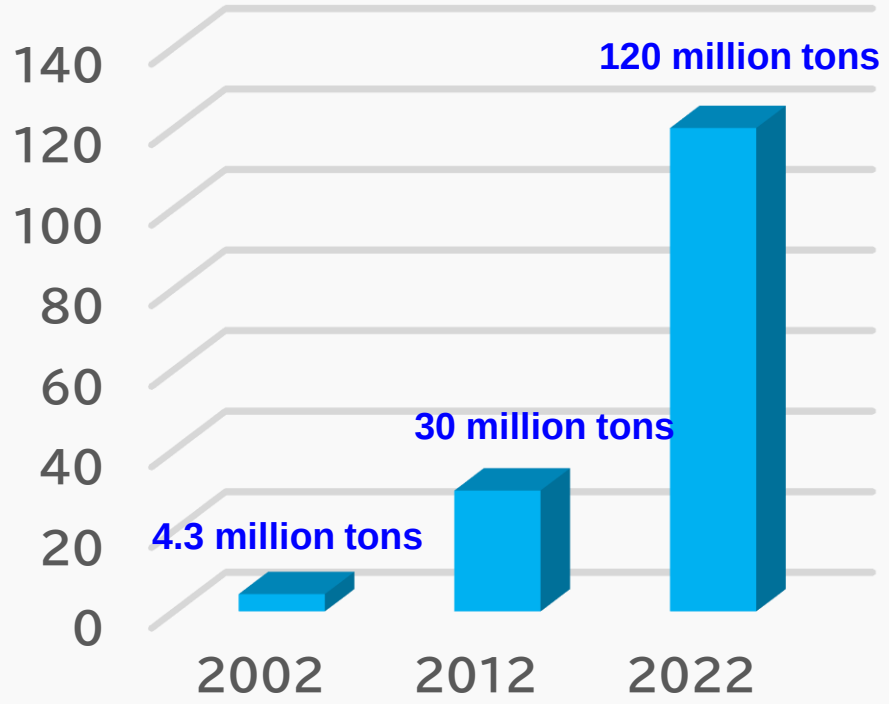
Pore size control in the Å order, water channel interconnection

UF membrane



Achieved finer pore size (preventing clogging) and increased number of pores (maintaining water permeability)

Total RO membrane shipments (water volume equivalent)



