CSIRO

Going beyond – new solutions and synergies in a fast-changing world.

Prof. Bronwyn Fox, Chief Scientist
19 February 2024

Australia’s National Science Agency

The big picture…

In a rapidly changing world, full of challenges and opportunity, science will do most of the heavy lifting

Who we are

Australia's national science agency

One of the world's largest multidisciplinary science and technology organisations

6,000+ dedicated people working across 59 sites globally

State-of-the-art research infrastructure

550 international collaborators in 69 countries

CSIRO

We solve the greatest challenges through innovative science and technology

Health and wellbeing

Future industries

A secure Australia and region

Food security and quality

Sustainable energy and resources

Resilient and valuable environments

CSIRO

CSIRO’s Statement of Expectations

- Applying science to advance our national interests
- Taking Australian Science to the World
- Advancing the Government’s policy priorities
- Advancing First Nations Science
- Achieving Net Zero Emissions and becoming a Renewable Energy Superpower
- Delivering a Future Made in Australia through the National Reconstruction Fund
- Research translation and commercialisation
- Supporting the health of Australians
- Managing research infrastructure and national facilities
- Promoting STEM; STEM Careers
- Communication of CSIRO’s science and research
- Driving the organisation’s performance

CSIRO

Going beyond: new solutions and synergies in a fast-changing world.

- Important global trends
- AI and Polymers
- Future Science and Technology Plan

CSIRO

Important global trends

CSIRO

Realising Australia's digital potential through the Internet of Things

Contributors:

Bronwyn Fox
FTSE

Deborah Lupton
FASSA

Paul Scuffham
FAHMS

Alan Finkel AC
FAA FTSE

Branka Vucetic
FAA FTSE

Gerard Goggin
FAHA

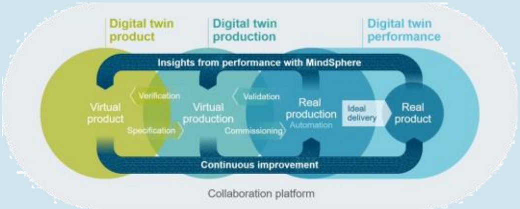
Holger
Regenbrecht

- 2020
- ACOLA
- Office of the Chief Scientist
- Australian Council of Research
- Department of Infrastructure, Transport, Regional Development and Communications

CSIRO

Realising Australia's digital potential through the Internet of Things – ACOLA 2020

Industry 4.0 or the Industrial Internet of Things



Sustainability in Supply Chains

GAIA-X: A Federated Data Infrastructure for Europe

CSIRO

2024

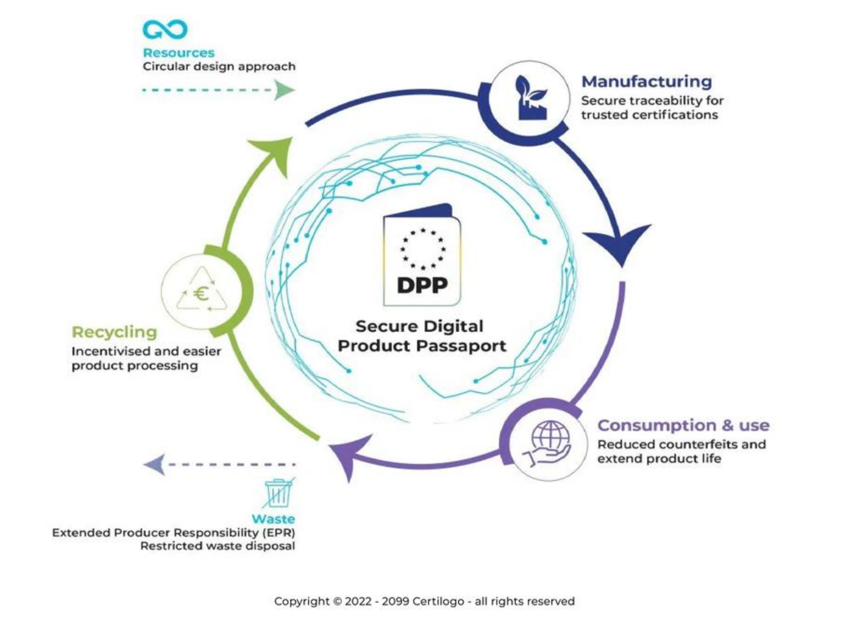
Circular Economy:

Recyclable and Bioderived Materials

Digital Product Passports for Carbon Emissions

WORLD MATERIALS FORUM

July 11th 2024 - Paris, France



‘They lied’: plastics producers deceived public about recycling, report reveals

Companies knew for decades recycling was not viable but promoted it regardless, Center for Climate Integrity study finds

The report says big companies may have broken laws designed to protect the public from misleading marketing and pollution. Photograph: Clemens Bilan/EPA

Plastic producers have known for more than 30 years that recycling is not an economically or technically feasible plastic waste management solution. That has not stopped them from promoting it, according to a new report.

“The companies lied,” said Richard Wiles, president of fossil-fuel accountability advocacy group the Center for Climate Integrity (CCI), which published the report. “It’s time to hold them accountable for the damage they’ve caused.”

