White Geomembranes in High Risk Contaminants - Immersion testing challenges and results.

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On behalf of;
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ATARFIL® Geomembranes

GEOANZ #1 ADVANCES IN GEOSYNTHETICS
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What are White PE Geomembranes?

- Geomembrane Designed for it's Thermal Properties (exceed EPA/BPEM by default)
- HDPE or LLDPE Geomembrane with White Top Layer
- Traditionally a Thin White Skin
- Black Layer(s) below, Core and/or Skin/Conductive
- White vs Black – different formulations / properties.

Why Design with White Geomembranes?

Temperature – liner surface up to 20ºC less / reduce thermal gradient to subgrade

- Heat is a Catalyst for Geomembrane Degradation – Exacerbates Stress Impacts and Stabiliser Loss
- Wrinkles (Peggs et al 1993) up to 40% less
- Geomembranes are Designed for Intimate Contact
- Mitigate Conditions that cause Subgrade/GCL erosion below
- Visual representation of damage if black core below

White vs Black Ingredients;

- Carbon Black vs Titanium Oxide

- Additional Formulation;
  - Higher Levels of Stabilisation Required
  - Anti-Oxidant Type and Function

- Need to be careful in comparing black and white testing (Formulation – can yield diff results)

White Geomembrane Design Limitations

Obvious - Project history is Black GMs

Durability observations – Lab testing
Surface Cracking

Why?

- **White (Titanium Oxide) is more difficult to stabilise than black / therefore additive sensitive**
- **UV Performance - Carbon Black good UV screen / TiO_2 allows penetration (photocatalysis)**
- **Titanium Oxide/Rutile performance and type**

White v Black performance comparisons

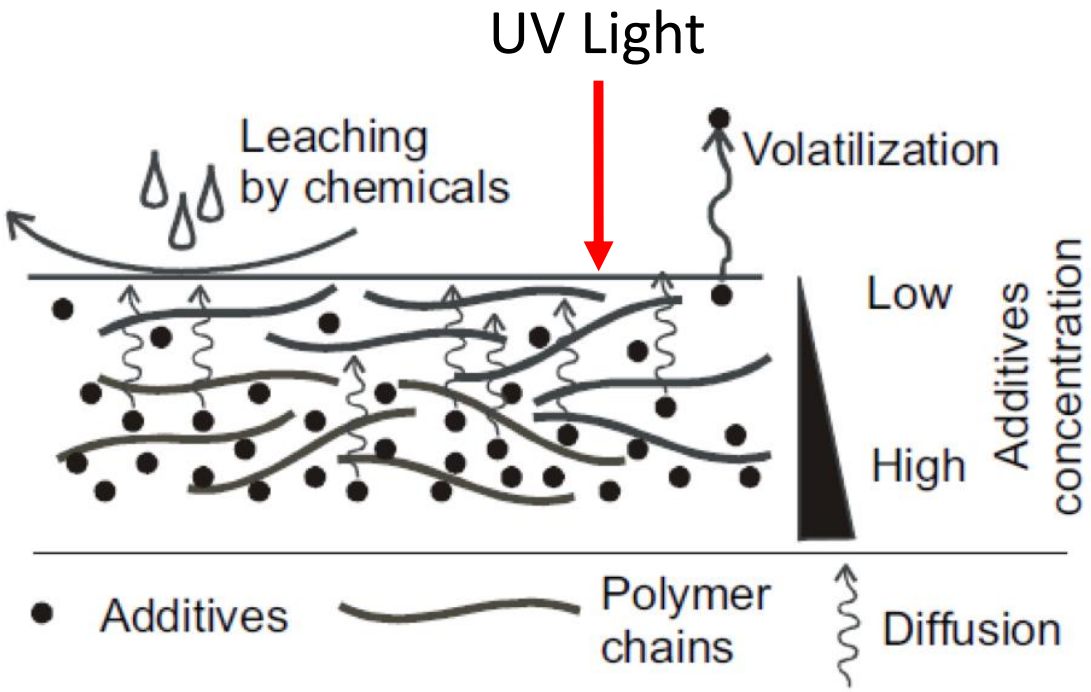


Image Courtesy ExcelPlas

Traditional Index Measures;

Oven Aging OIT and HPOIT
Oven Aging UV - Important

Project Specific Measures

Pot and Thin Film Immersions
SCR and Tensile Tests – immersion
HPOIT/OIT – immersed and OA
Real-time UV/OIT/SCR exhumations

What observations – traditional tests?

