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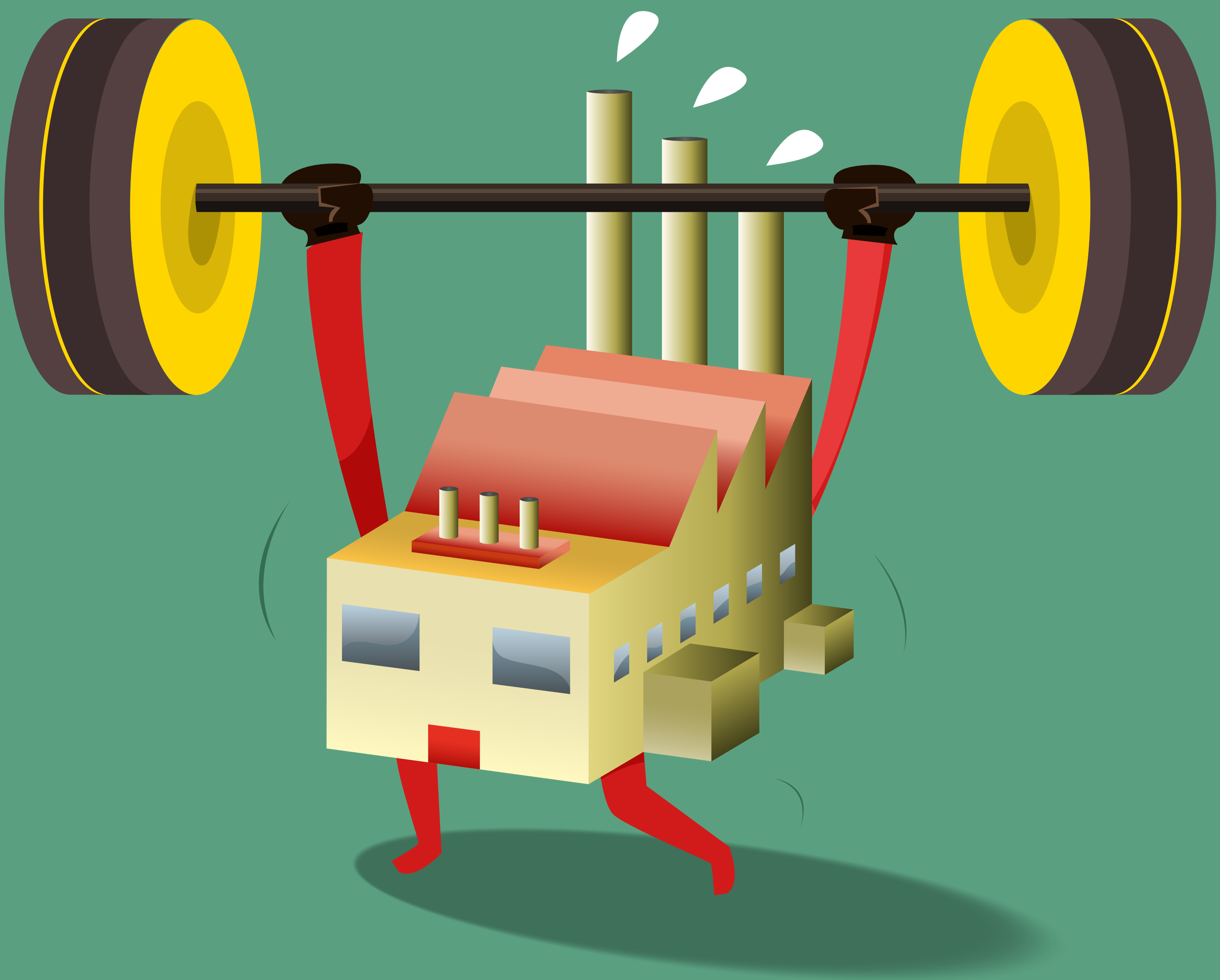

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Closing the loop, adding value

Johan Verbeek describes an innovation which uses waste blood from meat processing to create a valuable bio-based plastic

PLASTIC products are ubiquitous in almost every industry and have been designed to be robust and durable. This, unfortunately, is also their greatest curse, in that they take a very long time to degrade in the environment unless designed to biodegrade.

