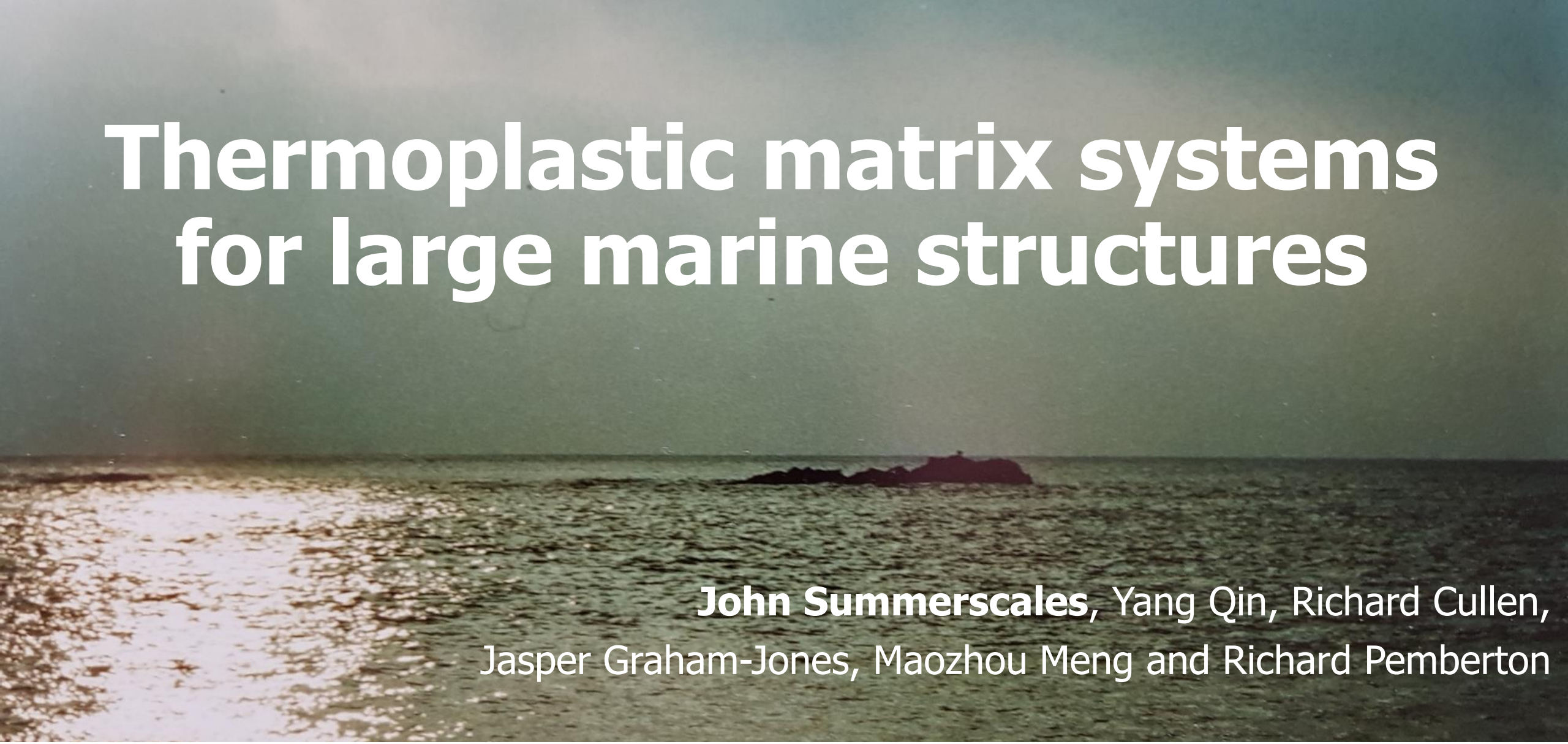
Thermoplastic matrix systems for large marine structures



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Jasper Graham-Jones, Maozhou Meng and Richard Pemberton

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Part of the INTERREG 2Seas program which is part financed by the European Regional Development fund