Oven Aging OIT/HPOIT

- Compression vs homogenization –lab techniques are critical

Oven Aging HPOIT of White Layer

- HPOIT <4000, some <14,000 mins

Oven Aging UV

- High Molecular Weight HAS
- +95% retained for White regularly
- Only observing loss +1600hrs, ASTM?

Conclusions – Traditional Tests;

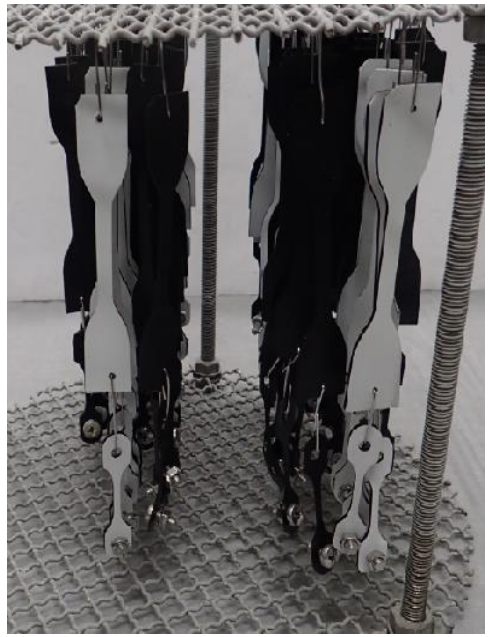
Oven Aging OIT and HPOIT

- Compressed samples, consistent but understand your lab…
- Homogenisation (OA) – if the ratio is not “exact”, expect variability
- Exacerbated by Conductive

  (Impacts of Carbon Black)

- Must understand individual layer performance
- Careful relying on single OIT/HPOIT tests (Arrhenius Plots)

Project Specific Testing;
- Pot and Thin Film Immersion Correlation



Pot Immersions;

3 temps min – 3 to 12 months

Measuring Tensile Properties

Measuring HPOIT/OIT/SCR

Thin Film Accelerated Immersions;

2 to 4 weeks at 85 deg.

Thin to 250 micron

Ficks Diffusive Path Assumption RE thickness/additive loss

Photos courtesy ExcelPlas

Project Specific Analysis;
- General Questions

Pot Immersions;

Double Sided Immersion – What side do we measure?

How long do we immerse?

What property do we test/when?

White or Black?

Thin Film Accelerated Immersions;

Correlation to Pot Testing?

How to extract a white sample?

Is testing at 85° C representative?

250 micron, is it representative?

Observations in Concentrated Brines

NaCl and Sodium Carbonate(s) – up to 300,000 mg/L

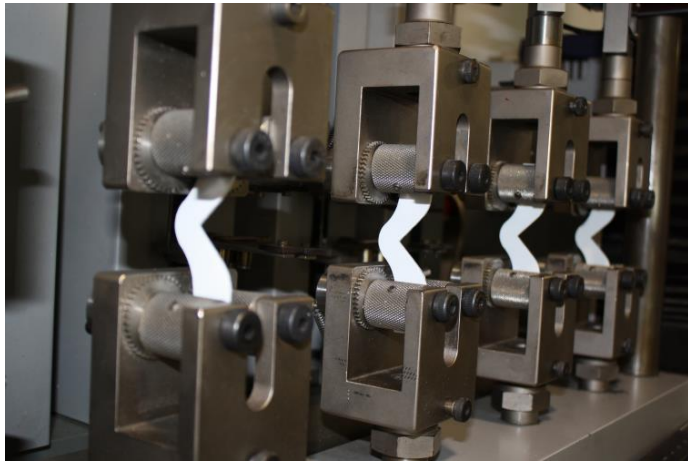
Applications – CSG / Various Salt Detentions

Rowe et al – Significant impacts on GM Life Expectancy

Thin Film (4 weeks / 85°C) and Pot Immersions (18 months 20, 60, 85°C)

Longevity (Arrhenius predictions);

- OIT rapid loss – targeted HPA processing additive
- HPOIT retention – 85% at 12 months 85 deg
- HPOIT values up to 14000mins for white layer alone – need to homogenise
- 90 year Arrhenius Prediction based on traditional ‘GRI’