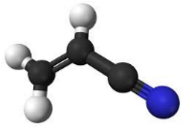
‘They lied’: plastics producers deceived public about recycling, report reveals | Recycling | The Guardian 15/02/2024

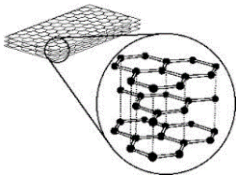
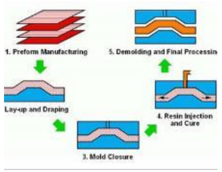
CSIRO

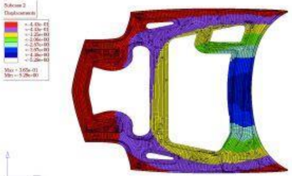
CSIRO

Sustainable Polymers

How do we remove fossil fuels from Carbon Fibre Composites





Monomer (Acrylonitrile & others) → Precursor Fibre → Carbon Fibre → Composites → Structures

- Biomass-based
- Recycled

- New materials
- Recycled Fibre

- Abatement
- Reclaim volatiles
- Hydrogen furnaces
- Sizing

- Matrix resins
- Rapid manufacturing
- Waste Recycling/ reduction

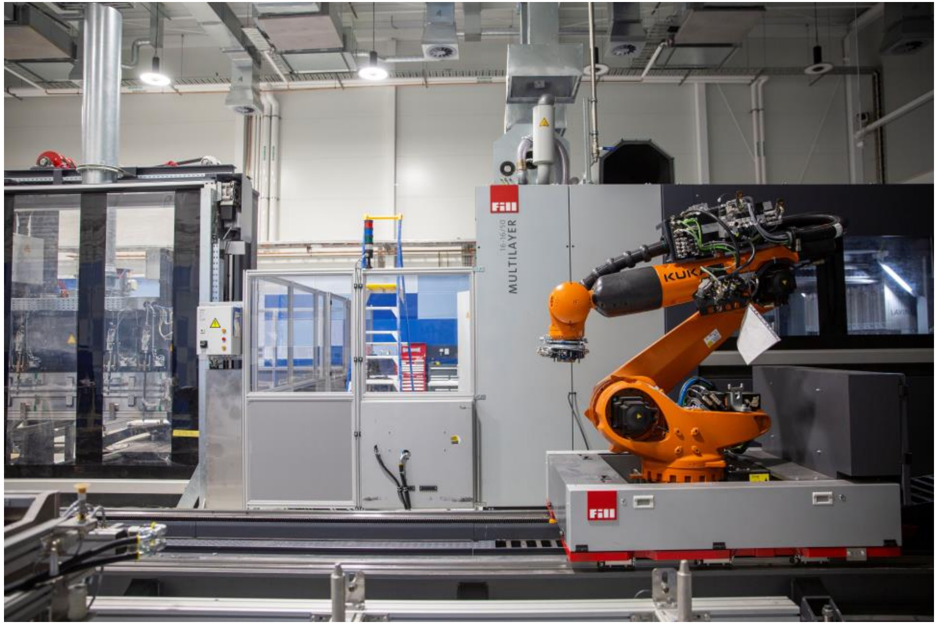
- Design for Recycling
- Reuse
- Repurpose

Recycling / Upcycling

AI and Polymers

Swinburne/CSIRO Industry 4.0 Composite Additive Manufacturing

The Industry 4.0 Testlab




Caution!
Achtung!

CSIRO SWINBURNE UNIVERSITY OF TECHNOLOGY

Double Diaphragm Forming (DDF) of Dry Carbon Fibre Tapes

Advantage of Tapes

- Minimal waste
- Weight reduction
- Automation

Tape

2D Preform

3D Form

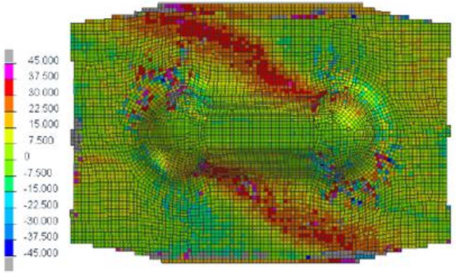
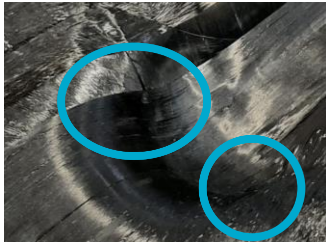


Figure 5-31: Distribution of fiber orientation deviation between PAMFORM simulation and DrapeWatch scan, BX225 preform (blankholding pressure 0 bar)

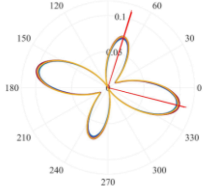
Common forming defects

Defects driven by process- (heat, pressure) and preform- (layup, material,..) parameters

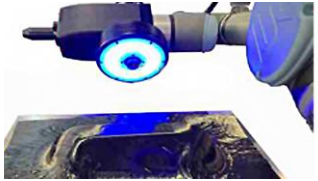
Bridging, In-plane / Out-of-plane wrinkles



Tape folding, Gapping, Wrinkles, Fibre Orientation



Eddy Current Sensor (Multiple Layers)
Fibre orientation, (In-plane wrinkles..),



Optical Inspection (Top Layer)
In-plane wrinkles, Tape folding, Gapping, Fibre Orientation

Laser Scanning Arm
Bridging, Out-of-plane wrinkles, Tape folding, Gapping

Goal

Characterize influence of **DDF process conditions** (Heat, Pressure) and **weld spot** interactions on Tape **friction/slip** behaviour.
Correlate process parameters to forming quality.

