



# Recycled by Design

Towards recyclable thermosets

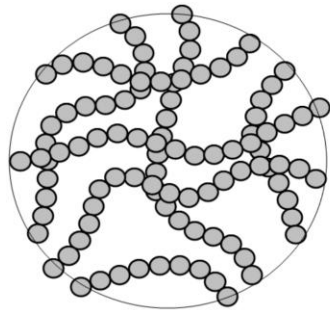


Richard Evans, Melissa Skidmore, Ranya Simons, Susan Holmes, Graeme Moad, Donya Ramimoghadam | Ending Plastic Waste Symposium, 23-24 May 2023

# What is a thermoset polymer?

## Thermoplastics (most plastics)

- Processable because they get soft when heated
- Maybe dissolvable
- Polymer chains are not interconnected.
- Polyethylene, polypropylene, PET, polystyrene.



# Issues in recycling thermosets

## **Tough to recycle**

- Thermal treatment
  - Energy
  - Oils fillers
- Mechanical treatment
  - Fillers
- Bury

- Embedded fibres can have greater value than the thermoset resin itself
- Limited recycling of thermosets occurs

# Making thermosets recyclable

A triggerable weakness needs to be introduced

Typical triggers

thermal

chemical

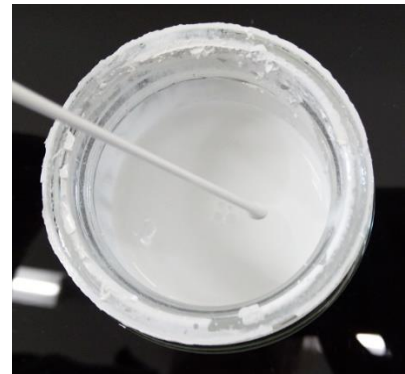


# CSIRO-Dulux Aqueous Enamel Project

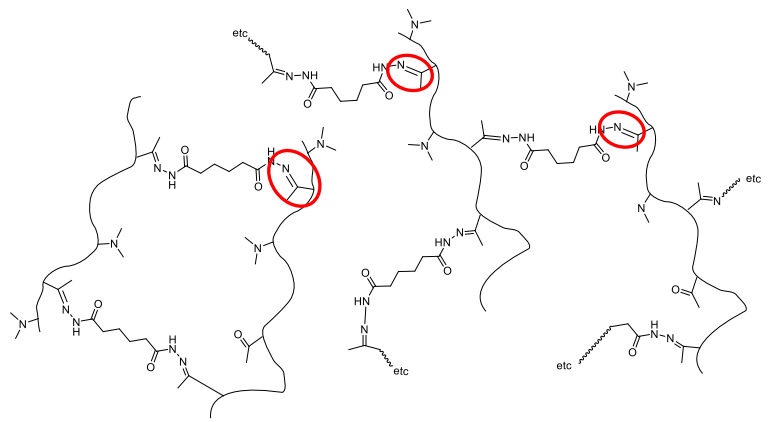



crosslinked cured resin

De-crosslinking  
solution



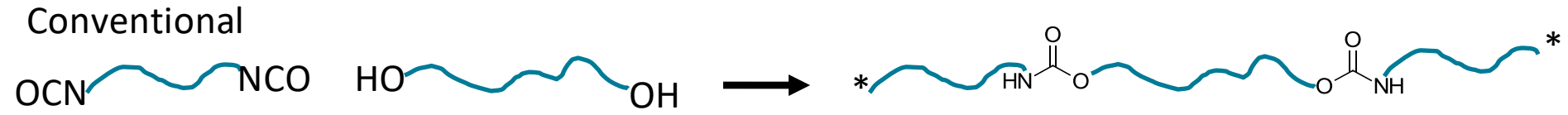
Reconstituted resin  
solution



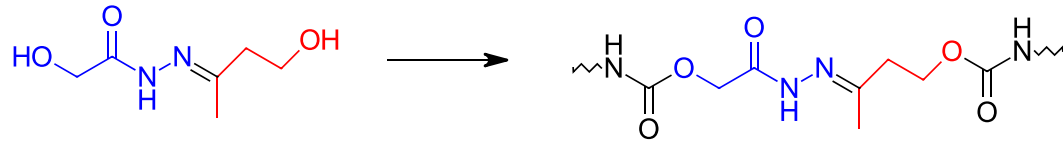
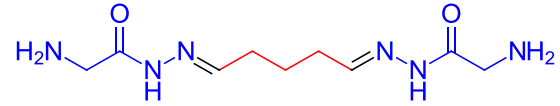
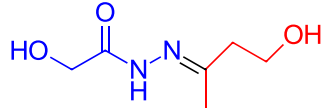
 = dynamic covalent bonds



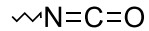
Conventional



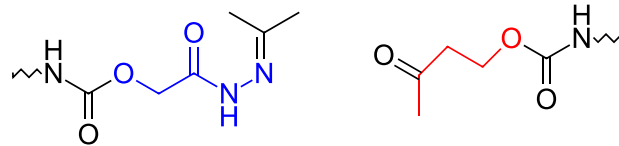
# Dynamic covalent bonds in diols/diamine



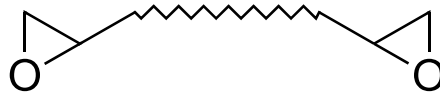
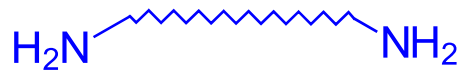
**Polyurethane**



De-crosslinking, **acetone**, solvent **H+** catalyst



# Epoxy resin challenge





# The challenge of thermosets

## Tough to recycle

- High performance
- Long life times
- Frequently Composite materials
- Smaller volumes

## Routes to recyclability

- Introduce a triggerable weakness
  - thermal
  - chemical

# Thank you