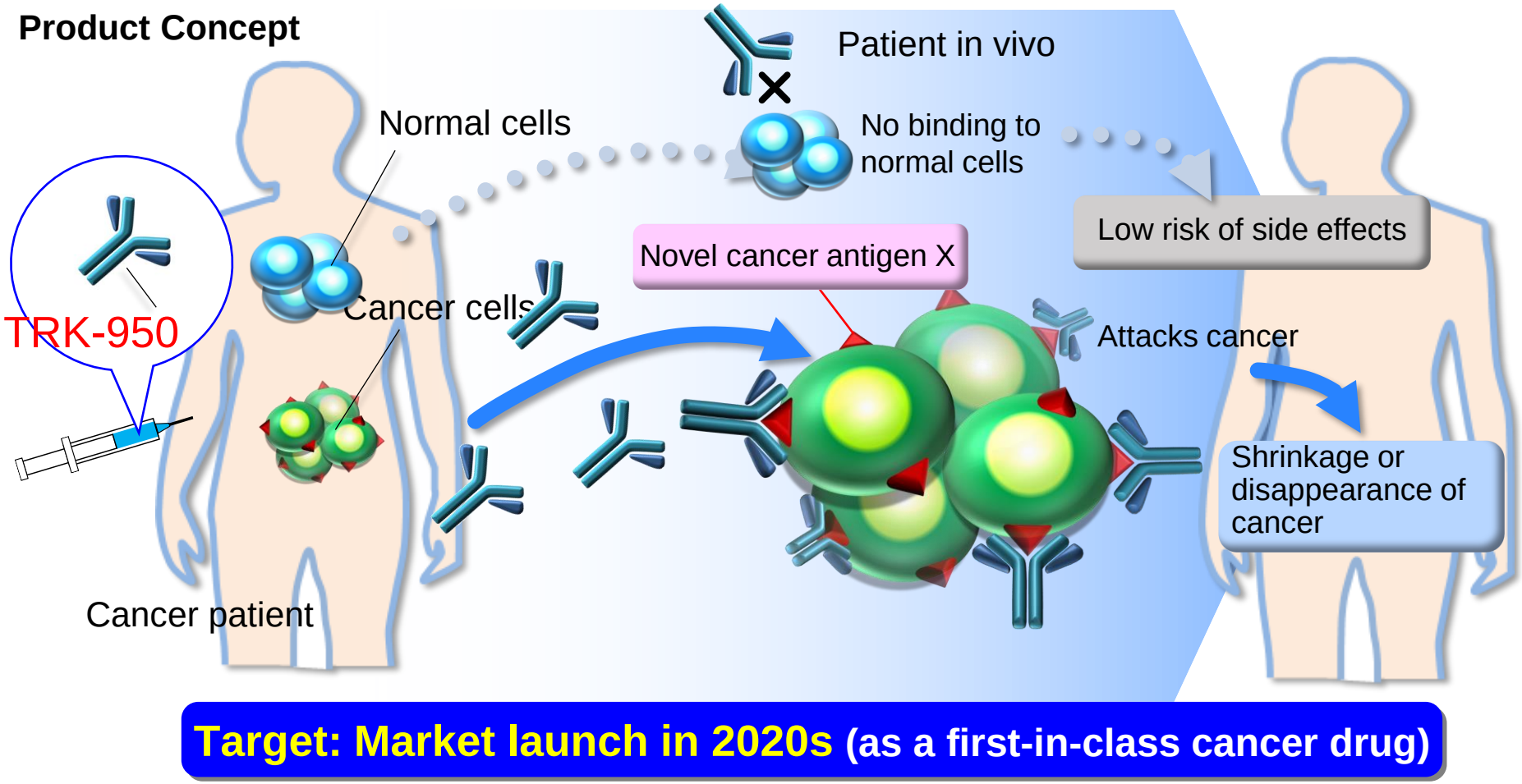
- **Delivered to 99 countries. The number of large-scale water treatment plants we have delivered to is over 100.**
- **Water volume equivalent: 120 million tons/day (equivalent to the daily water use of 840 million people)**

Development of Innovative Cancer Antibody Drug: TRK-950

■ About TRK-950

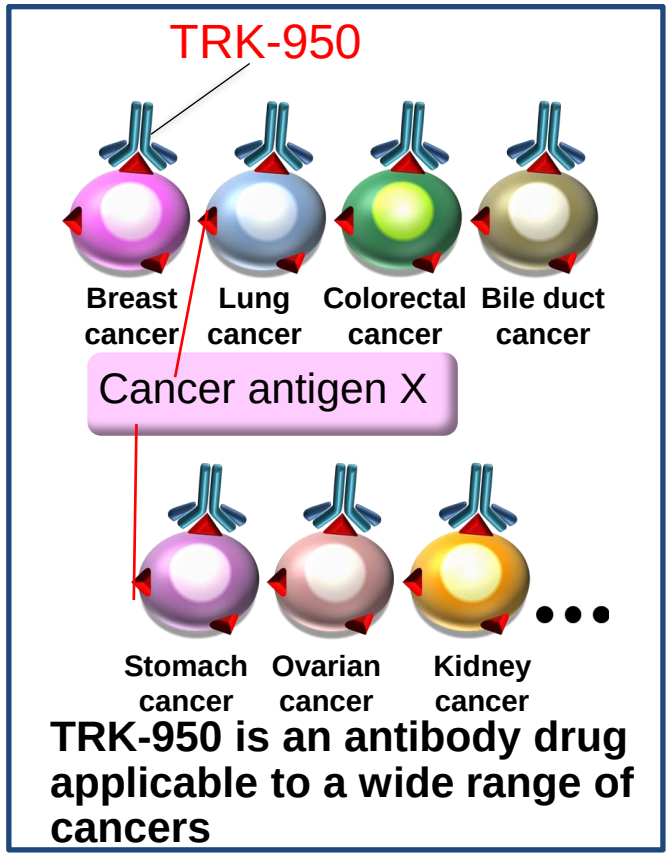
- An antibody drug targeting the novel cancer antigen X discovered by Toray.
- Clinical trials have shown promising results in terms of safety and efficacy in humans.
  Plan to move on to Phase II trial