CSIRO

SWINBURNE UNIVERSITY OF TECHNOLOGY

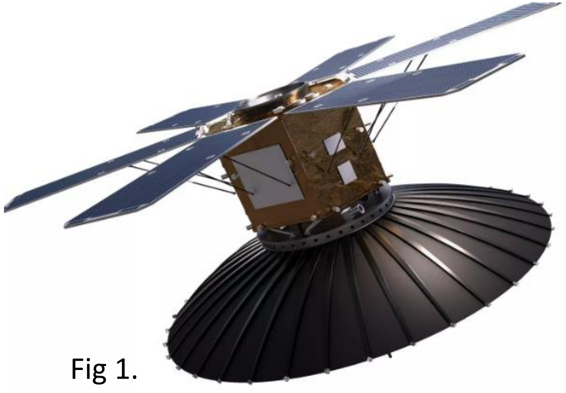
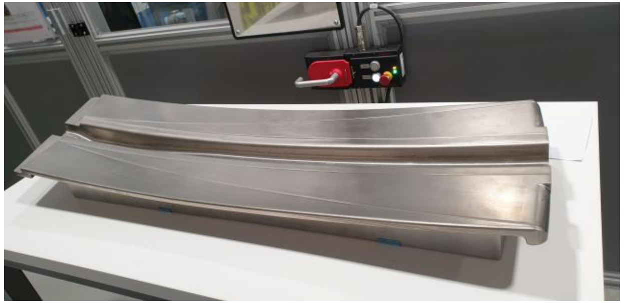
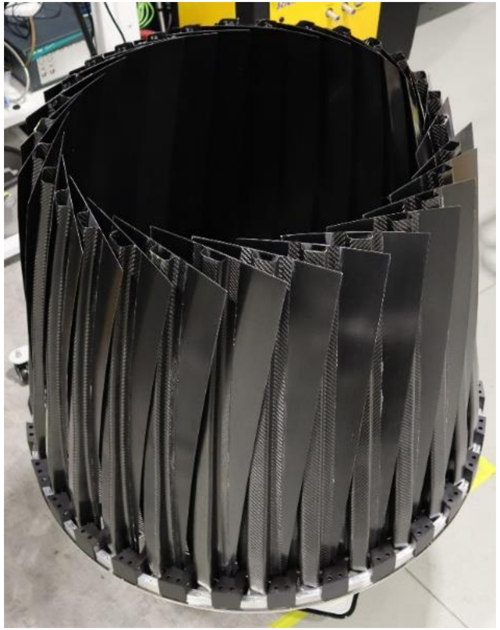


Fig 1.



3D printed Titanium tool



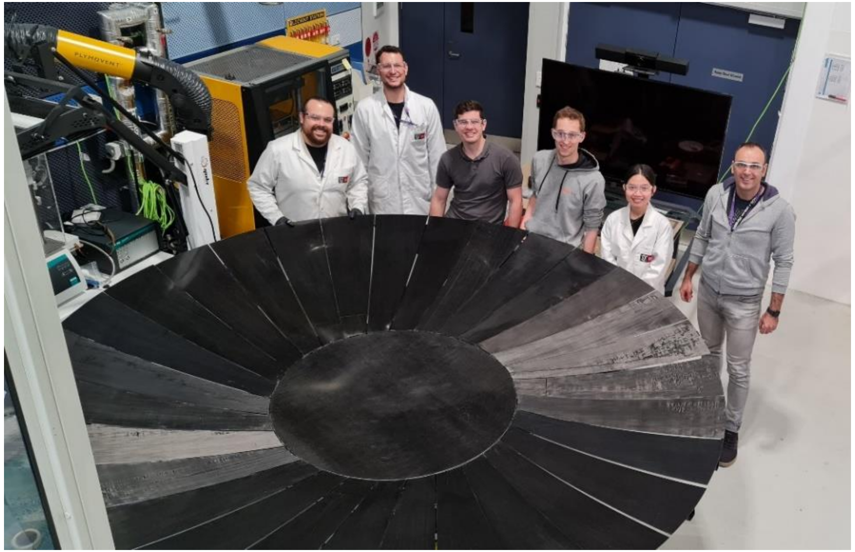


Fig 1: https://www.airbus.com/en/products-services/space/earth-observation/earth-observation-portfolio

Collaborative Research Hubs: Aerostructures Innovation Research (AIR) Hub

- Leading advanced manufacturing researchers (Swinburne, ARENA2036, Monash, CSIRO, the Australian Synchrotron) + industry aerospace companies (Boeing, Marand, Quickstep, Cablex, Furnace Engineering).
- **Aim:** Create new jobs via the development and commercialisation of new technologies supplied internationally.
- Strengthen the supply chains to build complex aerostructures for civil aerospace, space, satellite, and unmanned aerial vehicle applications.
- **Focus:** Automation and digitalization of the manufacturing of advanced composite structures, primarily aerospace with spillover potential to other advanced manufacturing (automotive, surface transportation, civil construction).

