

Starboard™: No Added Formaldehyde Alternative to MDF Derived from Starch

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Starboard™: Overview

- Aim
- Thermoplastic vs. thermoset adhesives
- Thermoplastic starch as an adhesive
- Initial laboratory studies
- Scale up and optimisation

Aim:

- Develop a drop in technology for point of sale applications
- Uses starch as a binder

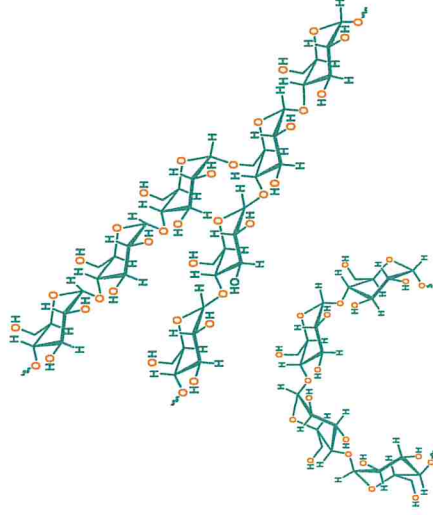


Thermoplastic vs Thermoset Adhesives

- Polymer technology typically exploited to act as adhesives. Common examples: urea-formaldehyde-based (eg. UF, mUF) and isocyanate-based (eg. pMDI)
- Typically synthetic polymers are used. Non-trivial synthetic routes. Toxic precursors
- A thermoset polymer resin cannot be released upon application of heat
- A thermoplastic can be cycled through heating and cooling

Starch as an Adhesive

- Starch – naturally occurring biopolymer
- Consists of glucose units joined by glycosidic linkages
- Biodegradable, renewable feedstock
- Pre-formed polymer! No need for polymerisation reaction to occur



Structure of amylopectin (top), amylose (bottom).



Thermoplastic Starch

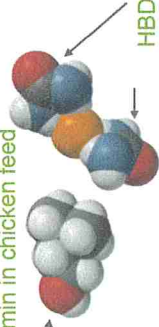
- Well known starch can be plasticised to make a thermoplastic material
- Novel plasticisers based on salts have been developed – *Deep Eutectic Solvents*



Deep Eutectic Solvents

- Mixtures of salts and Hydrogen Bond Donors
- Most components are **INEXPENSIVE** (c.a. £1/kg), Non-toxic, Non-flammable, Biodegradable, Versatile (>10⁵ liquids)

Salt eg: Choline chloride – A vitamin in chicken feed



- HO₂C-R₁ Acids
- H₂N-C=O-R₂ Amides
- HO-R₃ Alcohols

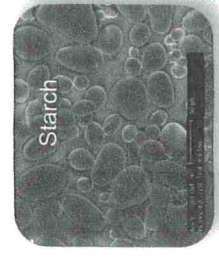
HBD eg: Urea – A common fertiliser

Abbott et al. JACS 2004, 126, 9142
Smith et al. Chem. Rev. 2014, 114, 11060



Thermoplastic Starch (TPS)

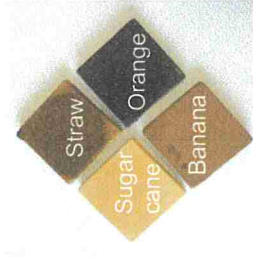
- Above approx. 70°C material starts to gel
 - Starch granules burst and gelation begins.
 - Forms strongly interacting macromolecular structure.
 - 1:1 ratio of starch: modifier is heated under pressure and forms a solid.



Thermoplastic Starch Composites

- TPS – based composite materials include:

- TPS: Eggshell



- TPS: Wood



Thermoplastic Wood - Starboard™

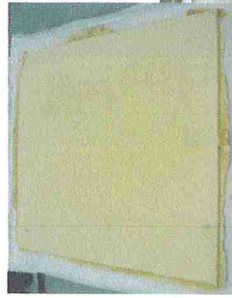
- Thermoplastic nature of the adhesive means it can be recycled
- The product is called Starboard™



Starch-based thermoplastic wood after forming (left), after grinding (centre) and then after reforming (right). This shows that it can be effectively recycled.

Scale up of Starboard™ Manufacture

- 200 kg TPS readily achievable
- 1,000 x 1,000 x 15 mm boards produced

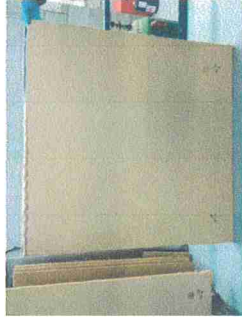


Validation Testing

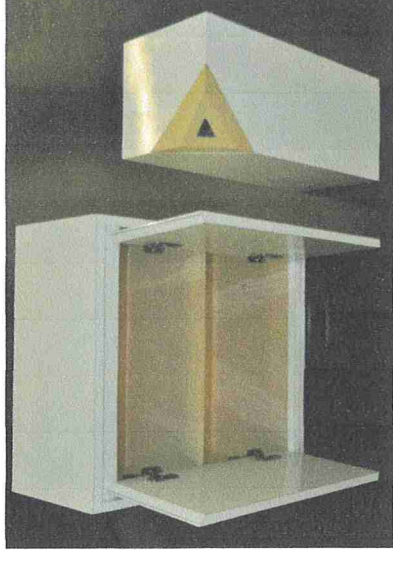
- Starboard™ exhibits (press times 9 min/230 °C, TPS content approx 1kg per kg wood):
- Internal Bond (EN319): 0.58 N/mm²
- Total Emitted Formaldehyde (EN120): 0.1 mg/100g board
- Density: 715 kg/m³
- Screw Hold (face): 1,419 N
- 24 hour swell: 46.00 %
- Need to reduce TPS content and press times
- Incorporation of waxes to reduce moisture uptake and further increase strength
- Expected to reduce impact of moisture

Process Optimisation

- TPS adhesive – viscosity approx. 300 cP
- c.a. 200 g wet resin loading per 1 kg wood
- TPS adhesive cost < £0.2/kg
- Press times of 2.5 – 10 min achievable
- Onset temp of TPS adhesive approx. 100 °C
- Testing on these boards underway



Demonstration Cabinets made from Starboard™



Point of Sale Unit made from Starboard™



Conclusions

- Inexpensive, no-added formaldehyde adhesive technology has been developed
- Scale-up and optimisation of resin manufacture has been realised
- Scale-up and optimisation of board manufacturing process currently underway
- For POS application Starboard™ behaves just like conventional MDF

Acknowledgements



THE ROYAL
SOCIETY

Brian Mercer Award for Innovation



BioComposites Centre
Innovation in biomaterials for industry

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EPSRC

Pioneering research
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