Technology Developments in Protective Coatings

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Agenda

- Protective coatings market
- Key technology drivers
- Examples of New technology
- The future

International

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Protective Coatings market

- Thermal (Coal, Gas, Oil) power stations
- Wind, Hydro & other renewables
- Nuclear

Power Generation

- Drilling rigs,
- Platforms,
- Floating production
- Subsea

Oil and Gas Upstream

- Chemical processing plants
- Refineries
- Storage facilities

Oil, Gas and Chemical

- Extraction, Pre-treatment
- Refining (Processing)
- Smelting
- Transportation
- Metals & Minerals

Mining

- Airports,
- Stadiums
- Iconic buildings
- High-rise buildings

HVI

- Water storage
- Waste treatment
- Desalination plants

Water and Wastewater

Technologies in PC

- Historically alkyds, Epoxies (70%) and Polyurethanes have provided the majority of coatings in PC
  - Alkyds for light duty
  - Epoxies/Polyurethanes for heavy duty

- The market is mature and new technologies take time to develop
  - Specification position
  - Track record is essential, especially for offshore use

- Many products and technologies exist in the market for a number of years

Key new technology drivers

1. Performance
   - Longer lifetime, especially offshore (Norsok/ISO12944)
   - Extended guarantees and Warranties
   - Gloss and colour retention
   - Third party testing

2. Productivity
   - Fast cure/Fast return to service
   - Power (electricity) generation

3. Environmental and legislation
   - VOC (High solids/Water based)
   - Product Stewardship
     - Heavy metals

New Technologies

- A number of new technologies have emerged to meet the key drivers which include :
  - Polysiloxanes
  - Polyaspartics
  - Fluoropolymers

1. Performance - Polysiloxanes

- A new technology for Protective coatings (patent protected)
- First introduced in the mid 90's as a replacement for an epoxy build coat and PU topcoat – 3 coat to a 2 coat system
- Key properties

Step change in durability
Low VOC (<250g/litre)
Isocyanate free
Can be formulated as one or two component coatings
Extensive use offshore in harsh environments

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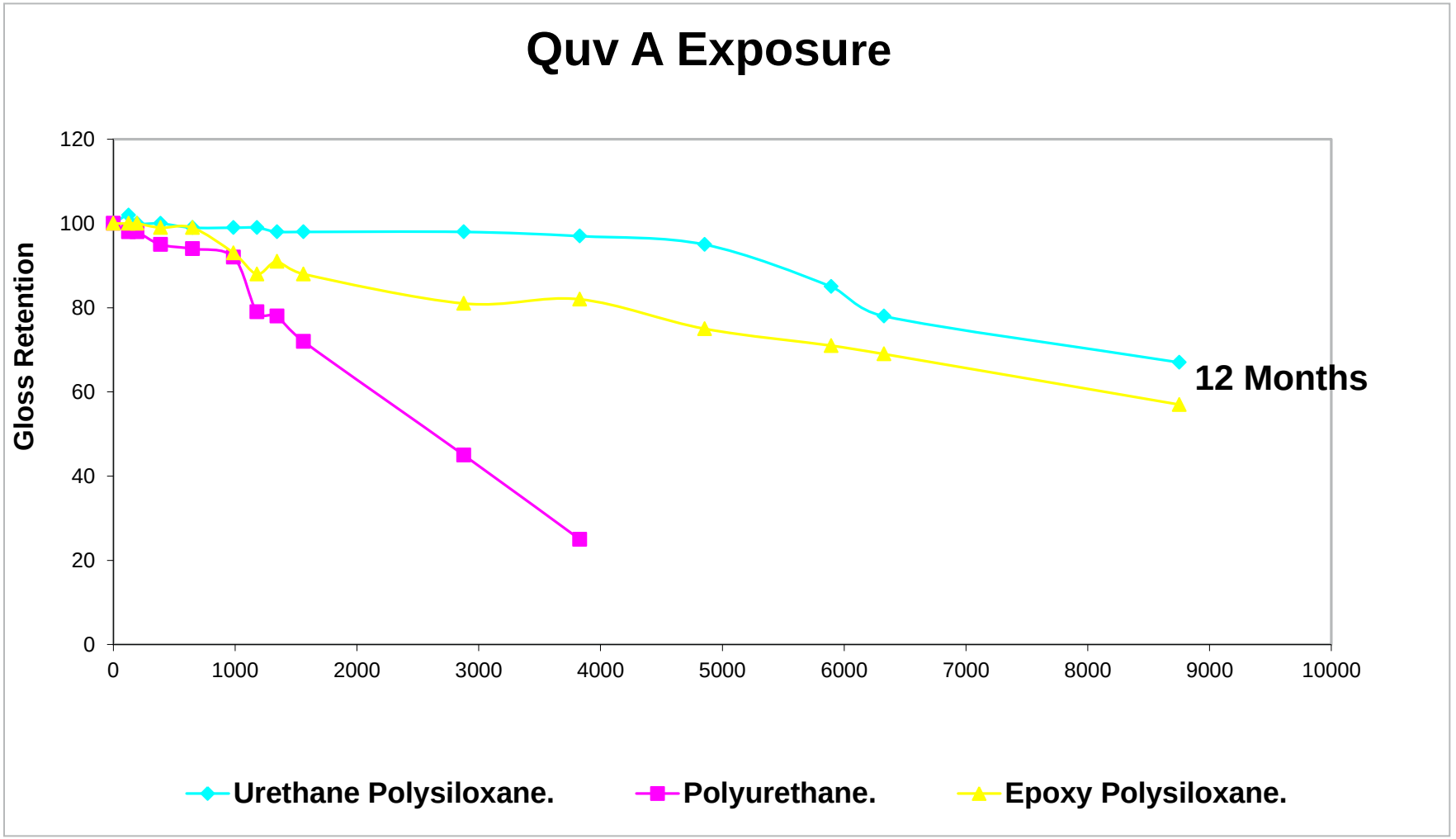
Polysiloxanes