CSIRO

SWINBURNE UNIVERSITY OF TECHNOLOGY

Collaborative Research Hubs: The Victorian Hydrogen Hub VH2 at Swinburne

- $10 million fund from the Victorian Government to build the Victorian Hydrogen Hub in partnership with ARENA2036.
- Designed to bring researchers, industry partners and businesses together to test, trial and demonstrate new and emerging hydrogen technologies.
- Translation of fundamental knowledge into skills, industry and community engagement.
- Unique opportunity to work across continents to create scaleable, global solutions.

Universal Hydrogen's twin-tank module uses carbon fiber-wrapped pressure vessels to store H_2 gas at 850 bar, enabling a 400-nm range for a *Dash 8* or *ATR* turboprop as well as easy transport and loading using existing infrastructure.

Photo Credit: Universal Hydrogen

CSIRO

Future Science and Technology

CSIRO

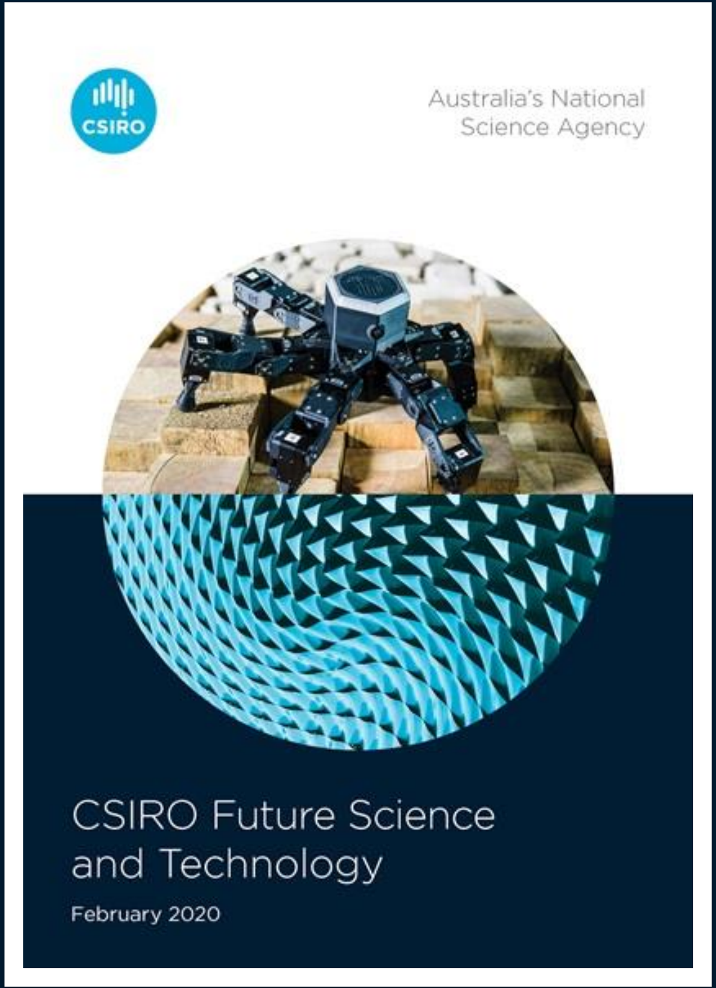
Future Science and Technology Plan

Created to address global, national and organisational challenges and opportunities in the areas of:

- Transformative and cross cutting science and technology capabilities.
- Shift towards digital and delivery, supported by enablers (Digital Academy, Managed Data, Ecosystem, and our laboratory and field infrastructure, and national facilities).
- Enhanced collaboration and inclusivity for more interdisciplinary and multidisciplinary work.
- Support for agile, yet long-term, research and development.

First developed in 2019 – 2020, the plan outlined the following transformative cost-cutting science and technology capabilities for CSIRO, in the areas of:

- Biological Science and Technology (Genomics, Synthetic Biology)
- Digital Sciences and Technology (AI & Machine Learning, Robotics, IoT, Sensing, Simulation and Modelling)
- Physical Sciences and Technology (Advanced Materials, Engineering, Quantum Technologies)
- Social Systems (Indigenous Knowledge and Science, Social Science & User Experience)



Shaping our next FS&T plan

- Refresh the current plan to incorporate new opportunities and enablers
- Inform and align longer-term organisational decisions and investments to ensure we are future-ready:
  - Workforce planning and career development pathways
  - Science infrastructure and capex
  - Future CSIRO strategies and programs.

Revised approach

1) What will science and tech look like in the next 10-20 years?