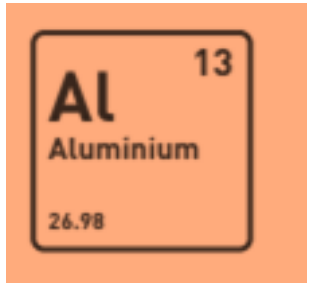


Observations in High pH

NaOH / KOH / Al Hydroxides

Applications – Phosphate/Bauxite RDAs , CKD Landfills

Rowe et al – Significant impacts on GM Life Expectancy from pH 9.5 to pH 13.5



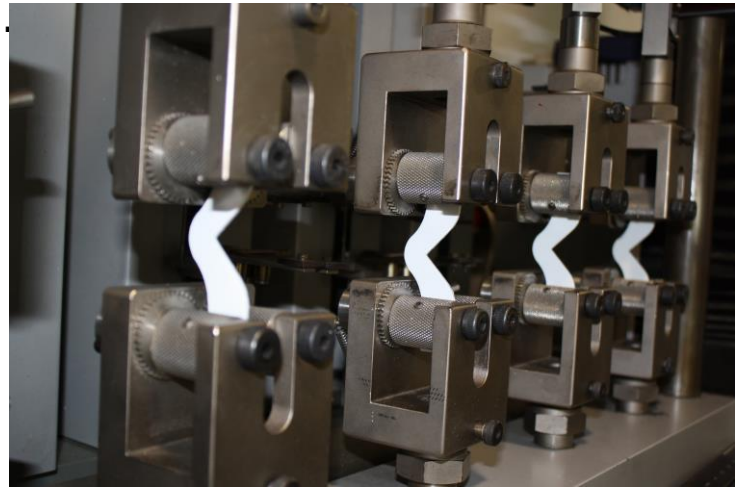
Thin Film (4 weeks /pH 14 /85°C) and Pot Immersions (pH 12 / 20, 60, 80°C)

Longevity (Arrhenius predictions compared very well);

- White Stage A (Minimal HPOIT Changes vs Black Loss +50%)
- OIT rapid loss – function of stabilisers, reflects Rowe and others
- HPOIT retention white – 84-96% retained (multiple product configurations).
- Heterogenity can impact ie different layers when mixed affect results.

  Conductive Layers Impact in Particular

- HPOIT results cyclic



Observations in Low pH

(Na_2SO_4 and HCl – pH 1)

Applications – Sulfuric Acid Leach / Heap Leach / Gold and Base metals

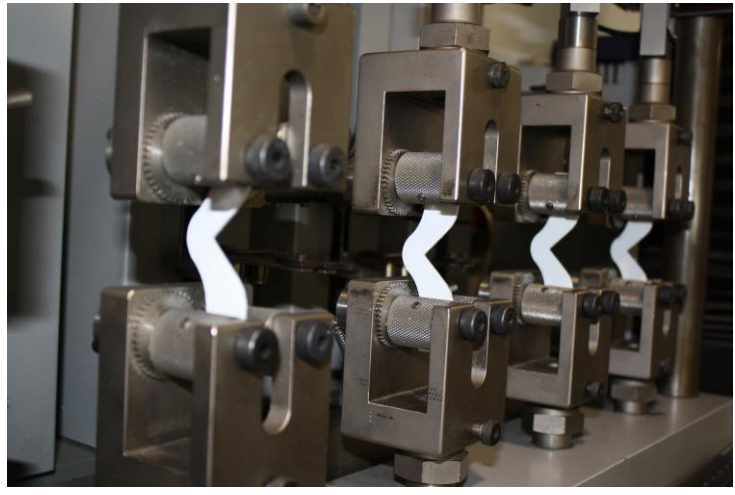
Rowe et al – Significant loss of OIT and HPOIT / pH 0.5 and pH 2 similar behaviour.

Pot Immersions 270 days (pH 12 / 20, 60, 85°C) / Thin Film TBC

Longevity (Arrhenius predictions);