GOALS

Drive for innovation
in new composite materials

Reduce the environmental impact
of composite maritime industry components

Evaluate durability
and long-term ecological impact from microplastics

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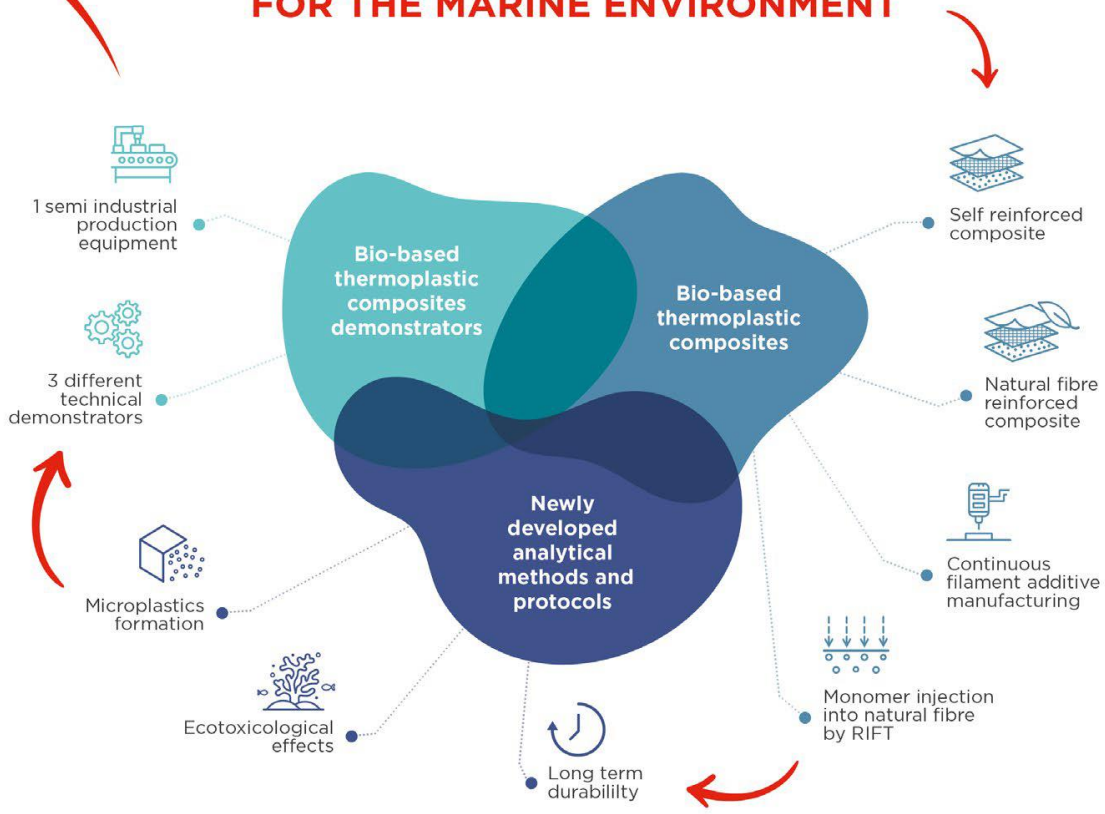
DEVELOPMENT AND DEMONSTRATORS OF DURABLE BIOBASED COMPOSITES FOR THE MARINE ENVIRONMENT



InterReg SeaBioComp project

natural fibres in bio-based thermoplastic

Sign up for the Interest Group to be kept informed of results, events, activities, etc.

http://www.seabiocomp.eu/interest_group/

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Large thermoset composite marine structures

- vessels up to ~75 m overall length
  - Visby stealth corvette, M5 (was Mirabella 5) yacht
- offshore wind turbine blades to 114 m
  - Siemens Gamesa SG 2.1-114

Images from http://www.mirabellayachts.com/mirabella5/
http://www.kockums.se/News/photostock/photosurface.html
https://www.siemensgamesa.com/en-int/products-and-services/onshore/wind-turbine-sg-2-1-114