Emerging/revolutionary science areas and why is it disruptive (i.e. how will it transform R&D)

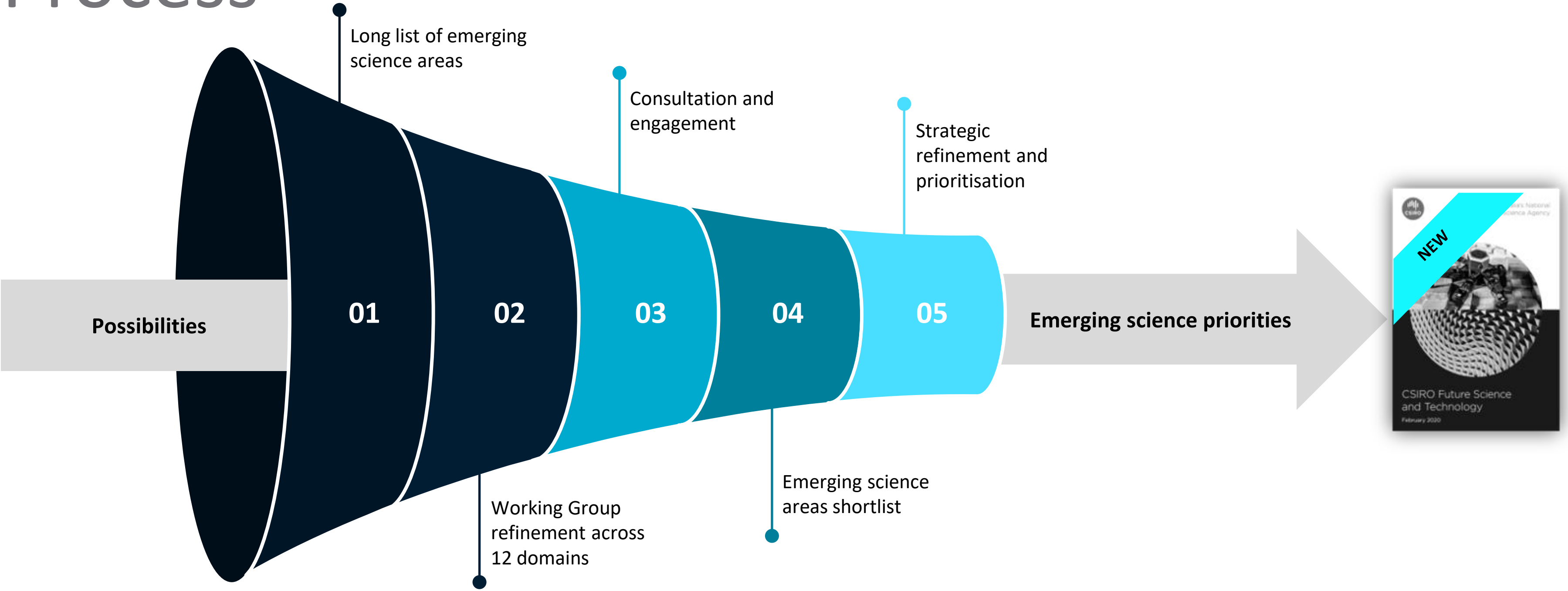
2) Where should CSIRO focus?

Define CSIRO's role in 2040 (high-level) and why

3) What should CSIRO do to prepare?

Organisational capability required

Process



Long list of emerging science areas
Consultation and engagement
Strategic refinement and prioritisation
Possibilities
01
02
03
04
05
Emerging science priorities
NEW
CSIRO Future Science and Technology
Working Group refinement across 12 domains
Emerging science areas shortlist

CSIRO

Revised Future Science & Technology: Domain shaping framework

Internal consultations will help to define ‘where we are today’ and ‘where we need to be’ along each of the three identified dimensions

1/ **How should CSIRO’s scientific discoveries in this domain be characterised in 10-20 years?**

Disruptive: Creates a new paradigm* — **Consolidating:** Builds on existing paradigms

2/ **Where should CSIRO deliver most value along the R&D value chain?**

Discovery of science — **Translation** of S&T

Integration of different S&T discoveries

3/ **What role should CSIRO play in the ecosystem?**

Primary: Pioneering or leading within the ecosystem — **Enabling:** Playing a supportive role within the ecosystem

Footnotes: *Novelty + combining disparate concepts & disciplines, Nature paper on CD index summary: Pace of innovation has slowed AFR Jan5 2023.pdf

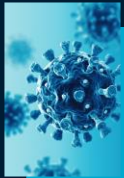
2040 science opportunities

Organisms engineered on demand

Entire ecosystems engineered and enhanced

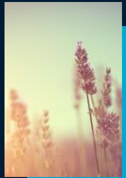
Indigenous knowledge systems are embedded

AI-enabled, adaptable, ubiquitous robots working with humans and in extreme environments



Ingestibles to predict and prevent diseases

Earth observation: remote predictions and interventions



Predicting phenotypes using multi-scale omics

Emission-free energy for everyone

Superior performing, cheaper, bespoke, recyclable materials

Socio-technical development unlocking human dimension

CSIRO

Research in Sustainable Polymer Systems

Ending Plastic Waste Mission

An 80 per cent reduction in plastic waste entering the Australian environment by 2030.

CSIRO

Why

- Each year, 90 billion tonnes of primary materials are extracted and used globally for plastics, with only 9 per cent recycled.
- The scale of production and detrimental impact of plastics is predicted to grow up to four times by 2040.
- Our mission will help protect the environment and generate circular economy opportunities that turns plastic waste destined for landfill into economic returns and jobs.

Waste data and knowledge platform

Data collection
Federated data catalogues that enable dynamic access to data from diverse sources across the ‘waste’ supply chain.

Data visualisation
Platforms to access, share, visualise and compare diverse datasets, live data streams and analytics products.

Data standards
Supporting improvements in reporting standards and common terminology.

