



Vitolane™ Technology

A Novel Process Route for Silsesquioxanes

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World Centre for Materials Joining Technology



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Vitolane[®] Technology

- Introduction to TWI
- Silsesquioxanes
- Addressing the Market Need





Vitolane™ Technology

Introduction to TWI



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TWI

World centre for materials joining,
surfacing and related technologies

www.twi.co.uk



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TWI in 2007

- Research & Technology Organisation (RTO)
- 60 year track record
- 570 staff
- £36M turnover
- Membership based
- 3500 Members
- Benefits to industry
 - improved efficiency
 - reduced costs
 - improved reliability
 - new products
 - innovation
- Professional Engineering Institute



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TWI Benefits Industry Through:

- Creating opportunities and solving problems through funded projects
- Providing licences to use patented technology
- Dissemination of fundamental and applied research



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Licensed Technology - Example 1

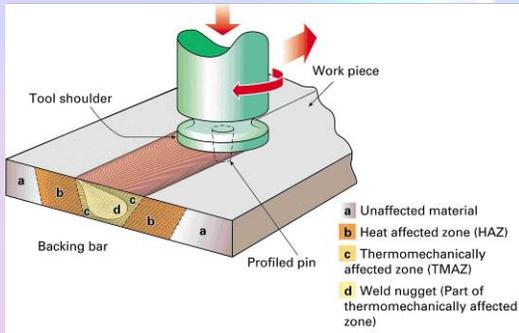


- Global sole licence issued to Gentex Corp
- Number of applications in use worldwide
- Key markets include medical, textile and consumer goods



Licensed Technology - Example 2

Friction Stir Welding



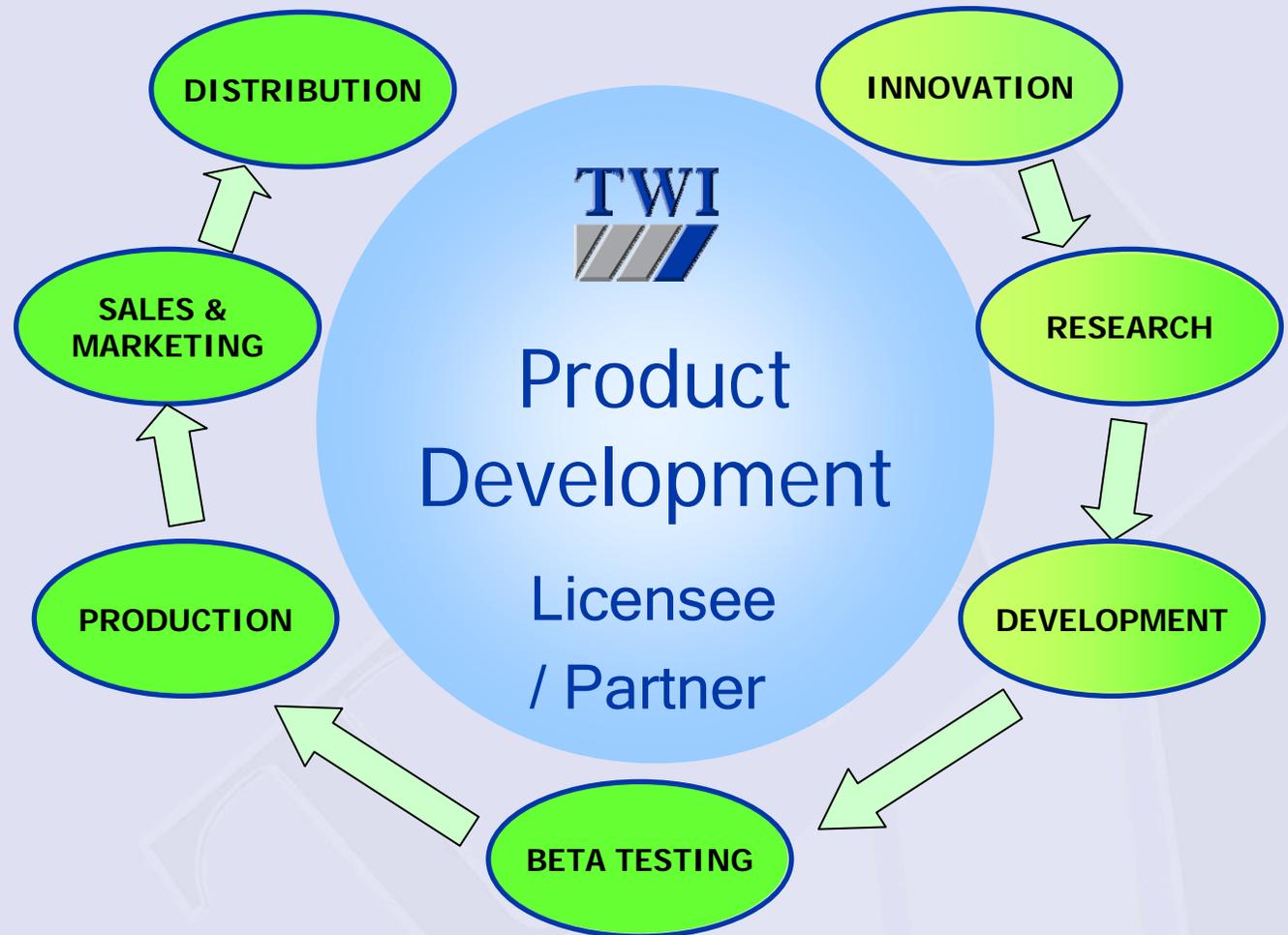
- 172 licensees worldwide
- In global use for aluminium
- R&D continues for steel, titanium & others