- Polysiloxanes have the bond O-Si-O in the backbone and can be blended into most organic polymer systems
- The higher bond strengths of the Si-O bond (108 K Cal mol-1) compared to the C-C bond strength (83 K Cal mol-1) which confers thermal stability and UV stability, the Si-O bond is already oxidised.
- The Polysiloxane (glass) is transparent to UV and not easily degraded if at all
- Usually blended with organic polymers to give flexibility and good adhesion
- Latest technology is capable of <100g/litre coatings
- The time taken for accelerated testing is more of a challenge!

Accelerated Durability



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Single pack Polysiloxane

New technology for M+R

- Patented AN chemistry
- <275 g/litre
- Very high durability
- Designed for brush/roller application
- Tin and heavy metal free

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Fluoropolymer

Key properties

- Very high durability
- Thin film application
  - 30-50 microns
- Buildings and bridges are typical areas of application

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Fluoropolymer

- This chemistry relies on a carbon fluorine bond
- C-F (105 K Cal mol-1) bond is very high energy and very difficult to break with sunlight. It can also strengthen the adjacent C-C (83 K Cal mol-1) bond making the polymer much more UV durable.
- Can be the highest durable topcoat and most resistant to weathering
- Mostly specified in Asia and the US where specific durability standards exist
- Can be supplied as liquid paint or powder

Accelerated artificial weathering

Exposes the coating to an environment, which magnifies the stresses of the natural environment

The stresses are:

- Light. Both energy (wavelength) and irradiance energy
- Temperature
- Humidity

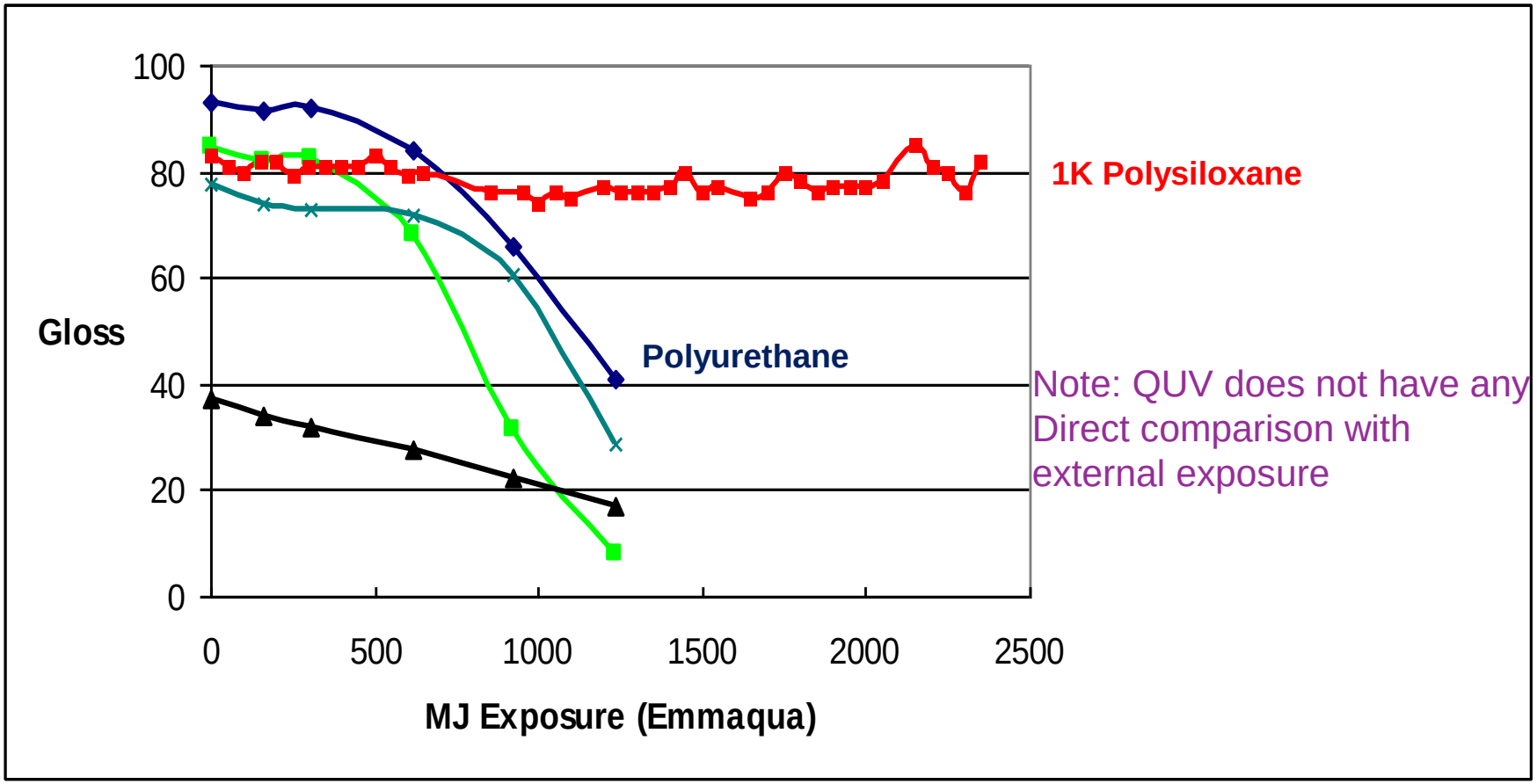
- Stresses are normally cyclical

EMMAQUA – New technology testing

Emmaqua

- 10 highly reflective specially coated mirrors are focussed onto the specimen target with an intensity of approx 8 suns.
- The device tracks the sun and exposes specimens to the full spectrum of sunlight, making it one of the most realistic accelerated tests available
- The test conditions can be varied to include Arizona or Florida and it also has the facility for a freeze cycle and water spray
- Exposure is quantified in terms of the total light dose of incident light. 300 $MJ.m^{-2}$ correlates to one years Florida exposure

EMMAQUA – 8 years Florida equivalent



Note: QUV does not have any Direct comparison with external exposure

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Ultra Emmaqua

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Third party test requirements

- Corrosion standards are required by our customers
  - Norsok
  - ISO12944
  - NACE and others
  - These tests are usually cyclic and include UV/Freezing (-15C) and salt spray.
  - Some tests require -60C and +60C cycling.