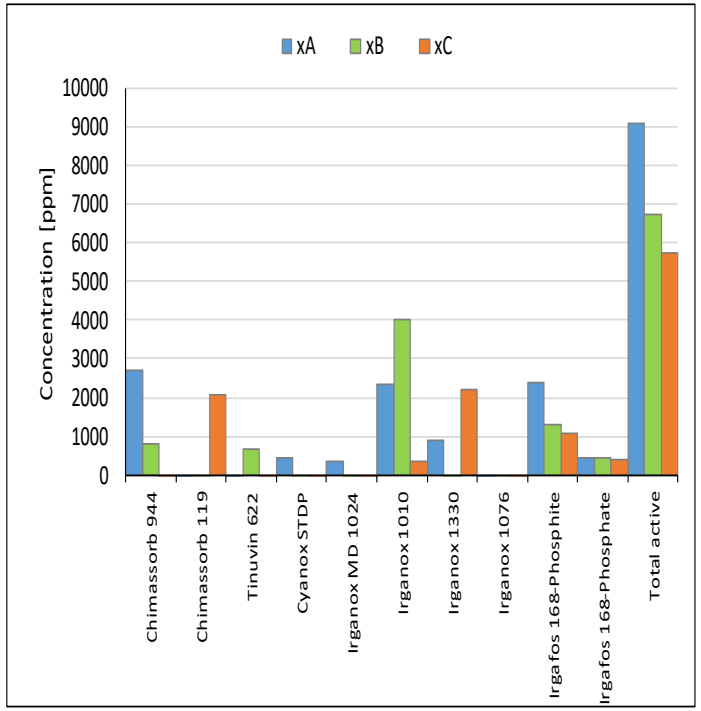
- •OIT rapid loss at 85 deg, reflects Rowe and others but challenges Arrhenius predictions
- • HPOIT retention – 96% , 129% at 60°C ??
- • Heterogenity can impact ie different layers when mixed affect results.
- Conductive Layers in Particular
- • Challenging Arrehenius Model – GRI based on OIT 50 years @ 90°C

NOTE Watch heavy metal catalysis in certain mine liquors.



White Performance - Why?

- Formulation Packages now targeted to chemistry (deformulation)
- Replication of resin in testing – allows formulation benchmarking
- Titanium Oxide grade is critical.
- Higher Mass of Formulation is surviving manufacture
- Stabilisers for processing/UV function are demonstrating increased Oxidation Resistance



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Observations;

- Arrhenius Predictions are indicating significant increased White Layer life expectancy
  Improved Formulation, Titanium Oxide Grade, Replication of resin in testing

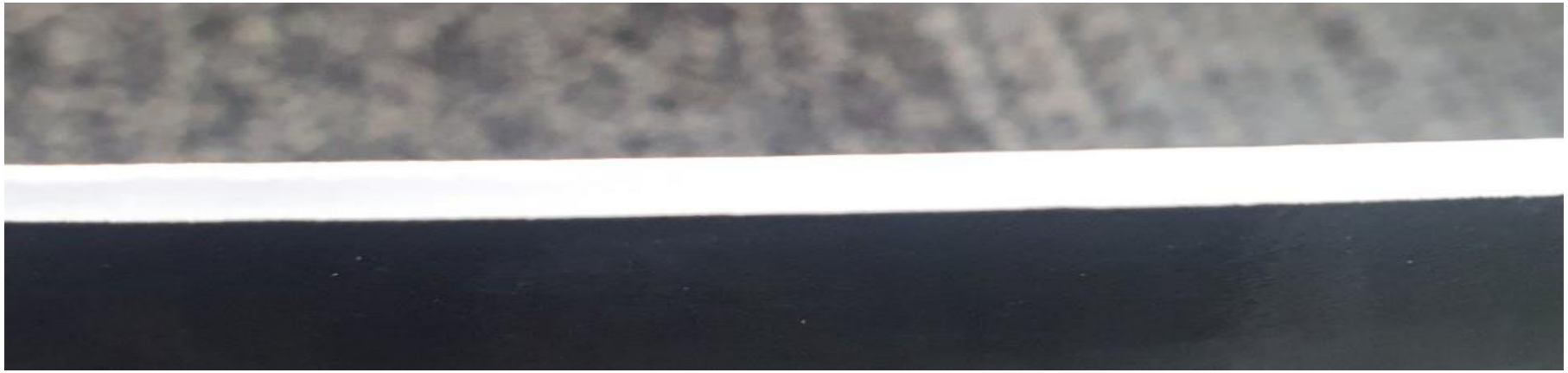
- High Moleculur Weight (HALS) can exibit huge HPIOT retention
  May not provide an Arrhenius measure – need OIT and HPOIT
  Time to test HPOIT can be prohibitive.

- OIT is consistently being used as the measure, which is good for testing times/cost

•Longevity (Arrhenius predictions) are observing increased life

Final thought;

- If the White Formulation is the High Performance Layer?
- If Thin Film Testing Demonstrates that Additive Loss is a Function of Thickness/Path?
- Should the White Layer comprise majority of the thickness?



Thankyou

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