 TORAY IR Day
Medium-Term Management Program Project AP-G 2025

Toray Group’s R&D Strategies

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Executive Vice President and Representative Member of the Board,
CTO, Toray Industries, Inc.
I. Characteristics of Toray Group’s R&D

II. Medium-Term Management Program, Project AP-G 2025

- Achieving Sustainable Growth
  (Increasing Sales Volume Focusing on Growth Areas)
- Ultimate Value Creation
  (Increasing Profitability by New Value Creation)
- Product and Operational Excellence

III. Business Expansion based on R&D
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

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 innovative process and equipment development, executing demonstrations

Analysis

(Research Centers, Toray Research Center, Inc.)

Analysis Technology

- Physical property evaluation
- Structural analysis
- Composition analysis
- Morphological observation

Latest Examples

- Direct molecular observation using high-end electron microscope

Chemical structure of pentacene

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

1 nm

Creating safe and cost-competitive processes from research results (also serves as a last resort in challenging times)
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)**
- **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 2025

<table>
<thead>
<tr>
<th>GR Business</th>
<th>SI Business</th>
<th>DI Business</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sustainability Innovation Business</strong> (*1)</td>
<td><strong>New</strong> Products that accelerate measures to counter climate change</td>
<td><strong>New</strong> Materials, equipment, technologies, and services that help improve convenience and productivity by supporting the widespread adoption of digital technology</td>
</tr>
<tr>
<td><strong>New</strong> Products that facilitate sustainable, recycling-based use of resources and production</td>
<td><strong>New</strong> Products that help provide clean water and air and reduce environmental impact</td>
<td><strong>New</strong> Products that help deliver better medical care and hygiene for people worldwide</td>
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<td></td>
<td><strong>New</strong> Cancer Antibody Drug TRK-950</td>
</tr>
<tr>
<td></td>
<td><strong>New</strong> Products that help deliver better medical care and hygiene for people worldwide</td>
<td><strong>New</strong> Semiconductor manufacturing and inspection equipment</td>
</tr>
</tbody>
</table>

#### SI & DI Projects

- Carbon fibers for aircrafts
- Electrolyte membranes for production of H2
- Bioprocess using membranes
- Chemical recycling using subcritical water
- Environmentally friendly offset plate
- RO membranes for seawater desalination
- Protective clothing
- Polyimides
- Semiconductor manufacturing and inspection equipment

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* (*1) New Business

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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>

<table>
<thead>
<tr>
<th>Current</th>
<th>Molding (1st)</th>
<th>Molding (2nd)</th>
<th>Adhesives</th>
<th>Assembly</th>
<th>Fasten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
<td>Molding</td>
<td>Assembly</td>
<td>Thermal welding</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Demand forecast of carbon fiber for pressure vessels

Expand at an annual growth rate of 42%

High-Speed Thermal Welding Technology

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

Model part

Expand at an annual growth rate of 42%

Stable Strength

High-grade (Ease of use)

Stable supply

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

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

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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.

Electricity from renewable energy

Power to Gas

Water electrolyzer

Komekurayama, Yamanashi Pref.

Production

Transportation, Storage

Use

Power to X

Industrial sector

Heat demand

Iron manufacturers

Transportation sector

Features of Hydrocarbon (HC) electrolyte membranes

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Alkaline water electrolysis</th>
<th>PEM water electrolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>%</td>
<td>80</td>
</tr>
<tr>
<td>High current density</td>
<td>A/cm²</td>
<td>0.3</td>
</tr>
<tr>
<td>Low gas permeability</td>
<td>a.u.</td>
<td>High</td>
</tr>
</tbody>
</table>

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

Plan to start production in 2024

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Accelerate initiatives including biomass plastics, material and chemical recycling

- **Raw material**
  - Fossil resources
  - Biomass
  - Emission gas (CO₂)

- **Production, use**
  - Raw material
  - Pellets
  - Toray materials (fibers & textiles, resins, films)
  - Used Plastics (including those generated outside the Toray Group)

- **Waste (minimize)**
  - Gas separation membrane
  - Carbon recycling
  - Chemical recycling
  - Nylon recycling from fishing nets
  - Depolymerization technology using subcritical water

- **Acceleration of initiatives**
  - Biomass plastics
  - Material and chemical recycling

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**Basic Strategy 1: Sustainable Growth**

- Electric power from renewable energy
- Hydrogen from renewable energy
- Water treatment

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- **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 CO₂ recycling used in Toray core polymers (**) in FY 2030**
  - 20% (*1 PET and nylon polymers)