Product Concept



Target: Market launch in 2020s (as a first-in-class cancer drug)

Superiority of Toray's Technology



TRK-950 is an antibody drug applicable to a wide range of cancers

Development of Separation Membrane Technology

Basic Strategy 1 Sustainable Growth

Market [Image]

Dialyzer

RO Membranes

LIVMOA™

Electrolyte Membranes

Creation of valuable materials from non-edible biomass

CO_2 Separation Membranes

Dialyzer

Production of Ultra-pure water

Separators for LIB

Blood purifier

Desalination

Dialyzer Ⅱ

Sewage reuse

Personal Protective Clothing

Bioprocesses using membranes

Blood Purifier II

Hydrolysis

H_2 Separation Membranes

Fuel Cell

Valuable chemicals

Sugar

Advanced water treatment

Collection of valuable materials

Oil water separation

New Energy

Chemicals

Health Care

Water Treatment

1970 1980 1990 2000 2010 2020 2030

Expansion to growth fields based on Toray's strong separation membrane technology

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Medium-Term Management Program, Project AP-G 2025

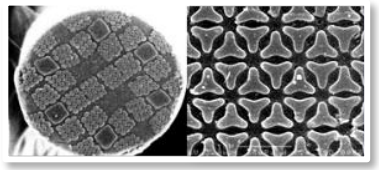
— Ultimate Value Creation

Creating Unrivaled Technologies and Products

Developing high-value differentiated products (unrivaled technologies and products) → Expanding share by becoming the industry's de facto standard
Securing and expanding profits by reducing costs

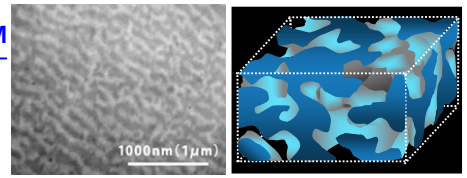
Field	Unrivaled technologies/products
Fibers & Textiles	Ultrasuede™, NANODESIGN™
Resins & Chemicals	PPS, transparent ABS, NANOALLOY™
Films	Lumirror™ release film for manufacturing PICASUS™ nano-multilayer film TORAYFAN™ thin film for automotive capacitor
Carbon Fiber Composite Materials	Prepreg for aircraft (regular tow) Carbon fiber for wind turbine blades（large tow）
Electronic & Information Materials	Electronic coating materials, OLED materials
Pharmaceuticals & Medical Products	REMITCH® oral pruritus improvement drug Anti-thrombogenic polymer (TORAYLIGHT™, TORAYSULFONE™, HEMOFEEL™)
Water Treatment, Environment & Amenity	RO membrane for seawater desalination

NANODESIGN™



Fiber precision Cross-section control

NANOALLOY™

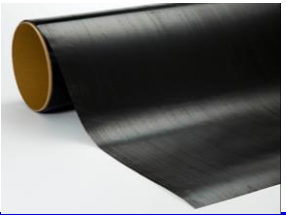


Polymer microstructure control

PICASUS™

Nano-multilayer/polymer design technology

Prepreg for aircraft



Carbon fiber defect control/ intermediate substrate design (resin, particles)

