E-waste Grant Project

Finding a solution to the e-waste problem

Why Waste It!

16 February 2022

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Epichem Pty Ltd

Australia's premier provider of synthetic and organic chemistry services

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Who are we

- Australian-based Commercial Chemistry Organisation
- Based in Perth
- Top Australian SME employer of PhD graduates
- 18 years success helping clients worldwide
- NATA Certified ISO 9001, Accredited 17025 & 17034
- National and State Export Award Winner

Experts in

- Medicinal, Synthetic & Organic Chemistry
- Reference Standards
- Custom Synthesis
- Analytical chemistry
- Materials science
- IP generation & protection

ECAAS ISO 9001 CERTIFIED QUALITY MANAGEMENT

NATA ACCREDITED FOR TECHNICAL COMPETENCE

The Situation

- An estimated **67 million tonnes** of waste is generated by Australians alone every year
- We are wasting finite resources by burying them as landfill
- As the population grows, so does the waste problem
- Current solutions to waste recycling are costly & labour-intensive
- In fact, **only 12%** of our waste in Australia is recycled
- We have a smart solution that supports the ideal of a circular waste economy – so not only waste management, but reuse, recycling and responsible manufacture

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Oxidative Hydrothermal Dissolution (OHD)

A novel continuous, hydrothermal process to convert macromolecular organic solids into low molecular weight organic chemicals using only

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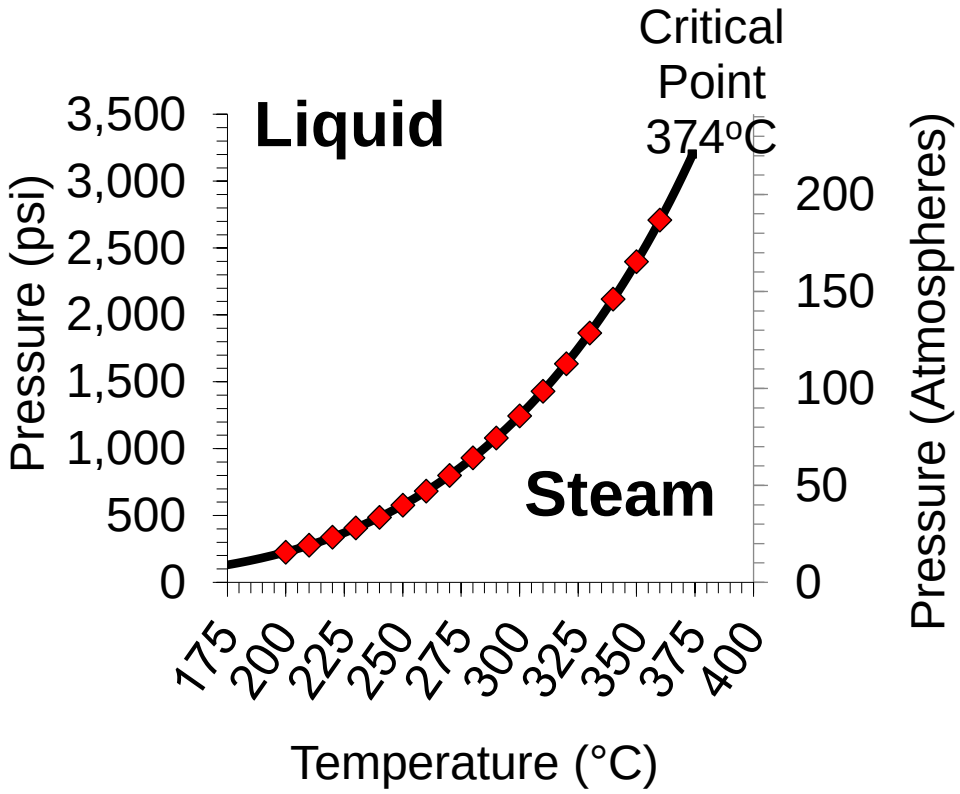
- Elevated temperature [+/- 270 °C]
- High pressure [+/- 2500 psi]
- Liquid water
- Molecular oxygen



OHD Process Advantages

- Technically straightforward & operates at industrially feasible conditions & rates
- Uses only water & oxygen, requires no exotic solvents or catalysts
- Readily achieves high to complete conversion of the starting solid with high recovery (typically 70-90+% C) of the products
- Environmentally friendly
- Produces little to no CO_2
- Minor gaseous product is mainly CO
- Relatively quick conversion rate
- No NO_x or SO_x or other problematic emissions