Artificial intelligence
Natural language processing to extract information from existing waste reporting processes. AI image analysis for plastics sorting and categorisation.

Data sharing
Privacy preserving technologies to enable data analytics while protecting privacy/commercial confidentiality of data providers.

Data analytics
AI and machine learning to enable waste data analysis including trend analysis, forecasting and fraud detection.

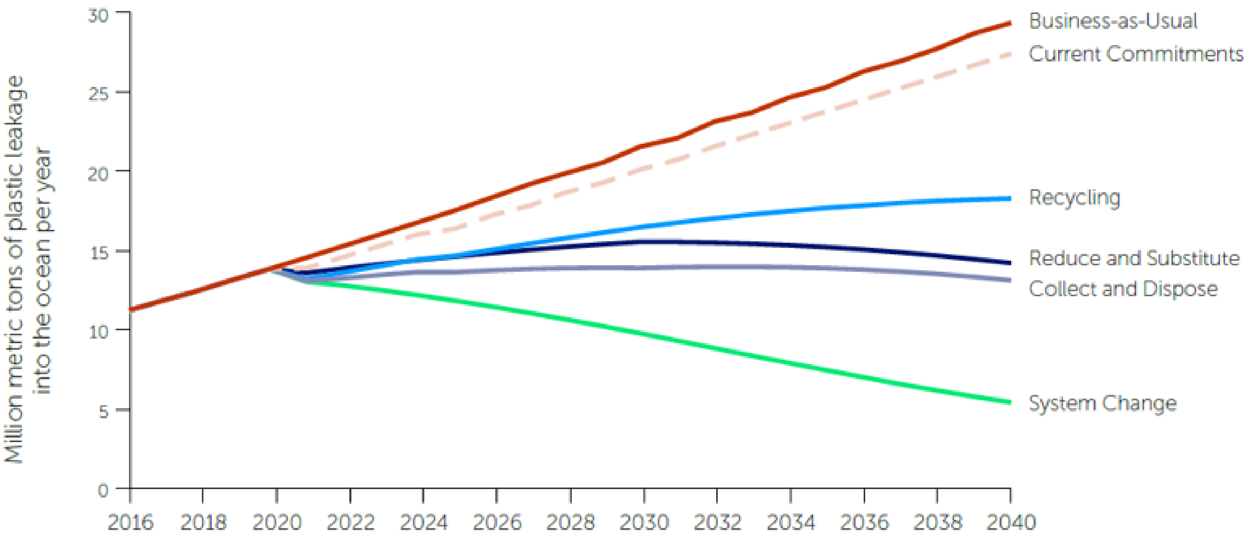
CSIRO

Single-solution strategies cannot stop plastic pollution

Breaking the plastic wave top findings, Pew Trusts, 2020

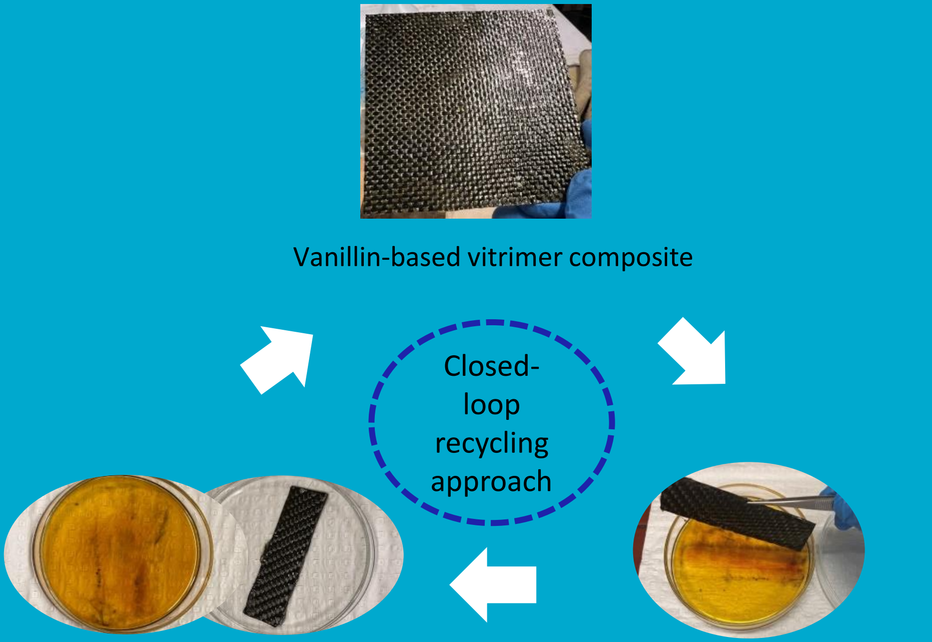
Figure 4: Land-based plastic leakage under different scenarios

The System Change Scenario would achieve about an 80 per cent reduction in annual plastic leakage into the ocean relative to Business-as-Usual, exceeding all other modelled scenarios