Commercial impact:

- >\$4.9billion: Estimated annual economic benefit to US manufacturing industry
- 60% cost saving: FSW specific design of Delta rockets
- 20 times faster than manual riveting: Eclipse business jet



Commercialisation Model





Vitolane™ Technology

Silsesquioxanes



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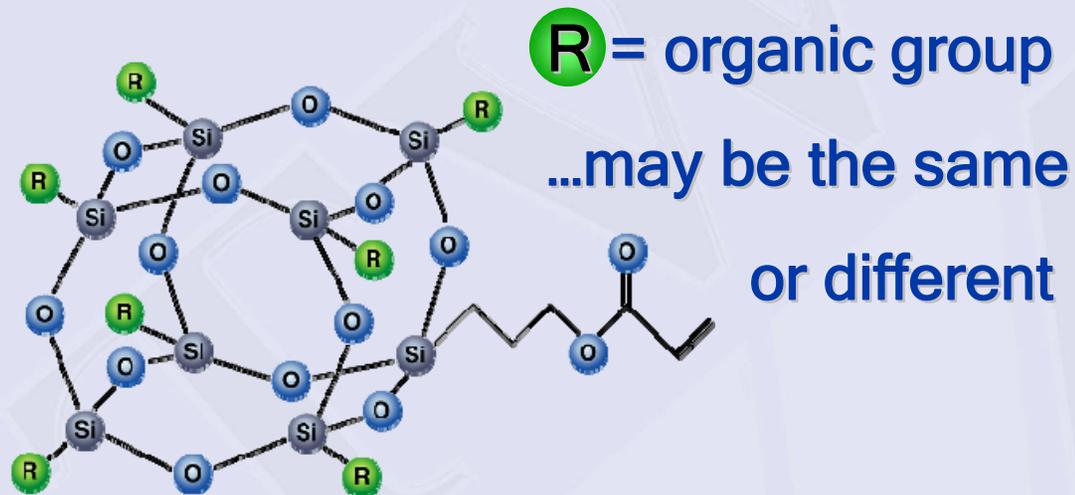
Background to Vitolane



- End users want better performing products e.g. coatings, adhesives
- Primary target: abrasion resistance
- Need to improve building blocks/ingredients used by formulators
- Development of tailorable silane based building blocks
- Outcome: *Development of an innovative synthesis route for the production of new building blocks - silsesquioxanes - offering a new technology platform to industry*

