Green Materials and Recycling End-of-Life Polymers in Steelmaking – An example of successful translation of research into industry

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Presentation Outline

• Challenges of conventional recycling of waste materials
• Rethinking waste – Science associated with transforming waste into value-added materials
• Address challenges by creating new opportunities
Glass Waste (Automotive Windscreen)
Reaction @ 1550 °C

Ferrosilicon alloy
Automotive Waste
End-of-life Products
E-Waste
Polymer Recycling Statistics (Australia)

Total plastics recycled:
- 12.6% - 2004
- 15.7% - 2005
- 15.9% - 2006
- 15.3% - 2007
- 18.5% - 2008
- 20.7% - 2009-2010

2010 National Plastics Recycling Survey, Australia
Global Production of PC

2000 = 1,679,341 T
2010 = 3,411,589 T
2020 ~ 6,090,999 T (Proposed)

Year 2005 – 6000 billion Waste CD/DVD ~ 5800 Tons of PC

*Global polycarbonate production volume 2006: approx. 2.9 million tons*

Bottles & Packaging 3%
Medical & Healthcare 3%
Construction 13%
Others 2%
Blends**15%
Optical Media 32%
Automotive 9%
Electrical & Electronics 23%
Molecular Formula: \((C_{16}H_{14}O_3)_n\)

- C: 75.5 %
- H: 5.5 %
- O: 19 %
XRD patterns displaying peak intensities of 100% (a) coke (b) HDPE (c) end-of-life rubber (d) PET plastics (e) Bakelite and (f) Polycarbonate
Need for Innovation

• Traditional recycling focuses on reusing materials in their original form – glass into glass, steel into steel.

• This model doesn’t work with more complex materials
• The traditional 3 R’s – Reduce, Reuse, Recycle – cannot cope with the complexity and volume of waste generated

• Need to reimagine and innovate in our approach to waste management

• Waste to value
Why Reform?

• There is no easy way to recycle complex materials simply into their original form

• Challenge of separating different materials

• Importance of looking at materials in terms of their elements
Rethinking waste

- We can begin to solve the challenge of complex or mixed waste if we think differently; that is if we begin to look at them not as familiar materials like glass and plastics but if we look deeper and ask ourselves what if we consider them as resources of elements, through innovation.
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Industry and Research partnerships

Recycling and renewable materials

New Sustainable Processes

Sustainability of materials processes

Sustainable Manufacturing

Research Focus: Cutting edge sustainable materials & processes
Emphasis: Environmental, industrial & community benefits
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• Knowledge, research outcomes and industry partnerships have enabled development of fundamental and applied science leading to technological advances in industry

• Human capital development
Partnerships

• Industry and academic partnerships have a significant influence on enhancing and promoting innovation

• Research and development plays a large role in fostering these connections, facilitating innovation and developing technology
Partnerships

• Innovation and technological development has the potential to improve practices, business, and people’s lives

• Moving from ideas to impact – transforming innovation into technology

• Creating new opportunities
  eg. Exporting innovative solutions
High Temperature Processing of Polymers

- Reactions of polymers known up to ~1000°C
- Higher temperatures of steelmaking: Reactions of polymers need to be understood for steelmaking applications

Behaviour of polymers at high temperatures
Structural transformations of Polycarbonate (PC) waste

Lc Value*  –  Coke : 1.5 nm
              Synthetic Graphite : 17.2 nm

Reference
Gas chromatographs showing the gases produced from the different blank substrates of a) coke, b) Rubber and c) HDPE after 1 minute at 1550°C

Glass In Automobile

Windshield

Window Glass
High temperature slag foaming facility

Schematic of the experimental arrangement

Steel Rod, Alumina Tube, Slag sample, Carbon Substrate, Alumina Holder, Cold zone, Hot zone, Gas Tray, Gas Outlet, Gas Inlet, Sample Tray, Quartz window, Thermocouple, CCD, DVD Recorder, Television.
Snapshots of slag droplets in contact with 100% MC, HDPE blend, rubber blend, and PET blend at 1550 °C as a function of time.
Visualization of high temperature reactions

Coke
Volume ratio measurements
HDPE vs. 100% Conventional coke
Rubber
Volume ratio measurements
Rubber blend vs. 100% Conventional coke

![Graph showing volume ratio measurements for different blends over time. The graph includes lines for 100% MC, MC-HDPE Blend, MC_HDPE Blend, 100% MC, and Palm Shell. The x-axis represents time in seconds, and the y-axis represents volume ratio, $V_t/V_0$. Different blends show distinct patterns over the time period.]
Polymer Injection Technology
a “Win-Win”

Industrial implementations at OneSteel in Australia indicate that the Polymer Injection technology will:

Reduce coke and electricity consumption

This technology is environmentally sustainable
Industrial implementation at OneSteel – a success story
### SSM Summary

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<th>Carbon (kg/heat)</th>
<th>FeO</th>
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<td>HDPE</td>
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### LSM Summary

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<td>Rubber</td>
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"Environmentally Sustainable EAF Steelmaking Through Introduction of Recycled Plastics and Tires: Laboratory and Plant Studies" Iron and Steel Tech magazine, April 2009, vol 6, no 43
Conclusions

Green Materials

• We need to consider the introduction of a 4\textsuperscript{th} R, which is REFORM.

• Reduce, Reuse, Recycle, Reform

• Materials processing including use of waste materials as a resource, through innovative thinking, will enhance sustainability and produce value-added green materials.
Conclusions

• New opportunities through recycling science are possible for industry.

• Complex wastes could be transformed into raw material resources.

• This could lead to environmental and economic benefits.