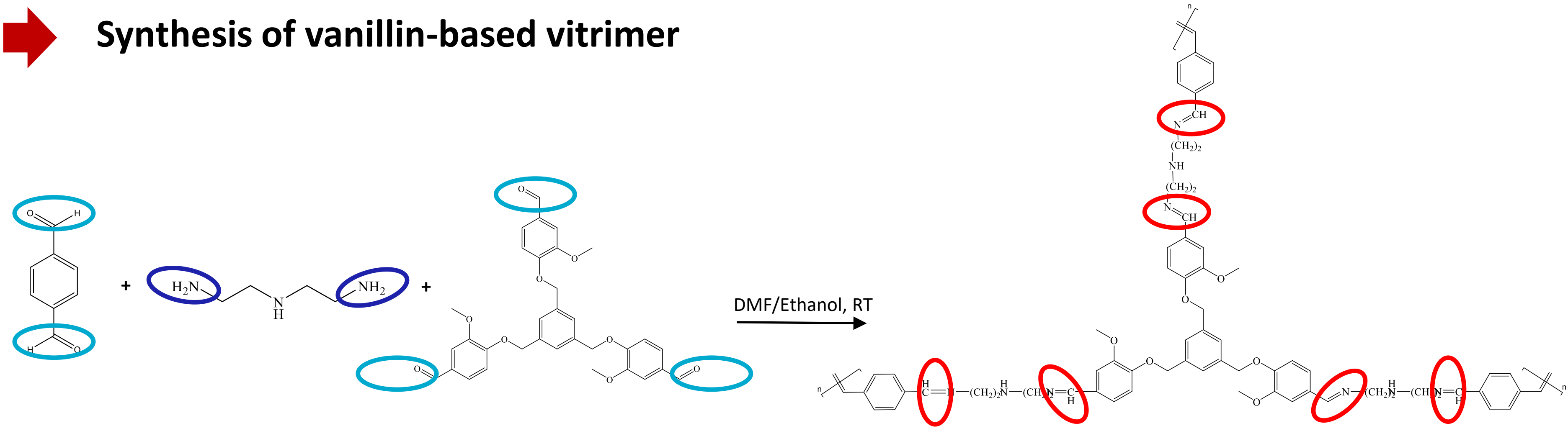
A Biobased and Recyclable Vitrimer for Carbon Fibre-Reinforced Composites

Tuyen Tran (Jane), PhD candidate, tuyentran@swin.edu.au
Department of Mechanical and Product Design Engineering
Supervisors: Prof Bronwyn Fox
Dr Robert Bjekovic
Dr Racim Radjef
Dr Mostafa Nikzad



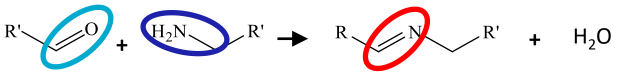
This project is supported by the Global Innovation Linkage (GIL) grant awarded by the Australian Federal Government

Synthesis of vanillin-based vitrimer

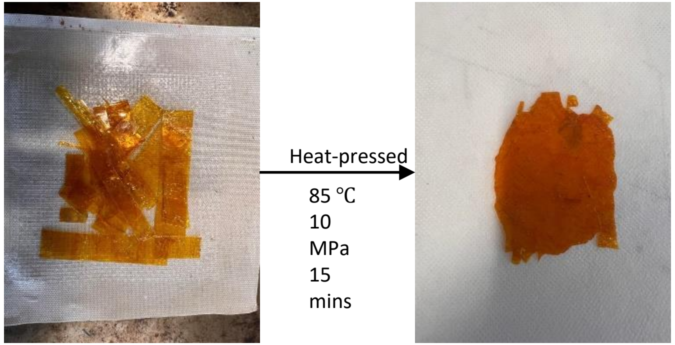


Terephthalaic acid (TPA) **Diethylenetriamine (DETA)** **v-monomer** **v-vitrimer**

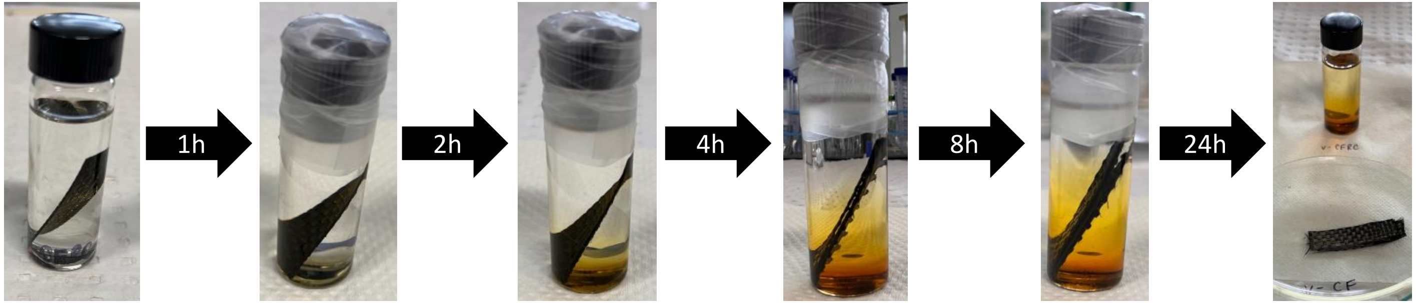
Imine condensation reaction



Re-processability of vanillin-based vitrimer



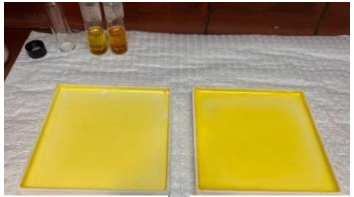
Recyclability of vanillin-based vitrimer composite