Silsesquioxanes - New Building Blocks

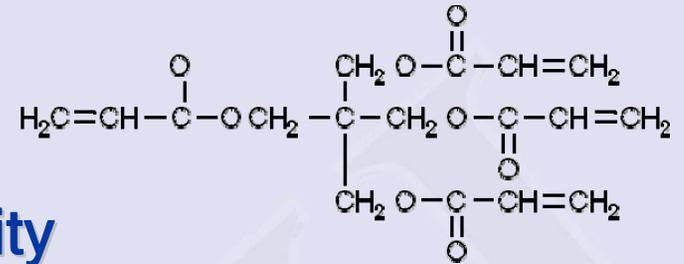
- Molecular organic - inorganic hybrid structures
- Ladder or cage configurations
- Molecular weight is determined by the number of silicon atoms



Silsesquioxanes - New Building Blocks

- High functionality

- many **R** groups



- Multiple functionality

- the same or different **R** groups

- Compatible

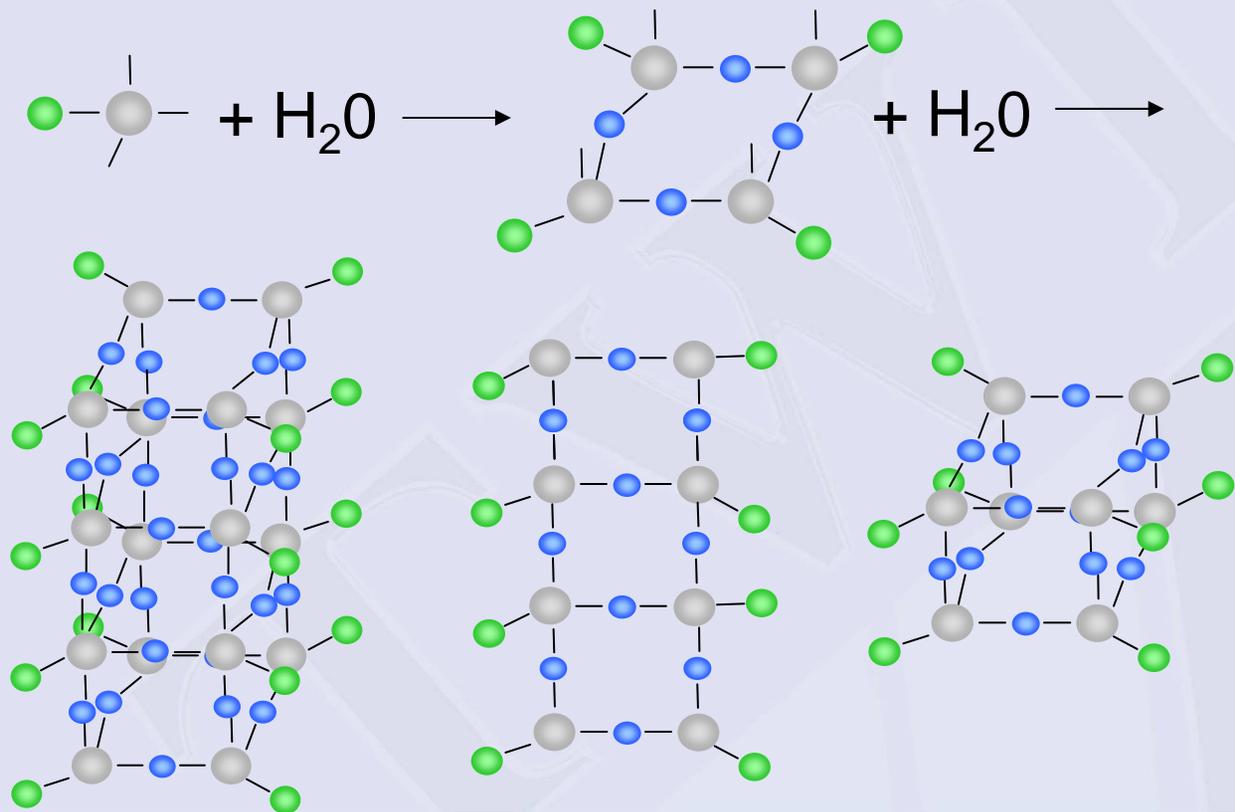
- Versatile

- coating, adhesive, etc

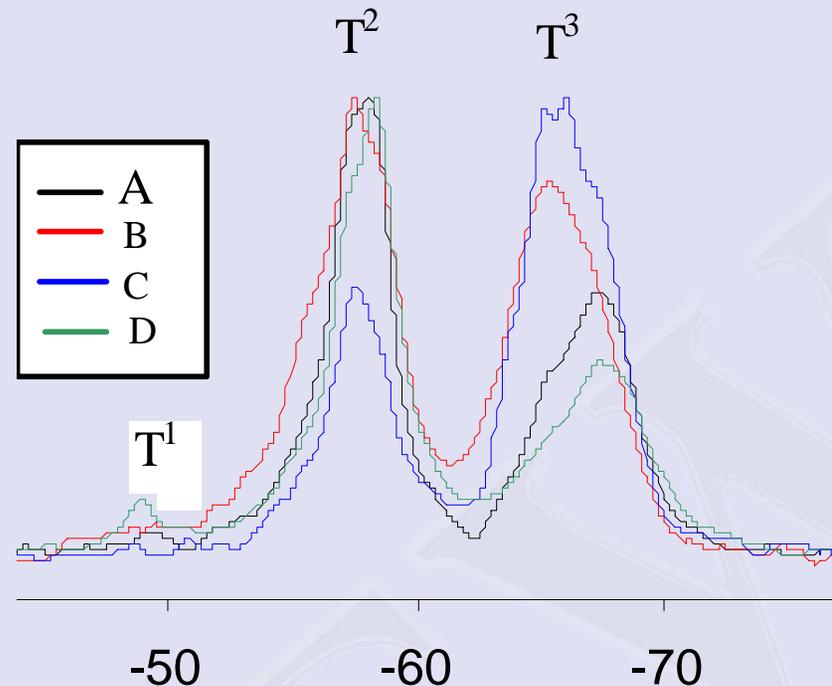
➤ Offers performance enhancements

Manufacturing Approach

- Employs sol-gel methodology using silanes (T)



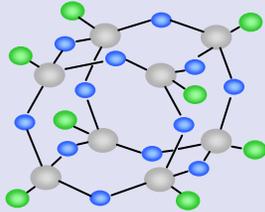
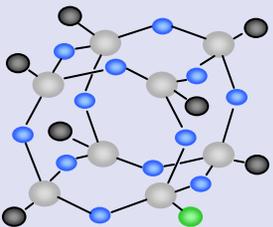