RO membrane for seawater desalination

Separation membrane technology (non-fouling/interfacial polycondensation)

We will continue to focus on development, mobilizing the collective strengths of our Technology Center to create key products and technologies that can drive the next generation of large-scale, highly profitable businesses

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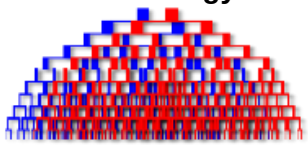
Expansion of Unrivaled Technologies and Products: Super Nanotech

Basic Strategy 2 Ultimate Value Creation

NANODESIGN™

Forming fiber cross-sections as “points” with unique flow control technology

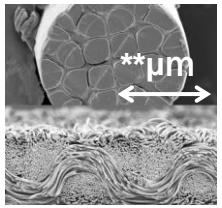


Free cross-sectional design

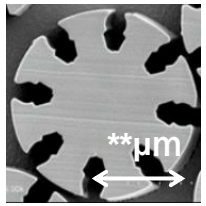
Diverse polymers

Multi-component composites

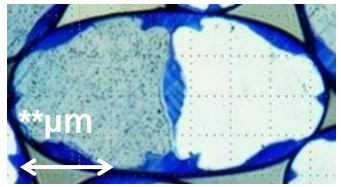
Main applications



UTS-fit



Nanoslit fiber



Kinari

Freely imparting luster, heat retention, water repellency, and elasticity to fibers

NANOALLOY™

Polymer A

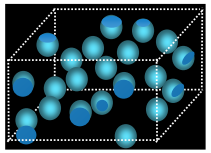
Polymer B

Nano dispersion

Polymer design

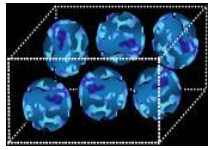
Dispersion and kneading technology

High-dimensional expression of multiple properties



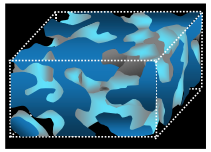
Heat resistance

Easy flowability



High resilience

Shock absorption

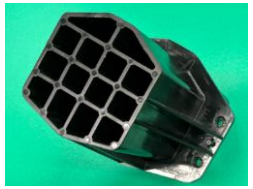


Chemical resistance

High resilience

Main applications

Racing bikes



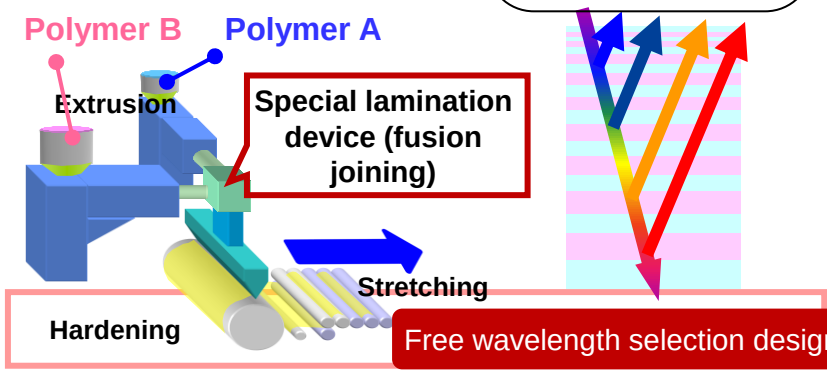
Shock-absorbing crash pads

Fishing rods

PICASUS™

Multilayer lamination process

Nano-multilayer film



Free wavelength selection design

Main applications

Films with metallic sheen

(Layer thickness: approx. 100 nm)

View angle control (AR-HUD)

FY 2022 Revenue: Approx. 12 billion yen → FY 2025 Revenue: Approx. 40 billion yen

Technology and Business Collaboration: Initiatives for Semiconductors

Basic Strategy 2 Ultimate Value Creation

Industry associations/ external resources

Semi Japan

semi

External consultants

R&D Division

Business Divisions, Group Companies

Corporate Marketing Planning Div.