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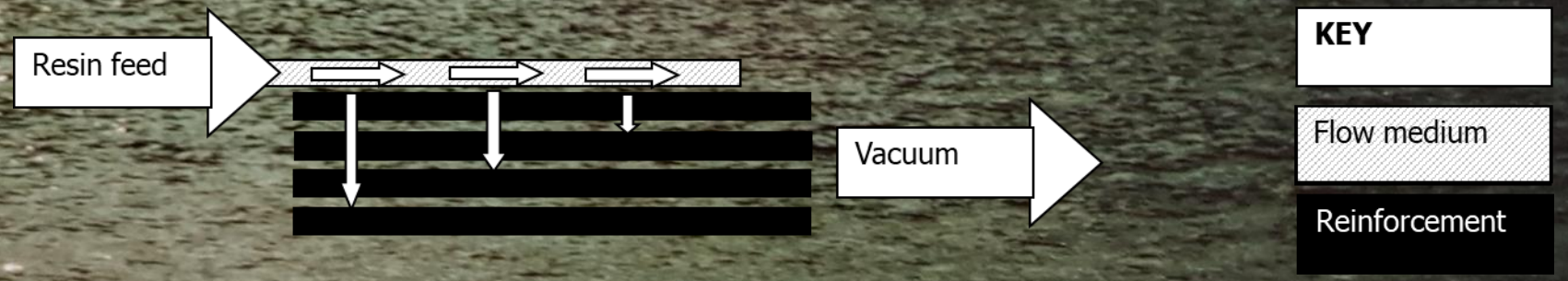
Resin infusion under flexible tooling with a flow medium (RIFT II)

- mould tool and membrane counterface
- long-range flow using a surface flow medium
- ideal viscosities from 200-1000 mPa.s



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Monomer infusion under flexible tooling: (MIFT) = *in situ* polymerisation process

- thermoplastic melt viscosity too high
- monomers are potentially usable
- make polymer during composite manufacture

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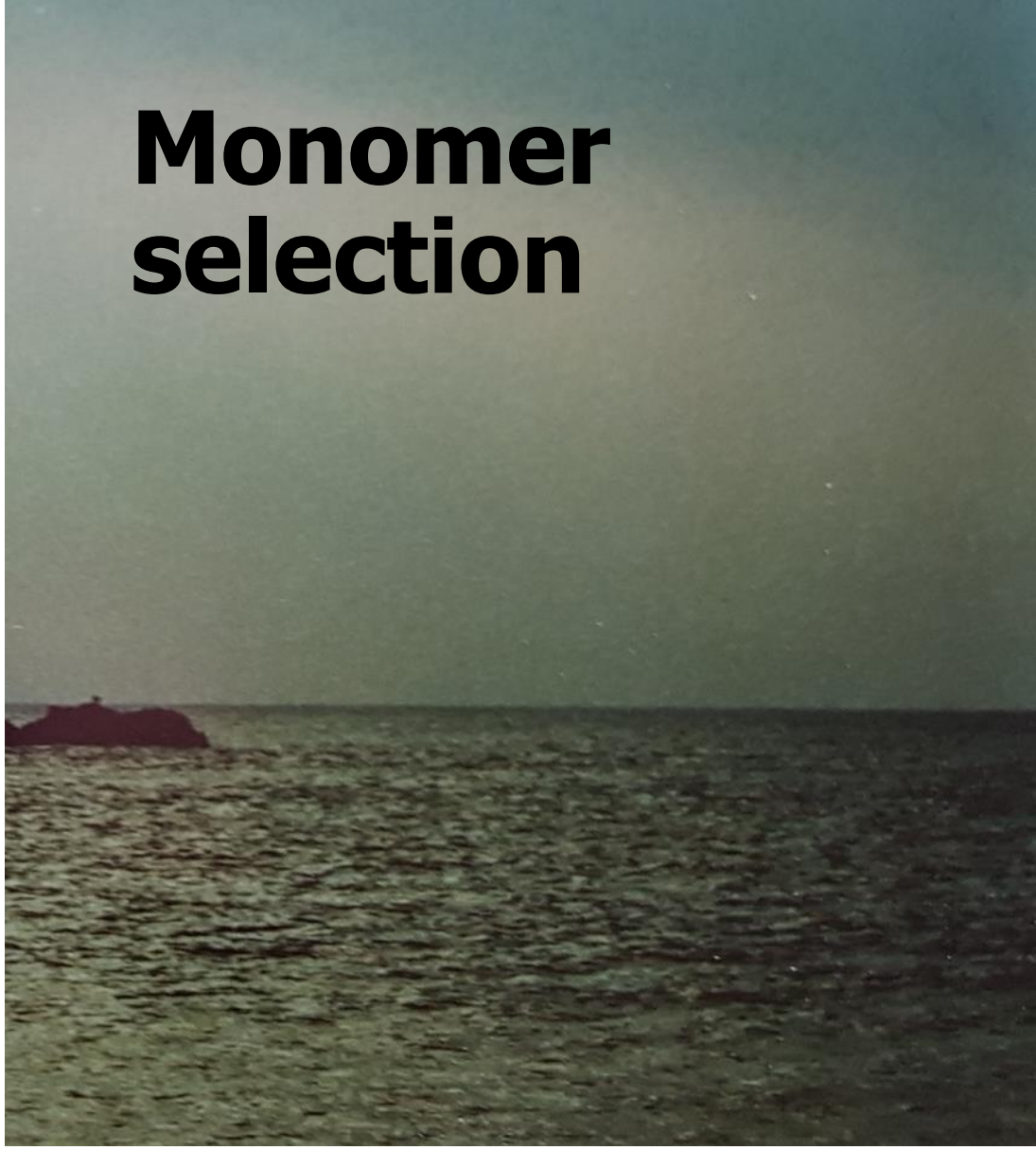
Monomer selection