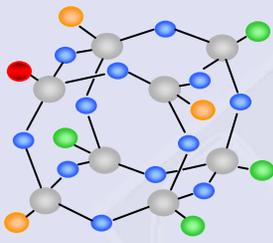
Silsesquioxane Structural Considerations



Renormalised ²⁹Si HP/DEC NMR spectra:
A Methacrylate C Acrylate
B Methacrylate/methyl D Acrylate/methyl

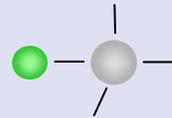
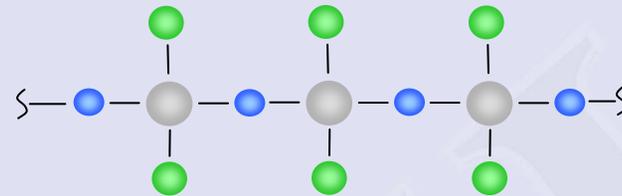
Courtesy of YH Han - PhD Thesis, Cambridge University 2006

Some Vitolane Variants

Molecular unit	Characteristics	Comment
Single 	Abrasion resistance	Six types already available
Double 	Abrasion resistance + hydrophobic	Under development. Unique
Triple 	Abrasion resistance, hydrophobic + adhesive	Under development. Unique

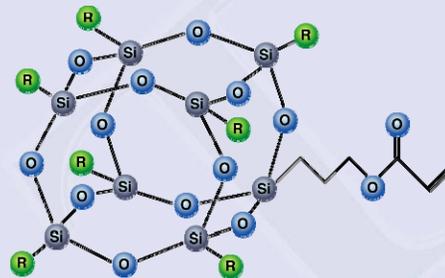
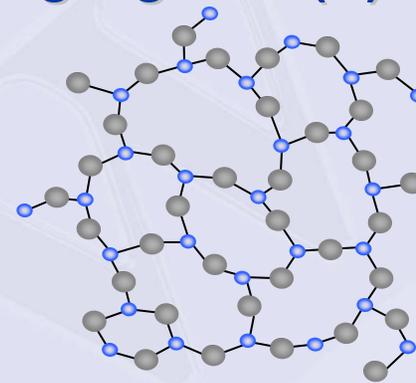
Silica Based Products