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Third party test requirements

- The requirements of the corrosion standards drives the choice of technology
  - Zinc based primers
  - Epoxy barrier coats
- Topcoats have to be compatible with these type of products and test regime
- Typical accelerated test times for C5M offshore environments are 6-9 months

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2. Productivity

Increasing focus on improving productivity

- For example Wind blades/OEM/Pipes
  - Fast cure technology is Polyaspartic
- Application methods are changing with more acceptance of twin feed/heated twin feed spray
  - Epoxy ultra high solids
- Tidal wave farms

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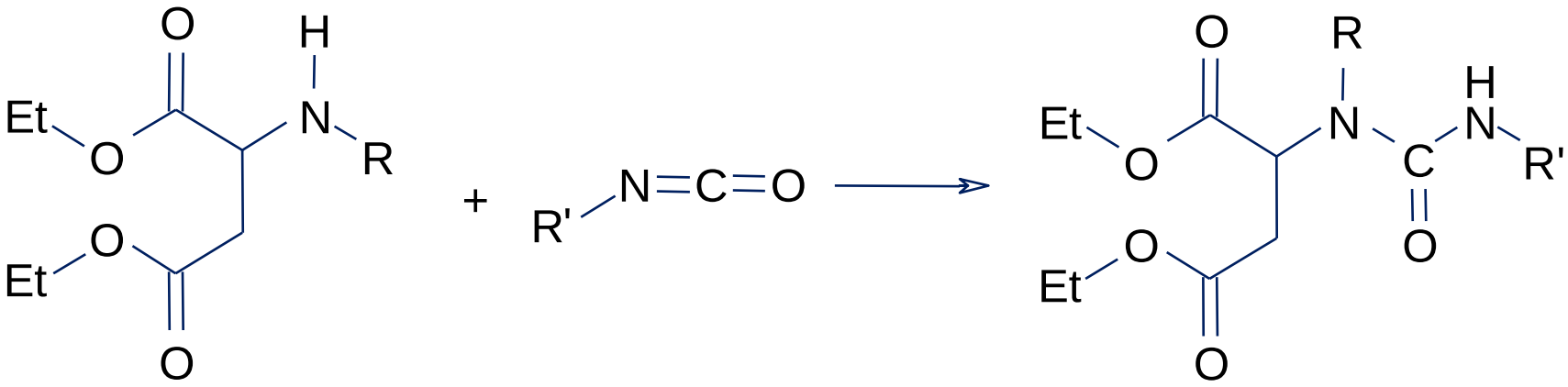
Fast cure Polyaspartics

Key properties

- Fast cure at a range of temperatures (0 – 40°C)
- Good balance of corrosion, aesthetics and physical properties
- Suited for OEM applications
  - Good gloss and early hardness
- C3 for DTM and up to C5 for 2/3 coat systems
- Tin free