Essential characteristics	Desirable characteristics
Liquid monomers	Bio-based monomer
YES	YES
Viscosity suitable for infusion (10-1000 mPa.s)	Long process open time for large structures
YES	YES
Process temperature < 200°C: no damage to natural fibre	Sensible cost/kg
YES	YES
Tg > use temperature: for structural applications	Low embodied energy and environmental burdens
YES	YES
Low water uptake: avoid matrix plasticisation	Recyclability
YES	YES

Icons from https://icons8.com/

Sustainable infused marine composites



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Potential systems

- cyclic butylene terephthalate (CBT) oligomers ✗ process temperature
- BPA polycarbonate ✗ process temperature and high viscosity
- lactam to polyamide ✗ wet Tg close to use temperature

- lactide to PLA ✓ meets outline criteria
- MMA to PMMA ✓ meets outline criteria

monomer selection paper under review

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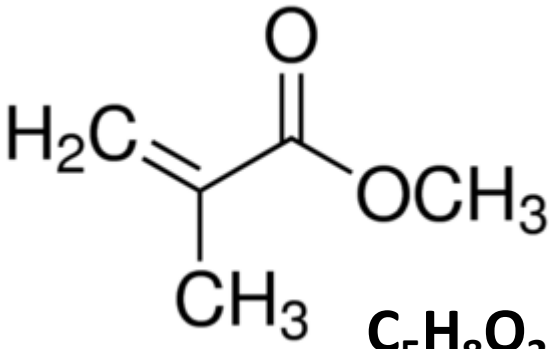
Methyl methacrylate

- addition polymerisation: no co-products
- "drop-in" substitute for resin processing
- bio-based monomer not yet commercially available
- material recovery low in end-of-life hierarchy



$C_5H_8O_2$

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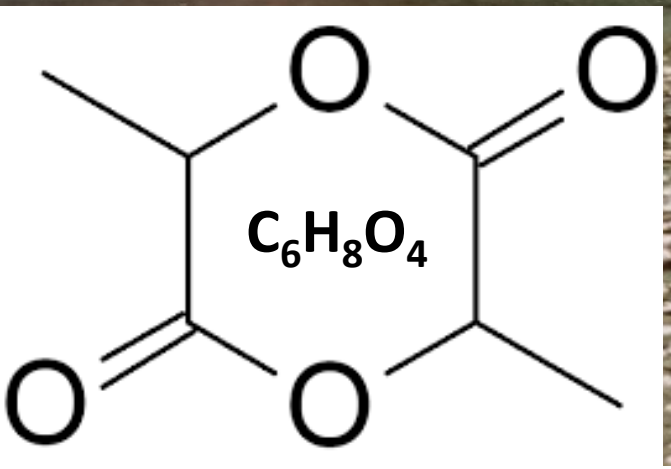
Lactide

- ring-opening polymerisation: no co-products
- high temperature (typically 120-180°C) processing
- bio-based monomer by default
- melt reprocessing high in end-of-life hierarchy



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D 1.4.2	3D mould tool development	Mould	1	28/02/2021	31/05/2021	U Ply	Creation of a 3D mould tool with sensible temperature uniformity.
D 1.4.3	Report about the optimisation of tool design and RIFT process	Report	1	30/06/2021	30/09/2021	U Ply	Report on tooling and process parameters for components fabricated by resin infusion under flexible tooling with a flow medium using in-situ polymerisation of a monomer to produce a thermoplastic matrix composite.