The Approach

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Build the reactor

- Partner with specialists in building the reactor
- Source parts for the reactor

Validate the reactor

- Test known materials in the OHD reactor such as coal, agricultural plant matter
- Test e-waste fractions
- Adapt reactor conditions to optimise target outcomes

Analyse products obtained from the reactor

- Collate and interpret data retrieved to advise on next steps

Source e-waste

- Obtained through total green recycling

Processing of e-waste

- Establish method to process e-waste to obtain specific particle sized solids

Analyse e-waste fractions

- Assess potential IP to assist on the direction of the study

The Build of OHD Reactor

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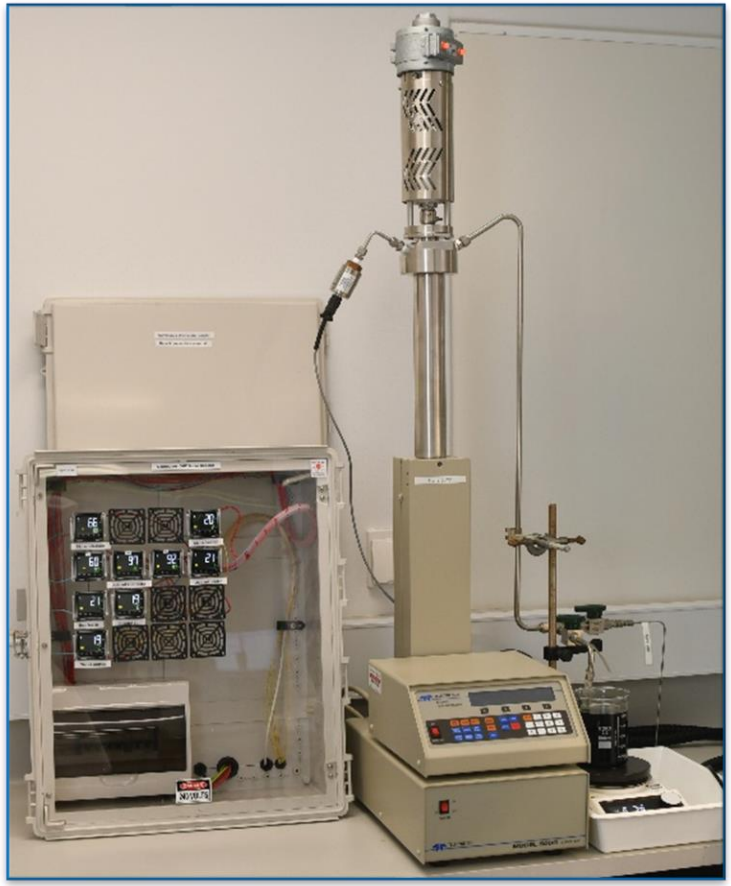
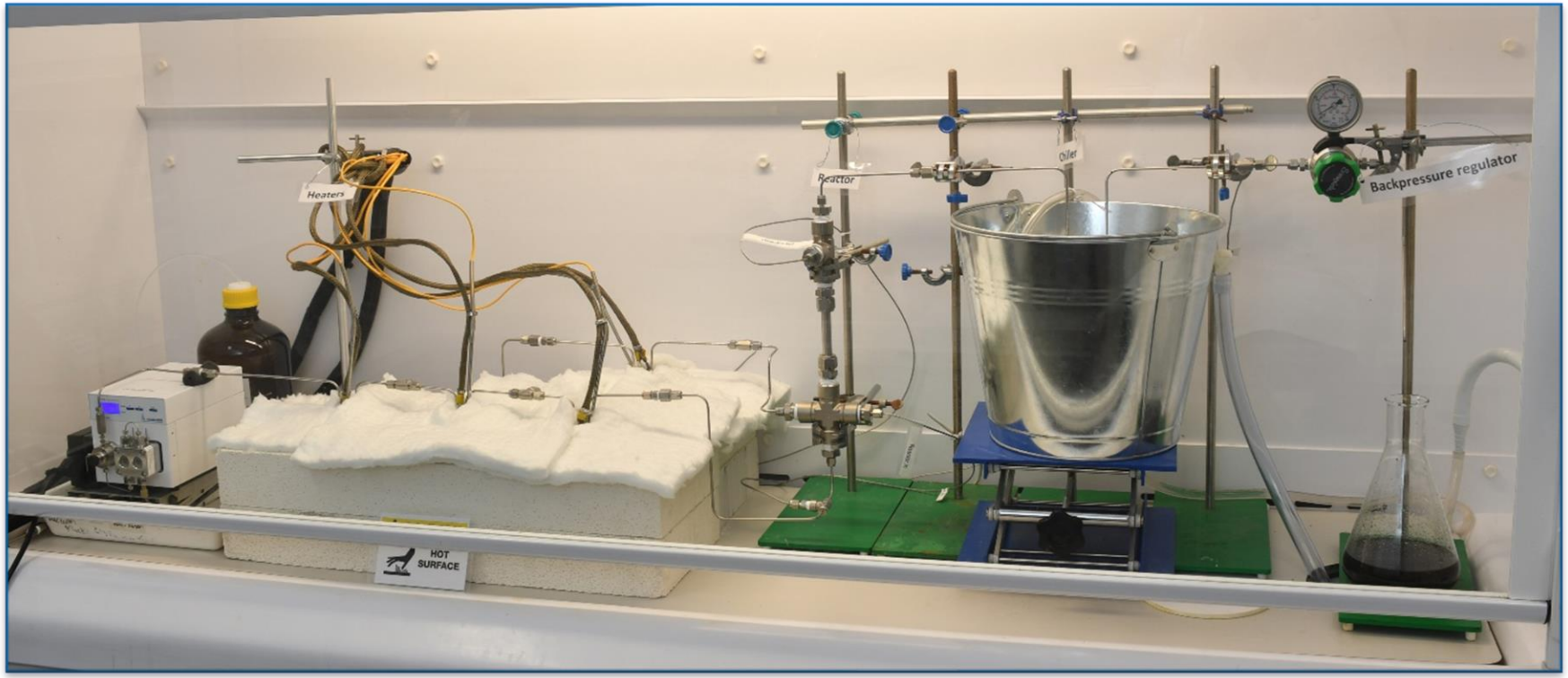
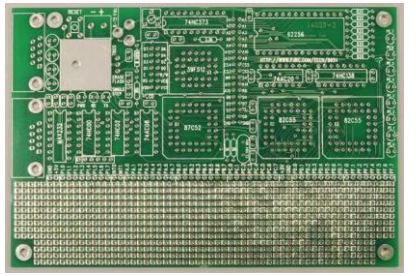