Customers

◎ Device manufacturers
○ Equipment manufacturers
○ Materials manufacturers

intel. SAMSUNG tsmc SK hynix Infineon Rapidus TEL SCREEN IBIDEN

(1)Utilization of internal customer channels
to clarify customer issues and propose solutions through internal channels

(2) Identification of latent needs
Interaction between researchers/engineers and customer engineers

(3) Responding to future trends and needs
(Silicon photonics, next-generation power semiconductors)

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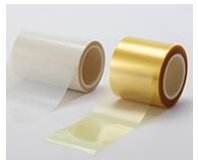
Materials



Polyimide coating materials (NMP free), high thermal conduction adhesive sheets, etc.

Manufacturing and inspection equipment

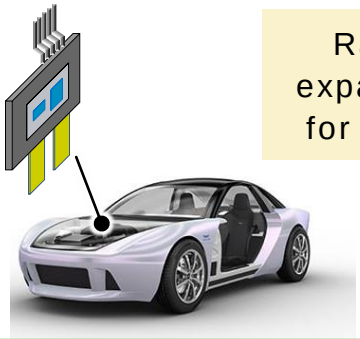
New company(TRENGEU) established in Germany (April 2023)

TRENG: Semiconductor inspection equipment, etc.

TRENG: Abbreviation of Toray Engineering Co., Ltd.

Customers

Power Module



Rapid expansion for xEVs

✓ Strengthening solution proposals for customers leveraging collaboration within the Toray Group and with industry associations as well as utilization of external resources

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Medium-Term Management Program, Project AP-G 2025

— Product and Operational Excellence

Creation of New Materials and Services / Production Cost Reduction and Quality Improvement

1. Creation of new materials and services

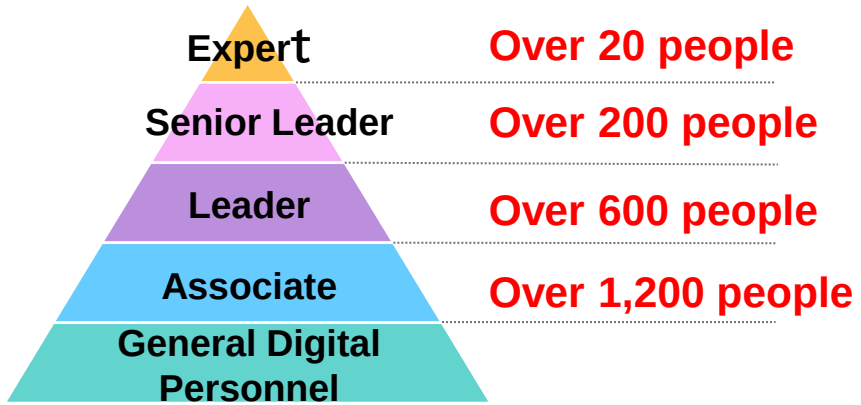
- **Leveraging collective strengths** (processing, engineering, and analytical technology)
- **Strengthening technology marketing functions**
- **Advancing carbon neutrality and resource recycling themes**
- **Leveraging digital technologies**
  (Advancing and developing simulation and informatics technologies)

2. Production cost reduction and quality improvement

- **Production process innovation**
  - Continuous production process development
  - Improving production efficiency using advanced process monitoring and data analysis
- **Raising the level of supply chain management using production planning simulations**

Investment related to digital technology: 20 billion yen

- Building a global data infrastructure
- Combining analysis and simulation tech.
- Cooperating with value chain partners
- Development of HR fluent in digital tech.