Silicones (D)



Silane Coupling Agents (T)

Silica Particulates (Q)



Silsesquioxanes (T)



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Addressing the Market Need



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Performance Enhancements



Solvent resistance
Transparency
Abrasion resistance
Dual cure - cure combining
UV cure
Anti-foam
Thermal cure
Permeation barrier
Hydrophobic
Adhesion
Scuff / Mar resistance
Hydrophilic
SMART
Performance characteristic
Anti-fog
High temp capability
Gloss retention
Stiffness
Flammability
Scratch resistance
Improved flow
Anti-soil
Anti-foul
Attribute combinations
Flame retardancy
Anti-mist
Hydrophobic + abrasion resistance
Gloss retention + heat resistance
Scuff resistant + heat + hydrophilic
etc

Supply Chain (part)

Raw materials

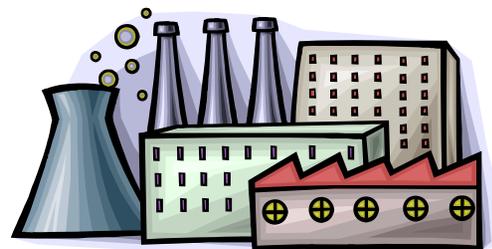


Organic products

Building Blocks



Formulators



Silane products



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Supply Chain (part)