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

New Nylon Synthesis Process

1. Discovery of microorganisms (world’s first)
   Intermediate generation amount: 1

2. Dramatic increase in generation amount
   Intermediate generation amount >1000

Applications

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

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

Energy consumption reduced by RO membrane concentration

Target: Commercialization around 2030
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)

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

- **Normal cells**
- **Cancer cells**
- **Patient in vivo**
- **Novel cancer antigen X**
- **TRK-950**

- **No binding to normal cells**
- **Attacks cancer**
- **Low risk of side effects**
- **Shrinkage or disappearance of cancer**

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

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**Superiority of Toray’s Technology**

- TRK-950 is an antibody drug applicable to a wide range of cancers:
  - Breast cancer
  - Lung cancer
  - Colorectal cancer
  - Bile duct cancer
  - Ovarian cancer
  - Kidney cancer
  - Stomach cancer

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(4) Products that Help Deliver Better Medical Care And Hygiene for People Worldwide

Basic Strategy 1
Sustainable Growth
Development of Separation Membrane Technology

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

Market [Image]

Dialyzer

RO Membranes

LIVMOA™

Dialyzer

Production of Ultra-pure water

Desalination

Separators for LIB

Blood purifier

Blood Purifier II

Personal Protective Clothing

Collection of valuable materials

Advanced water treatment

Oil water separation

Sewage reuse

Collection of valuable materials from non-edible biomass

Creation of valuable materials from non-edible biomass

Hydrolysis

H₂ Separation Membranes

Fuel Cell

Valuable chemicals

Sugar

Bioprocesses using membranes

Advanced water treatment

Expansion to growth fields based on Toray’s strong separation membrane technology
Medium-Term Management Program, Project AP-G 2025

— Ultimate Value Creation
Creating Unrivaled Technologies and Products

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

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.

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

Fiber precision Cross-section control

Polymer microstructure control

Nano-multilayer/polymer design technology

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

Separation membrane technology (non-fouling/interfacial polycondensation)
Expansion of Unrivaled Technologies and Products: Super Nanotech

**NANODESIGN™**
- Forming fiber cross-sections as “points” with unique flow control technology
- Free cross-sectional design
- Diverse polymers
- Multi-component composites

**NANOALLOY™**
- Polymer A
- Polymer B
- Nano dispersion
- Heat resistance
- Easy flowability
- High resilience
- Shock absorption
- Chemical resistance
- High resilience

**PICASUS™**
- Multilayer lamination process
- Nano-multilayer film
- Extrusion
- Special lamination device (fusion joining)
- Hardening
- Stretching
- Free wavelength selection design

**Main applications**
- Racing bikes
- Shock-absorbing crash pads
- Fishing rods

**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

- **R&D Division**
- **Corporate Marketing Planning Div.**
- **Business Divisions, Group Companies**

### Toray Group
- **Materials**
  - Polyimide coating materials (NMP free), high thermal conduction adhesive sheets, etc.
- **Manufacturing and inspection equipment**
  - New company (TRENGEU) established in Germany (April 2023)

### Customers
- **Device manufacturers**
- **Equipment manufacturers**
- **Materials manufacturers**

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

- **Industry associations/external resources**
  - Semi Japan
  - External consultants

- **Utilization of internal customer channels**
  - to clarify customer issues and propose solutions through internal channels

- **Identification of latent needs**
  - Interaction between researchers/engineers and customer engineers

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

- **Technology and Business Collaboration: Initiatives for Semiconductors**

- **Basic Strategy 2**
  - Ultimate Value Creation

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Medium-Term Management Program, Project AP-G 2025

— Product and Operational Excellence
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
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

<table>
<thead>
<tr>
<th>Fields</th>
<th>Priority issues for the Technology Center</th>
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<tbody>
<tr>
<td>Fibers &amp; Textiles</td>
<td>NANODESIGN™, recycled fibers</td>
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<tr>
<td>Resins &amp; Chemicals</td>
<td>PPS resin, NANOALLOY™ resin, fine particles</td>
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<tr>
<td>Films</td>
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<td>Intermediate materials for industrial use, fuel cell electrode substrates</td>
</tr>
<tr>
<td>Electronic &amp; Information Materials</td>
<td>Electronic coating materials, environmentally friendly printing materials</td>
</tr>
<tr>
<td>Pharmaceuticals &amp; Medical Products</td>
<td>APOA2-i, acute lung injury treatment column</td>
</tr>
<tr>
<td>Water Treatment, Environment &amp; Amenity</td>
<td>RO membranes for seawater desalination, air filters</td>
</tr>
<tr>
<td>Others, new businesses, basic and foundational themes</td>
<td></td>
</tr>
</tbody>
</table>

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