Establishing a base of human resources fluent in digital technologies totaling 2,000 people group-wide

Enhancing value creation capability and competitiveness by adopting digital technologies with a focus on the frontlines

TORAY

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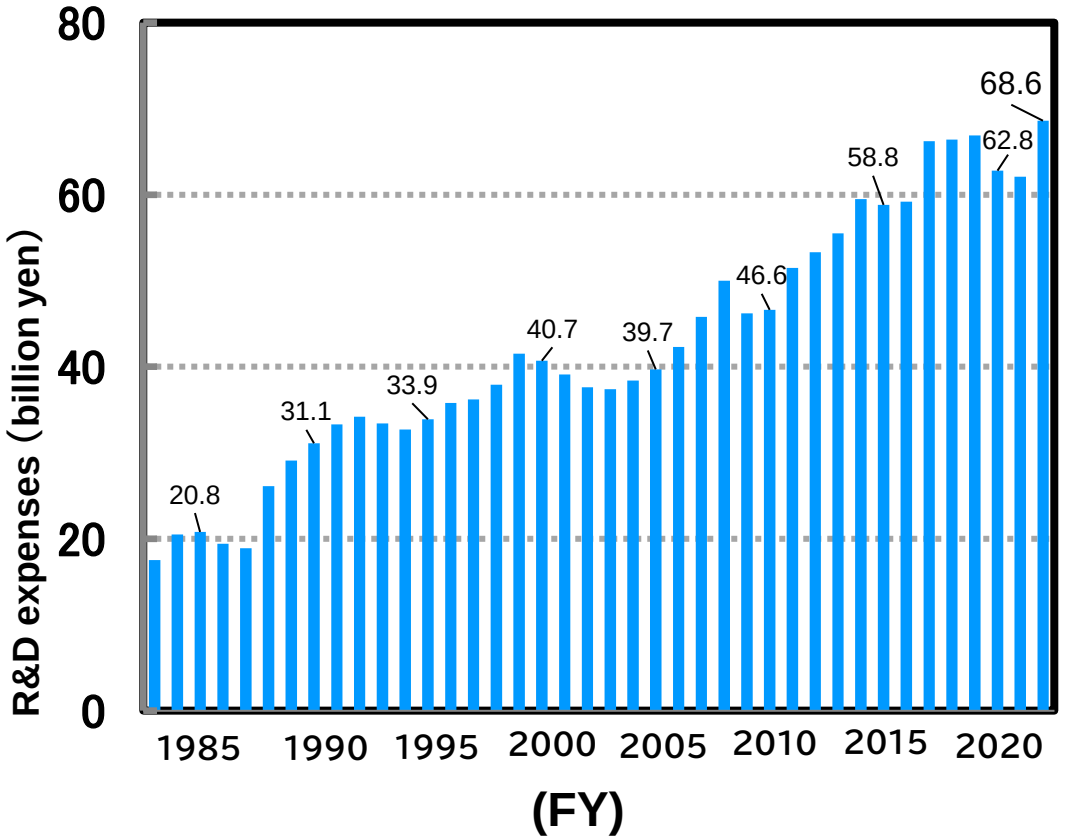
Business Expansion based on R&D

R&D Expenses:
How the Technology Center Contributes to the Business by Addressing Priority Issues

R&D expenses (consolidated)



Planning to invest about 220 billion yen under the current three-year medium-term management program (previous medium-term management program: about 195 billion yen)

Priority issues for the Technology Center

High value-added themes prioritized by each business field

Fields	Priority issues for the Technology Center
Fibers & Textiles	NANODESIGN™, recycled fibers
Resins & Chemicals	PPS resin, NANOALLOY™ resin , fine particles
Films	Nano-multilayer film, lithium-ion battery separator film
Carbon Fiber Composite Materials	Intermediate materials for industrial use, fuel cell electrode substrates
Electronic & Information Materials	Electronic coating materials, environmentally friendly printing materials
Pharmaceuticals & Medical Products	APOA2-i, acute lung injury treatment column
Water Treatment, Environment & Amenity	RO membranes for seawater desalination, air filters
Others, new businesses, basic and foundational themes	