E-Waste Samples Used

- ABS plastic (used in plastic appliance housing material)
- PC Circuit Boards
- Mobile Phones
- PVC/Copper Cables
- Screen 1 Fines (Fines that are collected from physical separation)
- Trommel Fines of e-waste (Fines collected after mechanical treatment)



Initial Findings

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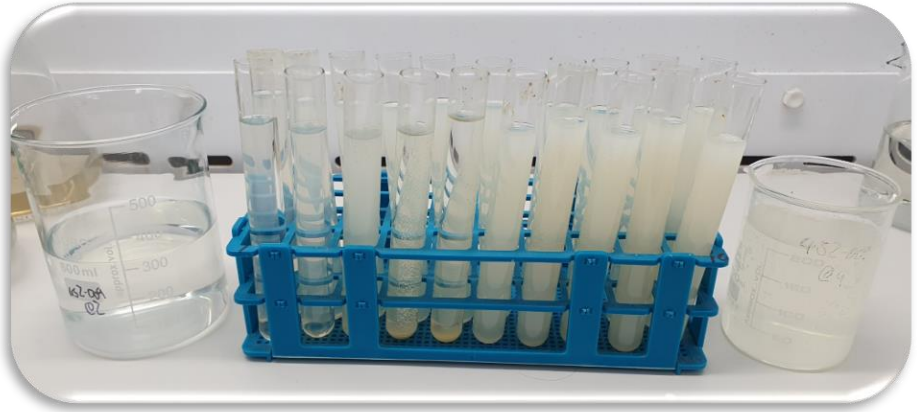
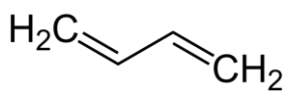
ABS Plastic