Polyaspartics



Aspartic acid ester

Isocyanate

Polyurea

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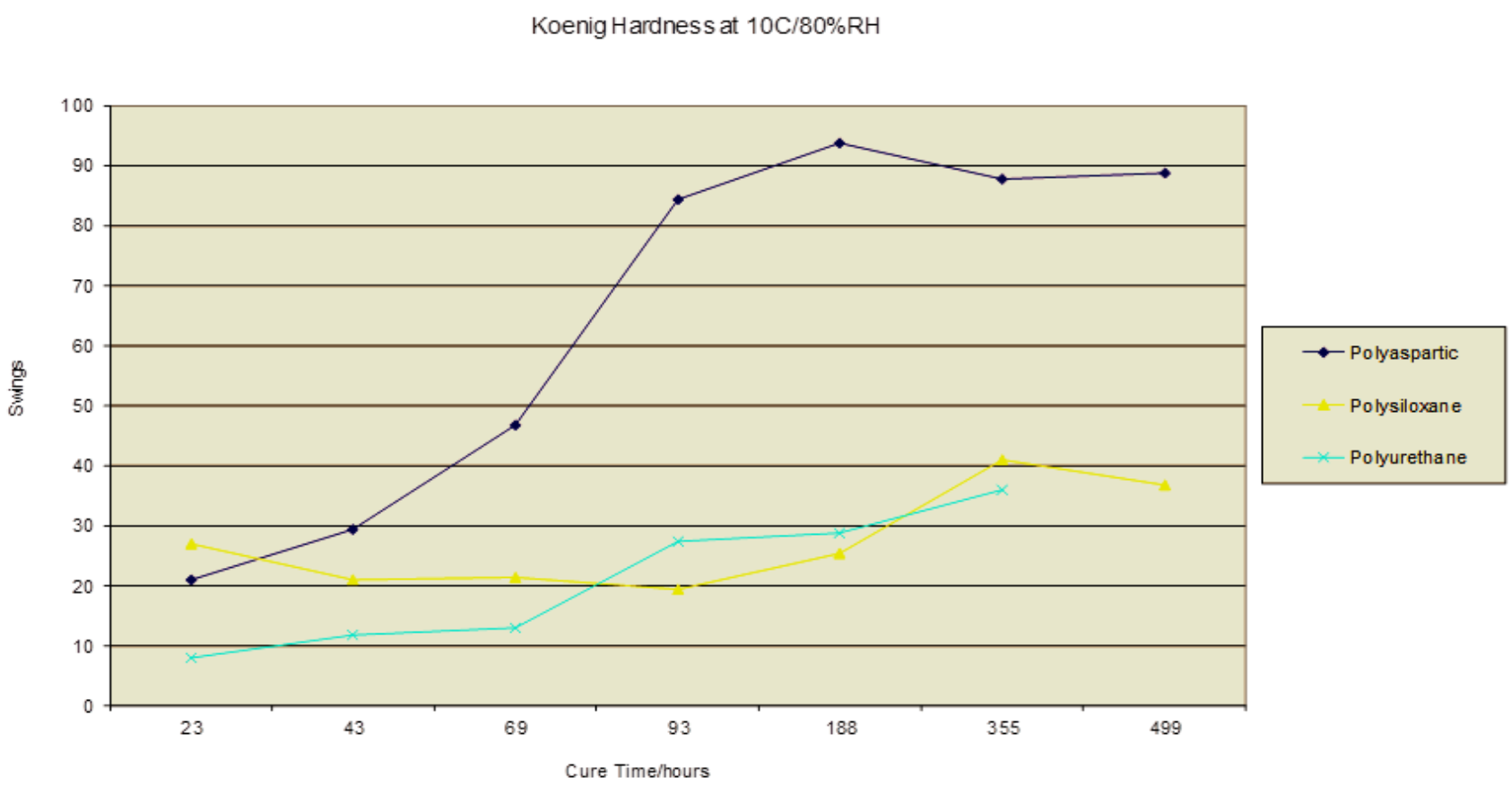
Polyaspartic hardness



Polyaspartic

- 2 Hours hard dry and moveable at 25C/60%RH
- DTM (150-200 microns)

Polyaspartic chemistry can give a range of dry speeds depending on the blend used.

Heated twin feed application

Temperatures of 50-90C have been used with cure times as short as 15 minutes.

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Silicone elastomers and their use in PC

- Marine fouling can cause a number of problems to occur on immersed assets
  - Increase the weight of floating assets
  - Increase hydrodynamic drag on tidal turbine blades
  - Cause difficulties in accessing critical areas of immersed devices for maintenance