Progress on Technology Center priority issues anticipated to add over 200 billion yen in revenue in fiscal 2025

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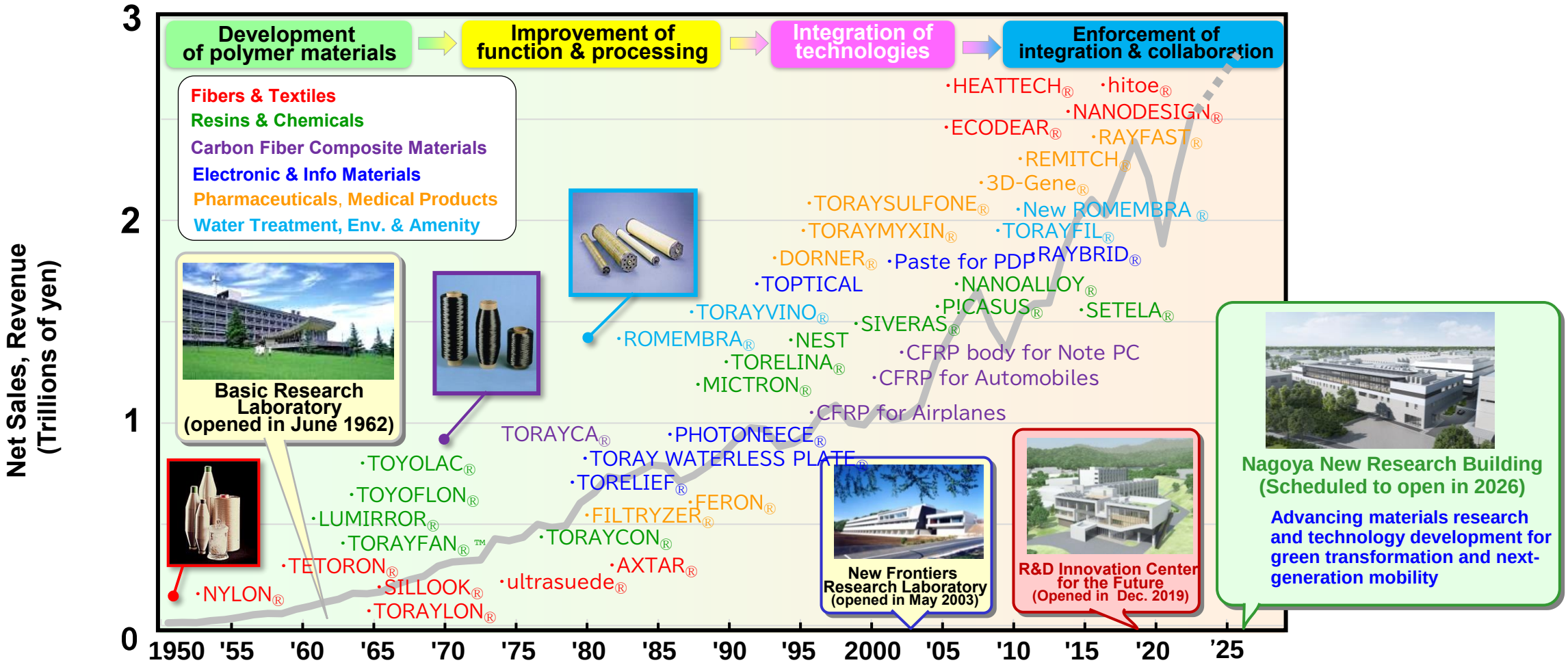
History of Toray's Business Expansion

-Research and development provide the key to building the Toray of tomorrow-



Toray has created new value by producing cutting-edge materials for over 90 years.
Toray will continue to create cutting-edge materials by leveraging innovative technologies based on its core technologies.

Innovation by Chemistry

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