Demonstrator component

- demonstrator component to be decided
- 3D mould tool with sensible temperature uniformity
  - completion deadline 31 May 2021
- optimised tool design and process for MIFT composite component
  - completion deadline 30 September 2021

Open to suggestions:
1 m square by 500 mm high?

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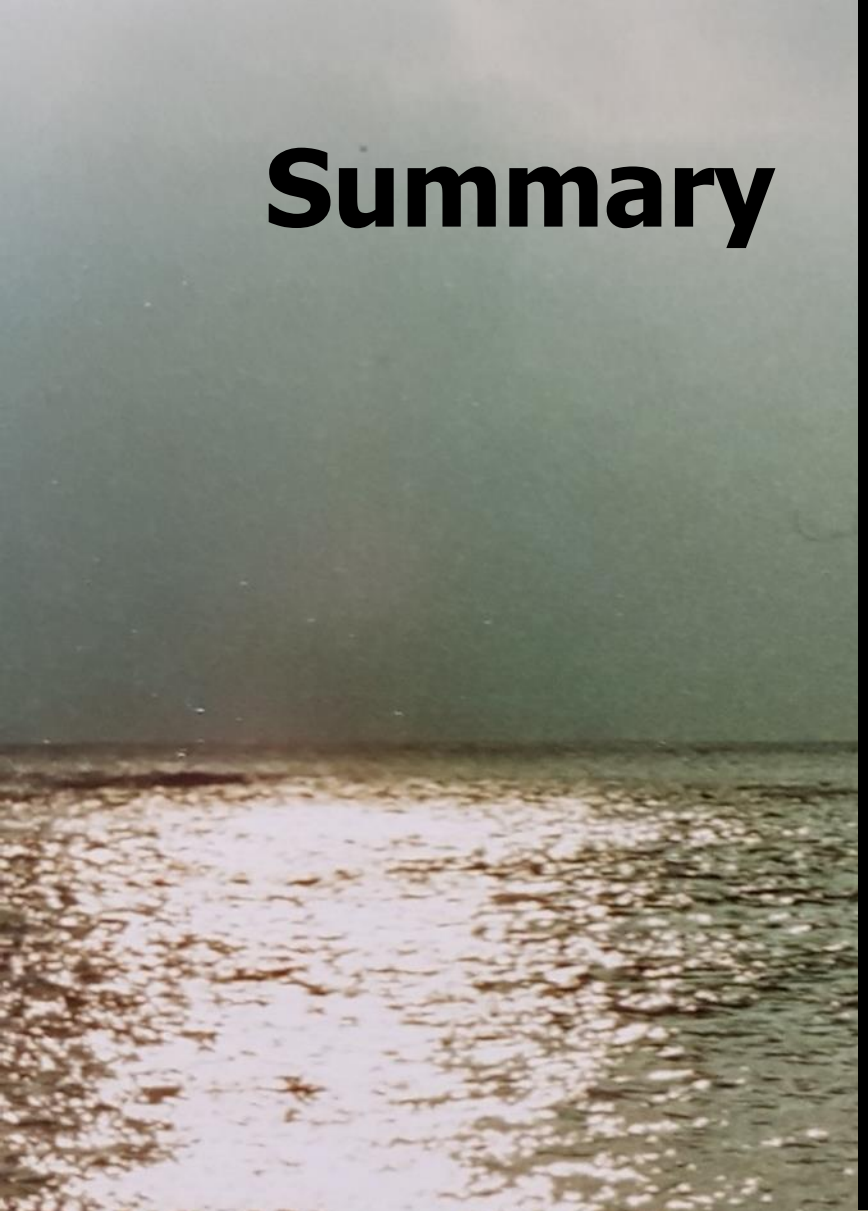

Summary

in situ polymerisation during MIFT for large marine structures

- methyl methacrylate
  "drop in" option/ambient temperature
  - bio-based not yet commercially available
  - lower in the recycling hierarchy

- lactide
  high-temperature process
  - bio-based by default
  - melt reprocessable

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