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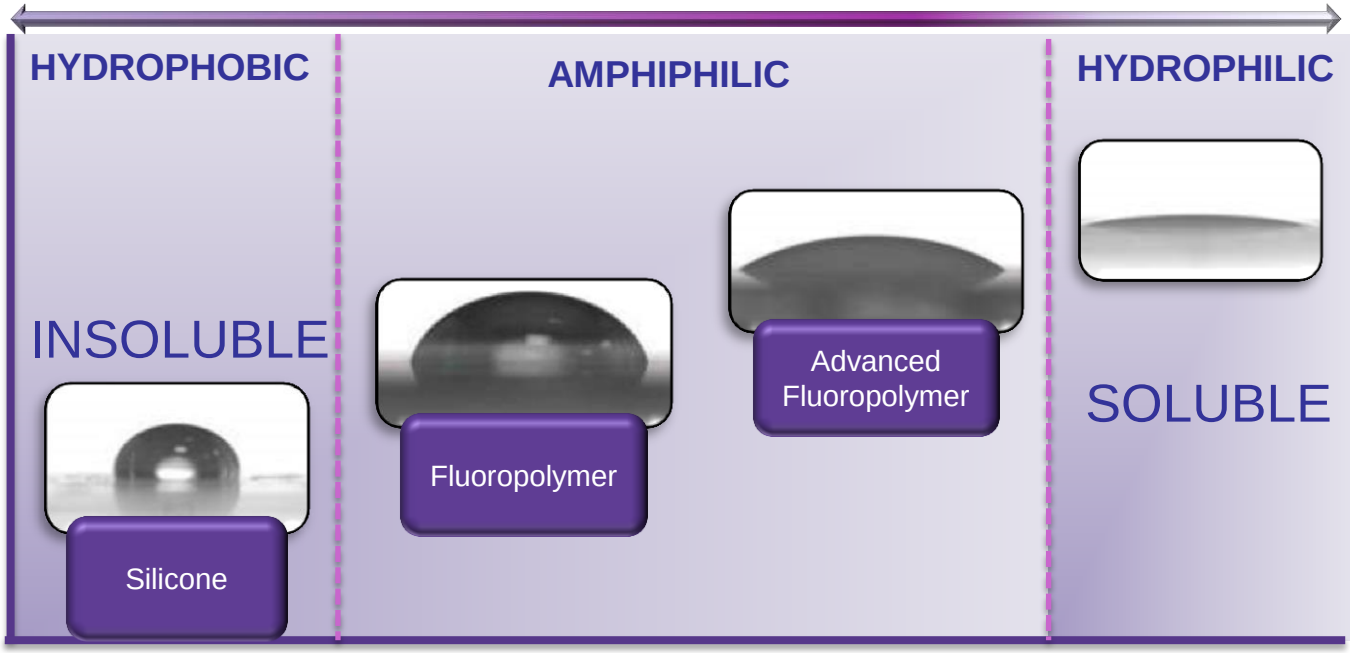
High performance ultra-smooth coatings and their use in marine energy

Amphiphilic fluoropolymer technology (None toxic antifouling)

- Generally marine life has a preference for either hydrophobic or hydrophilic surfaces
- Advantage of amphiphilic technology is it combines characteristics of both types of surface
- Delivers improved water flow and inhibits more marine life than other coatings



Silicone elastomers and their use in PC

What does this mean in practice?

- Reducing hydrodynamic drag can help in maintaining the torque of the device and therefore deliver designed power from the unit
- It can reduce maintenance costs by alleviating the need to hire divers to clean the device of marine fouling before maintenance can take place

High performance ultra-smooth coatings and their use in PC

A real life example

- A 30 month trial was undertaken at a hydroelectric plant in Brazil. The test was to compare a Fluoropolymer foul release coating with a coal tar

Fluoropolymer foul release

Coal tar epoxy

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Wave & Tidal assets protected by AkzoNobel

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3. Environmental - VOC

- VOC legislation
  - Continued focus from all regions of the world to reduce VOC's
  - Predictions that by 2020 it will be below 250g/litre
  - China tax >420g/litre, California <100g/litre

- The technology options are either water based or high solids
  - Epoxies
  - Polyaspartic
  - Polysiloxane
  - Polyurethane

Water based - VOC

- Key properties
  - Low VOC, <100g/litre
  - Single or two component
  - Good durability
  - Easy to apply thin films
  - Hybrid systems.
  - Performance equivalent to solvent based
- Drawbacks
  - Poor drying at low temp/high RH

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VOC HS Polyurethanes

Key properties

- Durability
- Flexibility of formulation
- Excellent Mechanical properties
- Adhesion to epoxies
- Track record

- Ability to formulate low VOC alternatives
  - <250 g/litre new product
  - Easy application at 50 microns without thinning

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Legislation

- REACH, K REACH, EPA, NICNAS

- Akzonobel programme

- Materials of concern
  - Isocyanates
  - Tin
  - Cobalt
  - Chromates
  - Coal tar

Isocyanate free

- A number of isocyanate free technologies (Interfine 629, Interfine 629HS and Interfine 691)
- Polysiloxanes
- Functional acrylics
  - Patented technology
  - <250g/litre VOC

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The future

- Uncertain!
- <100g/litre? Solvent free?
- Higher durability and lifetimes
- Lower film thickness and lower cost systems
- Functional coatings

Any questions?