Raw materials

Building Blocks

Formulators



Organic products



Silane products



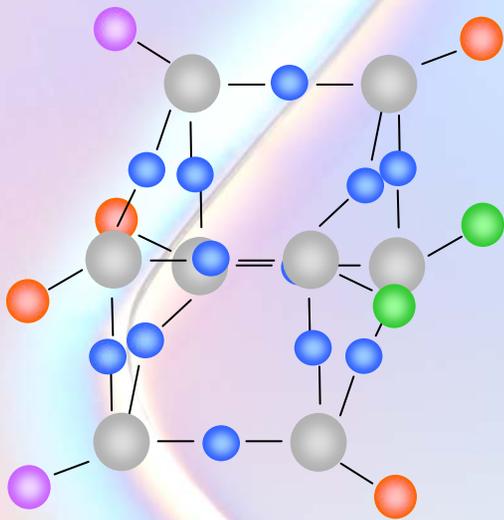
Silsesquioxanes ($\text{RSiO}_{1.5}$)_n

Silane coupling agents

Silica particulates



Degree of Innovation



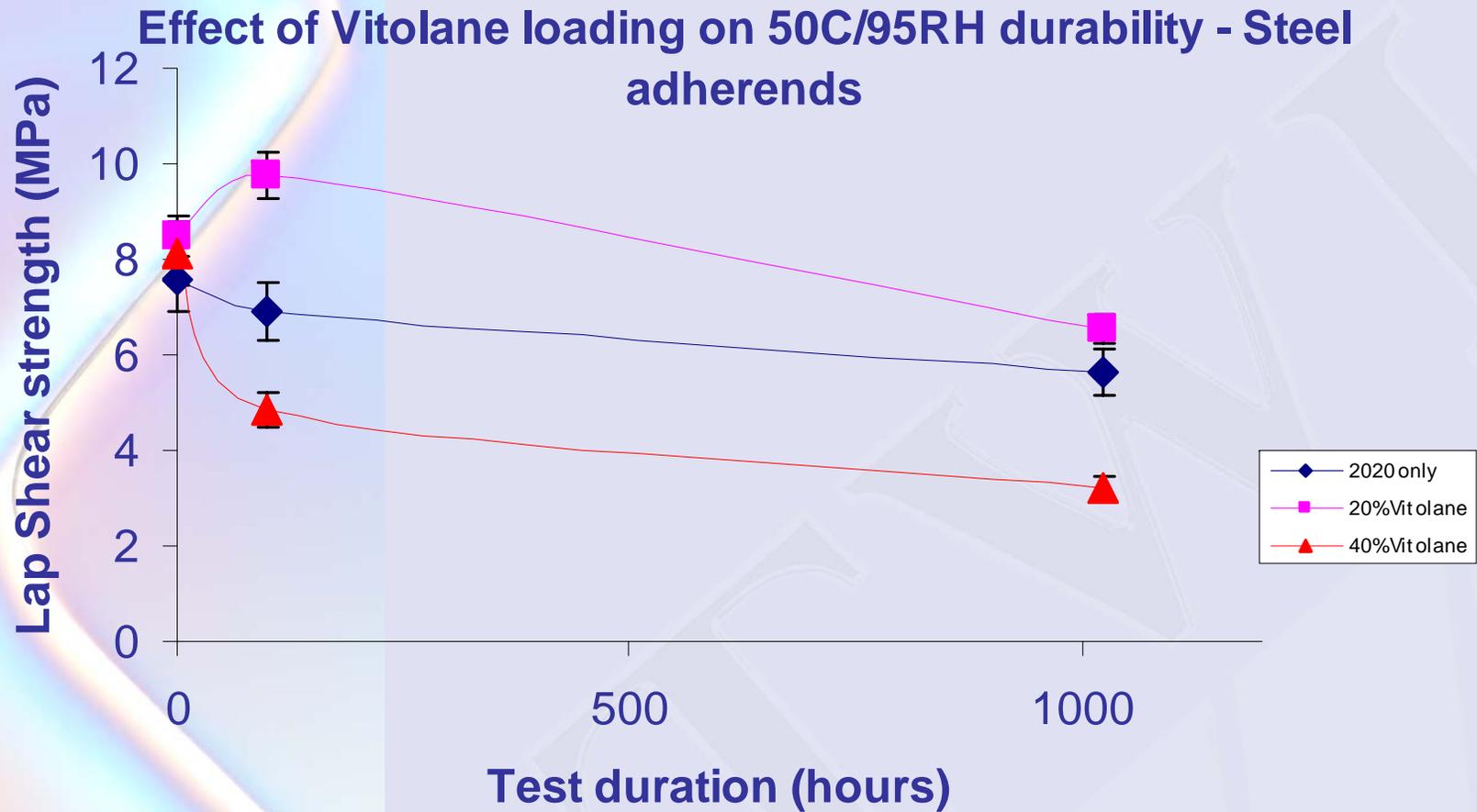
- To address market drivers, a completely new class of resin products has been developed.
- Silica based systems permit the level of chemical manipulation needed to allow the necessary attributes to be engineered into such resin products.
- The Vitolane process allows closer control over silane hydrolysis and condensation reactions enabling new resin products to be made.