As such, plastic products form a significant part of the waste disposal problem, representing up to 8% of the solid waste stream in my home city of Auckland and many governments, including New Zealand, have now implemented waste strategies to mitigate the problem. In 2010 the New Zealand government replaced its overly-ambitious previous target of zero waste by 2020 with the *2010 Waste Strategy document*. The newer strategy contains two main goals for businesses and local government: to reduce the harmful effects of waste, and to improve use of resources, particularly where economic benefits can be found. Adding value to co-products is a key theme of wider government strategy, and it has demonstrated that it means business by setting the food industry an ambitious target to double the value of today's food exports to NZ$120bn (US$94bn) by 2025.

The meat processing industry in New Zealand is vast, and generates huge amounts of waste. Here we look at an innovative method which adds value to some of that waste by converting blood from abattoirs into plastics for use as biodegradable plant pots, growbags, and equipment for the meat processing industry.

The number of animals being slaughtered worldwide per year is staggering – approximately 292m calves and cows, 515m sheep, 345m goats and 1,244m pigs.

one man's meat

Producing meat generates an enormous volume of waste from animal carcasses, for example intestines and blood. The number of animals being slaughtered worldwide per year is staggering – approximately 292m calves and cows, 515m sheep, 345m goats and 1,244m pigs.

Animal byproducts can represent up to 75% of an animal's live weight. If the biological waste from meat processing is not properly treated it could lead to serious environmental problems as these have a very large biological oxygen demand, requiring costly wastewater treatment systems.

The industry recognised this problem early on and now processes the waste by rendering it into co-products. Rendering is the process where the leftover carcasses and viscera are processed and separated into usable products. Most important of these are tallow, meat-and-bone meal, leather, and blood meal. During rending the waste products are minced, cooked and separated in what can only be described as a very impressive process engineering operation. These by-products are, ironically, almost just as valuable as the main products from meat processing.

During the slaughtering process, meat quality is preserved by sealing the intestinal track: a clip is used to seal the killed animal's wind pipe (or weasand) and a plug for the anus. Strangeness aside, this step is vital, because if the contents of the intestines were accidentally spilled over freshly-exposed meat, those parts would have to be removed and could not be sold.

Meat processors rely on these clips and plugs to be effective and very reliable during processing and a variety of designs are currently on the market, mostly produced from robust petrochemical polymers. The down side is that removing them from the animal prior to rendering costs time and therefore money. In addition, if the plastic

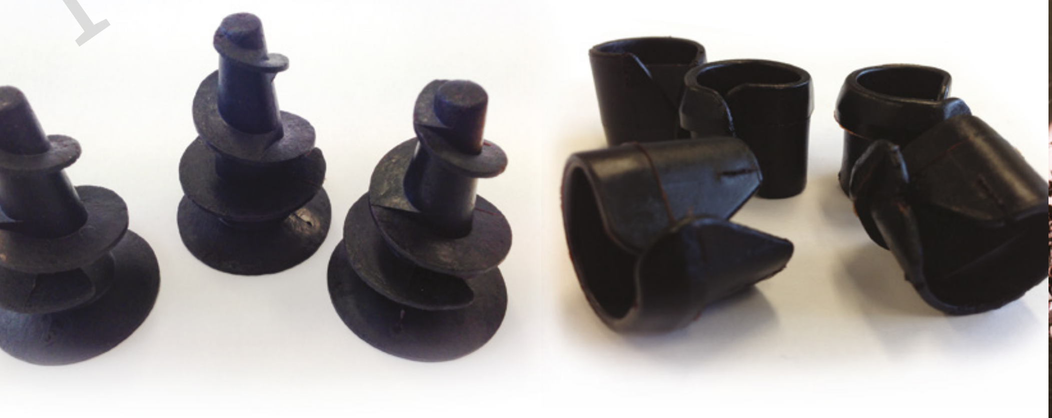
Having plastic clips and plugs made from a material that could also be processed as part of rendering would save costs for meat processors and renderers.

products are not removed prior to processing they can end up in meat and bone meal, thereby degrading its quality. Often meat and bone meal is used as animal feed or as additive for pet food. It should go without saying that you don't want to have pieces of plastic tainting these products.

plastic, but nicer

Having plastic clips and plugs made from a material that could also be processed as part of rendering would save cost for meat processors and renderers as it would reduce labour cost associated with removal of these products nor would it compromise the renderer's products.