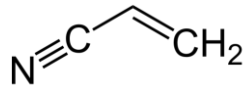
OHD Processing



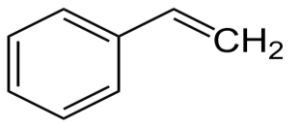
OHD Liquor



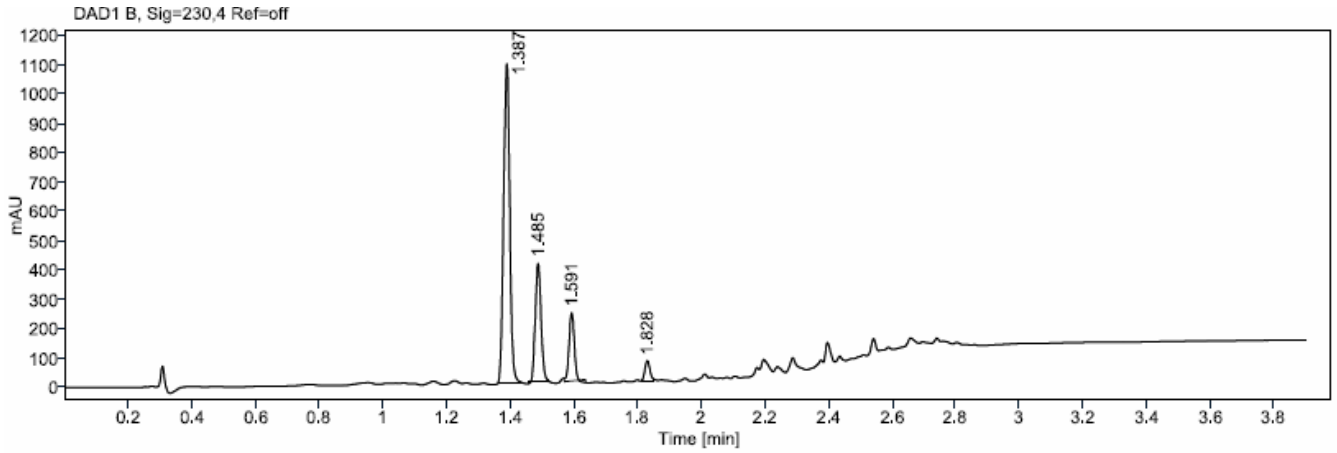
Acrylonitrile



1, 3-**B**utadiene



Styrene



What we confirmed

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- OHD technology successfully processes e-waste samples
- Removes plastics through oxidative dissolution , concentrating the major metals such as gold, tin, copper, iron and zinc
- Minor metals also identified were silver, barium, nickel, chromium, magnesium and manganese
- Converted plastics in the e-waste into small organic molecules which can potentially be used as feedstocks
- Potential Monomers and additives for further plastic and chemical manufacturing
- Conversion of the plastics into small organic molecules gives potential for biodegradability

Next steps…

- Optimise e-waste, scale up & partnering
- Trial more different types of waste from diverse sectors, ie eg:
  - Coal
  - Solar Panels
  - Batteries
  - Textiles
  - Anti-corrosive film
- Optimise the OHD process specific to different waste materials
- Determine OHD processed solids biodegradability via respirometry tests

A final note…
Revenue Generating End User Products

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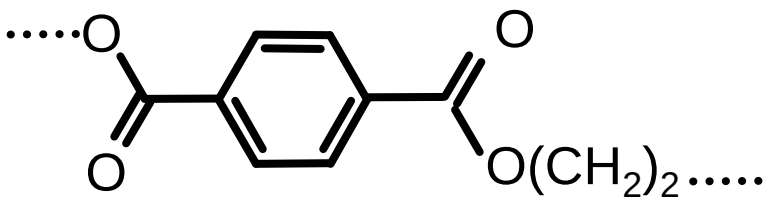
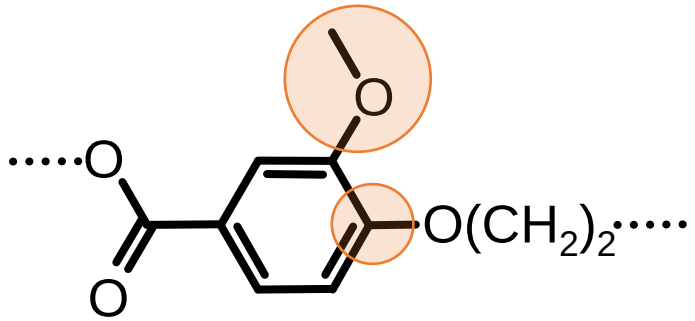
Polyethylene Terephthalate (PET)



- T_g = 67 °C
- T_m = 265 °C
- NOT readily biodegradable

Polyethylene Vanillate (PEV)



- T_g = 55 °C (84 °C)
- T_m = 254 °C (276 °C)

Biodegradable!