CSIRO

SWINBURNE UNIVERSITY OF TECHNOLOGY

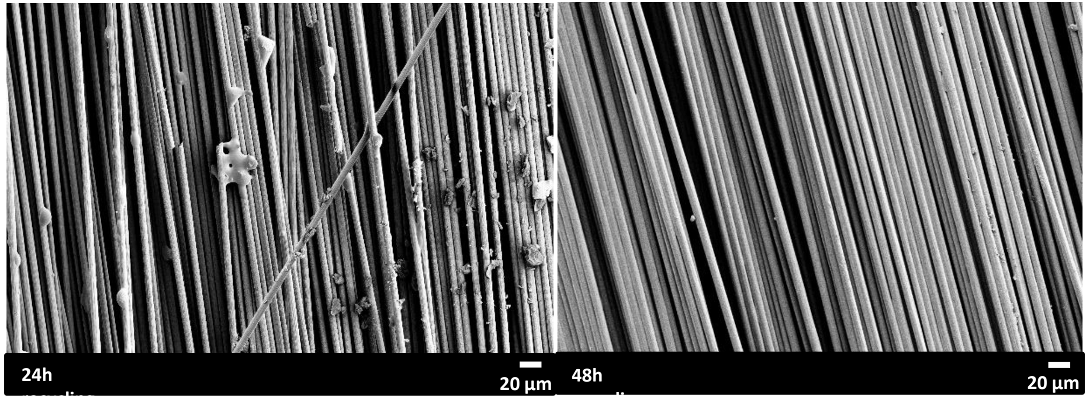
Results – Scanning electron microscopy (SEM) of recovered carbon fibre



Original vitrimer

Recovered vitrimer

SEM




In a fast changing world, we must continue to collaborate across the innovation ecosystem to solve the greatest challenges

Questions?

CSIRO

APPLICATIONS AND USE

VITRIMAX T130 is designed for high-performance, moderate temperature sporting, automotive & industrial applications. **VITRIMAX** T130 has a glass transition temperature of 130 °C, while having the added benefit of full end of life recyclability.

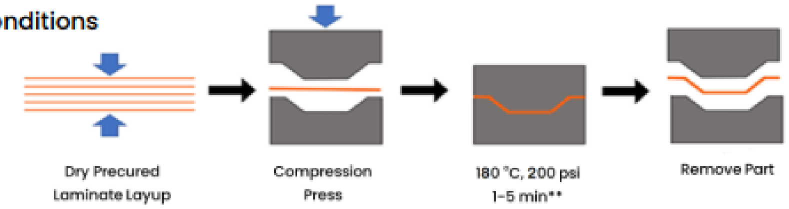
BENEFITS AND FEATURES

- Pre-cured prepreg exhibits indefinite ambient shelf-life
- Rapid and high throughput, out-of-autoclave, compression molding
- Cost competitive
- Complete end-of-life recyclability of resin and fiber
- Tg of 130 °C

CURE AND HANDLING

The suggested oven cure is 150 °C for 1h followed by 180°C for 1 h.

Rapid Heat Mold Conditions



**Dwell time depends upon the number of plies in a laminate:

5 plies: 1 minute (180 °C, 200 psi) / **15 plies**: 3 minutes (180 °C, 200 psi) / **30 plies**: 5 minutes (180 °C, 200 psi)

CSIRO

RESIN PHYSICAL PROPERTIES			
PHYSICAL PROPERTIES	VALUE	UNIT	TEST
Color	yellow to red	-	-
Mix Ratio	2.5:1	imine:epoxy	-
Initial Viscosity at 70 °C	30,000	cP	ASTM D2196
Pot life at 70 °C	90	minutes	-
Cured Resin Density	1.05	g/cm^3	ASTM D792-20
Moisture Uptake	<1	Weight %	ASTM D570
Flexural Strength	135	MPa	ASTM D790
Flexural Modulus	3420	MPa	ASTM D790
Cured Resin Tg	130	°C	ASTM 7028

CURED CARBON FIBER PREPREG PROPERTIES			
PHYSICAL PROPERTIES	VALUE	UNIT	TEST
Fiber	2585-12K	-	-
Weave	Unidirectional	-	-
Fiber Mass	139	g/m^2	-
Nominal Cured Ply Thickness	0.15	mm	-
Nominal Fiber Volume	62	%	-
Fiber Density	0.93	g/cm^3	-
Glass Transition Temperature	130	°C	ASTM D7028
Tensile Strength	250	ksi	ASTM D3039
Tensile Modulus	16.5	msi	
Flexural Strength	123	ksi	ASTM D7264
Flexural Modulus	18	msi	
Compressive Strength	130	ksi	ASTM D3410-16
ILSS	10	Ksi	ASTM D2344

STORAGE AND HANDLING

Shelf Life: Mallinda's **VITRIMAX** T130 resin has a shelf life of 1 year if left unopened. The resin should be stored in dry storage temperature of 5-60 °C.

Disposal of any unused materials should be in accordance with state and federal regulations. **VITRIMAX** T130 offers full end of life recyclability for reuse of all materials.