Step forward Novatein – a thermoplastic polymer made from blood meal. Blood meal is mostly protein, which in its simplest form is a polymer.



(Left to right): The 'Port Jackson' rectal plug for sheep processing from Bestaxx Innovation; Weasand clip made from Novatein; Novatein granules.

(Left to right): Other products produced from Novatein – plantpots and weed mat pegs.

Aduro Biopolymers continues to... develop a range of bio-derived polymers and materials for use in plastics, composites, agriculture and horticulture, manufacturing and construction sectors.

Considering the number of calves and cows slaughtered per year and that an average cow would contain about 40 l of raw blood, the total worldwide blood meal production from cattle would be about 2m t/y. If all of this were turned into plastic, about 3m t of plastic can be produced – not counting blood meal from non-bovine sources. Although this number is dwarfed by the 280m t of petrochemical plastics, the niche market this represents cannot be overlooked.

Thermoplastic polymers (ie plastics) can be extruded and injection moulded by softening followed by shaping and cooling. They are polymers that soften when heated and flow when pressure or shear is applied. In everyday plastics, this is relatively easy as bonds between polymer chains are easily broken. However, in protein-based materials this is not as easy, as their structures feature a wide range of chemical interactions such as hydrophobic interactions, hydrogen bonding and covalent cross-linking. Cross-linking is especially severe in blood meal, so converting it into a thermoplastic material was an enormous challenge.

The science behind Novatein originated in 2007 and continues to be developed by the School of Engineering at the University of Waikato. A process was designed whereby blood meal can be converted into a thermoplastic polymer using a selection of additives, water and plasticisers. The granules can then be manufactured into injection-moulded or extruded products using industry standard equipment. At the time, all that was missing was a specific product to start the ball rolling with our thermoplastic.

Commercialising started in 2008 when Waikatolink (the technology transfer office of the university) identified the commercial potential of the material, which now has patents in several countries.

Between 2008 and 2012, research focussed on understanding the technical challenges inherent to the material. Even though it was shown that it is possible to make a plastic product from blood meal, very little was known about why and how it works. In the five years following the initial discovery, more than 35 researchers explored different aspects. As a result, we now understand that a protein-based thermoplastic in many respects resembles that of a semi-crystalline material but also with some distinct differences. A semi-crystalline polymer will melt when heated whereas a pure amorphous material will simply soften. Novatein resembles the semi-crystalline structure of regular thermoplastics, but only softens like an amorphous polymer. This posed some difficulties for processing, mostly relating to mould cooling and ultimately its mechanical properties.

the lightbulb moment

One of the greatest obstacles during this period was a lack of funding. In the absence of a specific product we saw technical progress slow down. Commercial interest was promising, but product manufacturers could not see an immediate need for a biodegradable product with these properties. In 2011, the Meat and Live Stock Association Australia (MLA) funded a project to identify a suitable product, optimise material properties for it and to partner with a suitable meat processing company to commercialise resin production. This was the first significant funding after the initial seed funding. At the same time, a strong relationship also developed with a local rendering company in the Waikato region which led to the formation of a new partnership (Aduro Biopolymers) to produce and sell Novatein.

Partly as a result of this partnership, the opportunity to produce a renderable weasand clip or rectal plug was also identified. Identifying these products was pivotal to the growth of Aduro Biopolymers and quickly led to new partnerships and product development, focussing on developing innovative bio-based plastic products (which could be rendered) for meat processors.

Today, Aduro Biopolymers continues to work with the University of Waikato and other commercial partners in New Zealand and Australia to develop a range of bio-derived polymers and materials for use in plastics, composites, agriculture and horticulture, manufacturing and construction sectors.

loop closed

What is so elegant about this application is that the starting material required for this product is obtained during meat processing, used during meat processing, and is disposed of in a similar process that would make it, ie rendering. And for those that take more notice of the maths, in this case the plastic produced from blood meal would be more than twice as valuable as the starting material. **tce**

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Chemical Engineering Matters

The topics discussed in this article refer to the following lines on the vistas of IChemE's technical strategy document *Chemical Engineering Matters*:

- Energy *Lines 1, 19*
- Food and nutrition *Lines 1, 12, 13*
- Health and wellbeing *Lines 1–2, 6–7, 18–19*

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