Case Study - Vitolane Adhesives

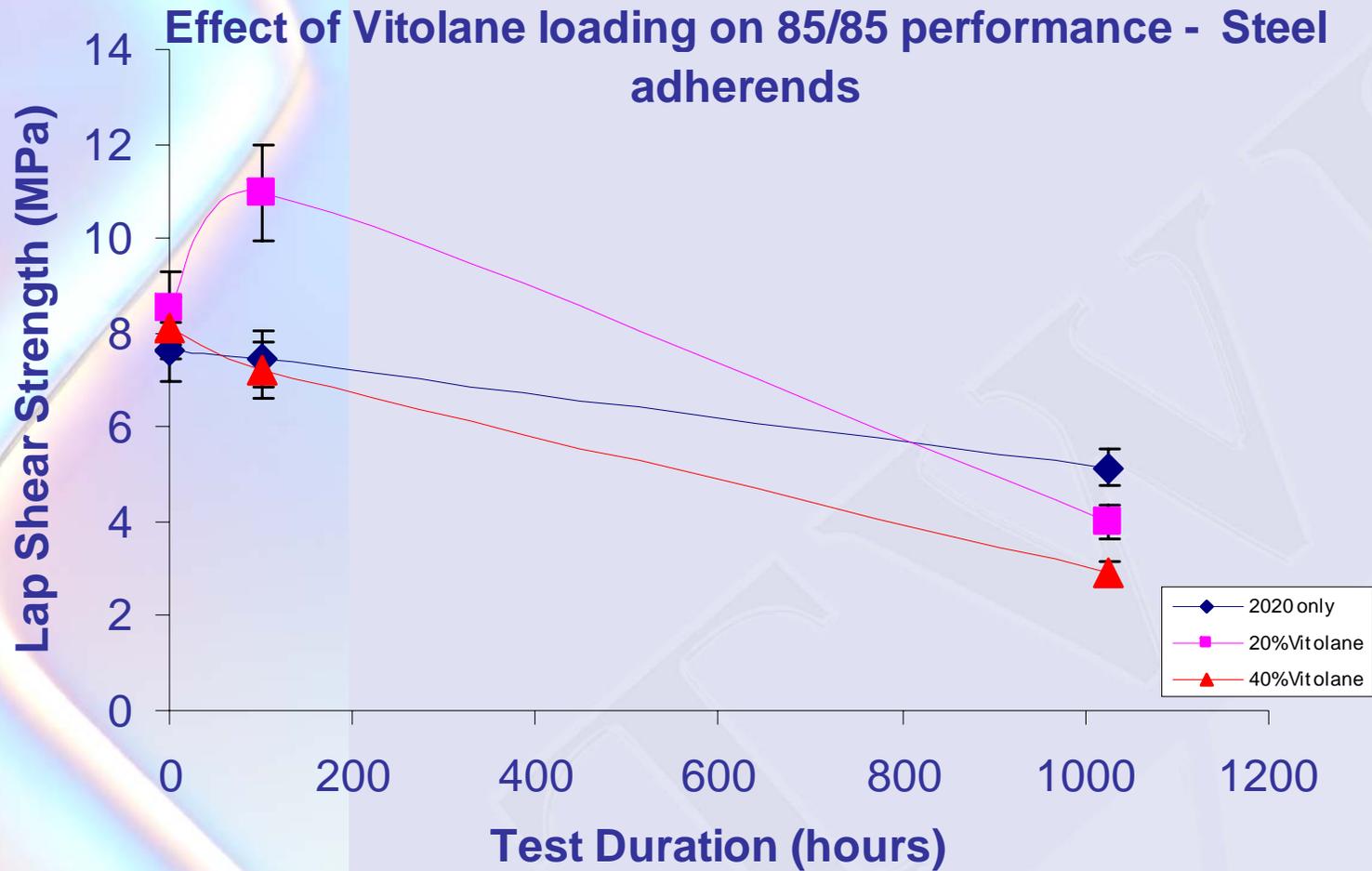
Epoxy functional silsesquioxanes

- Incorporated into Araldite 2020
- Lap shear tests
- 10 μ m bond-line thickness
- 50°C/98%RH exposure
- 85°C/85%RH exposure
- Exposure times of 100 and 1024 hours

Results (1)



Results (2)



Vitolane Adhesives Summary

- Highly compatible with epoxy/amine formulations
- Testable joints produced with Vitolane loadings up to 60wt%
- Apparent improvement in joint strength of the for 20wt% Vitolane loading after exposure to conditions of high heat/high humidity
- No apparent change in failure mode by incorporation of the silsesquioxane (predominantly adhesive)

Vitolane™ Technology

- Fills gap in market with a new *technology platform*
- Affordable method of making silsesquioxane oligomers
- Growth potential
 - increased demand for raw material
 - opportunity to use new building blocks in formulations
 - flexible approach to meet wide market needs



Current Position

- Significant interaction with marketplace
- Sample provision (22kg, single and double functional)
- Compatibility, blending and performance information generated

Feedback received

‘ ..the US team are excited by Vitolane and were thinking about functionalities to do things other than just abrasion resistance.’

‘Very excited’ by results

‘Nice results in hardcoats’



The Opportunity

Vitolane Technology: an innovative synthesis route for the production of new building blocks - silsesquioxanes - offering a new technology platform to industry

TWI has IP protection:

- EP1232219 (granted)
- US application 11/424,513 (pending)

More information can be found on:

www.vitolane.com



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Summary



- Vitolane technology is a potentially disruptive building block fabrication route
 - TWI is engaging with potential partners across the supply chain
 - Market pull and supply issues are all being considered
- New prospective partners are welcome!



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