Source: Mialon et al., 2011
Lang and Kordsachia, 1981
Hirakawa 2011

Oxidative Hydrothermal Mineral Extraction

Can OHD be used for innovation in minerals processing?

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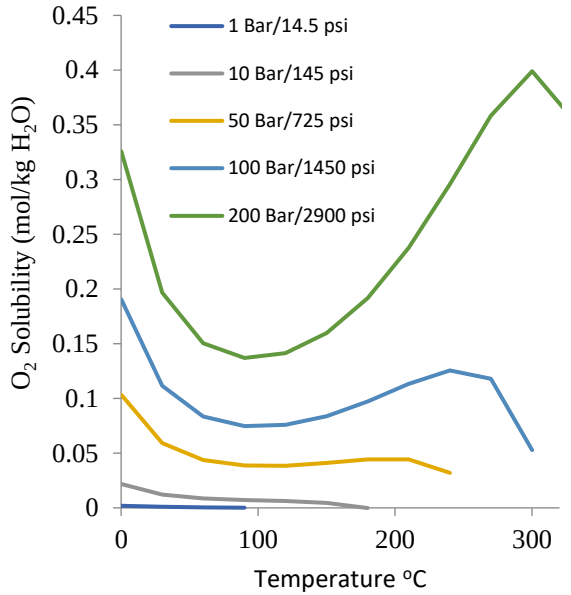
OHD-related mineral extraction concepts to be explored:

- Direct leaching & extraction of mineral ores
- Pre-treatment of refractory ores
- Other recovery or refining processes

Related to high pressure oxidation (HiPOX) & pressure leaching

How does the absence of a gas phase affect oxidative process of minerals?

Oxygen Solubility in Water vs Temperature



Acknowledgements

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Swagelok

GALACTIC SCIENTIFIC

Government of **Western Australia**
Department of **Jobs, Tourism, Science and Innovation**

total green recycling

Thermaquatica

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Additional Slides

Feedstock Processing by OHD

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Feedstocks

Feed slurry

OHD reactor

Oxygen/ water

Raw liquor

Bio-stimulant

Concentration

Separation

Solids

Platform & fine chemicals

Oxygenated fuels

Carbohydrate syrup (cellulosic biomass)

Green renewable chemicals (biomass)

Policy Alignment & Government Incentives

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2020 federal budget

- $250m injection over 4 years into waste & recycling initiatives

2019 national waste policy

- 10% reduction in waste generation per capita by 2030
- 80% average resource recovery rate from all waste streams
- Phase out problematic, unnecessary plastics by 2025

West Australia's waste avoidance & resource recovery strategy for 2030

- Avoid, recover, protect
- 10% reduction in waste generation per capita by 2025
- 70% recovery of material by 2025

Australia's biofuel production 30-year growth target

- Currently lagging biofuel production relative to global average, working to achieve 30-year target
- Launched new bioenergy road map for greener future

Australian Government incentives for renewable energy

- Carbon credits, grants, financial assistance (ARENA[1]) (CEFC[2])

Corporate social responsibility goals

- Australia's big 4 banks have joined RE100 & announced commitment to 100% clean energy by 2025

OHD Flow Reactor
Conversion Potential

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- Plastics into renewable fuels
- Coal into diesel or agricultural biostimulants
- Rubber tyres into liquid fuels/valuable chemical products
- Trees into cellulosic ethanol &/or fine chemicals
- Leftover stock or crops into liquid fuel, cellulosic ethanol & agricultural biostimulants

Scaled up OHD flow reactor designed by Australian scientist Ken Anderson, currently operating in Illinois State University USA

OHD Highlights

Capitalising on policies at national, state & local government levels towards zero organic waste to landfill

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Proof of Concept

- Coal
- Lignocellulosic biomass (ie plant matter)
- E-waste

External Outcomes

- Removal of organic waste
- Conversion of organic waste to valuable end-user products, fine chemicals & critical metals
- Reduce landfill
- Convert liabilities into assets

Internal Outcomes

- Validation of inorganic processing
- E-waste conversion
- IP generation/patent protection
- Very broad Biomass/Feedstock License Field
- Territory includes Australia, New Zealand, Singapore, Hong Kong, South Korea & Taiwan

Chemistry expertise in collaboration & partnership with energy, agriculture, mining, oil & gas & waste sectors