

## How White-Surfaced HDPE Geomembranes Are Susceptible to Crack Formation and Propagation

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# Introduction

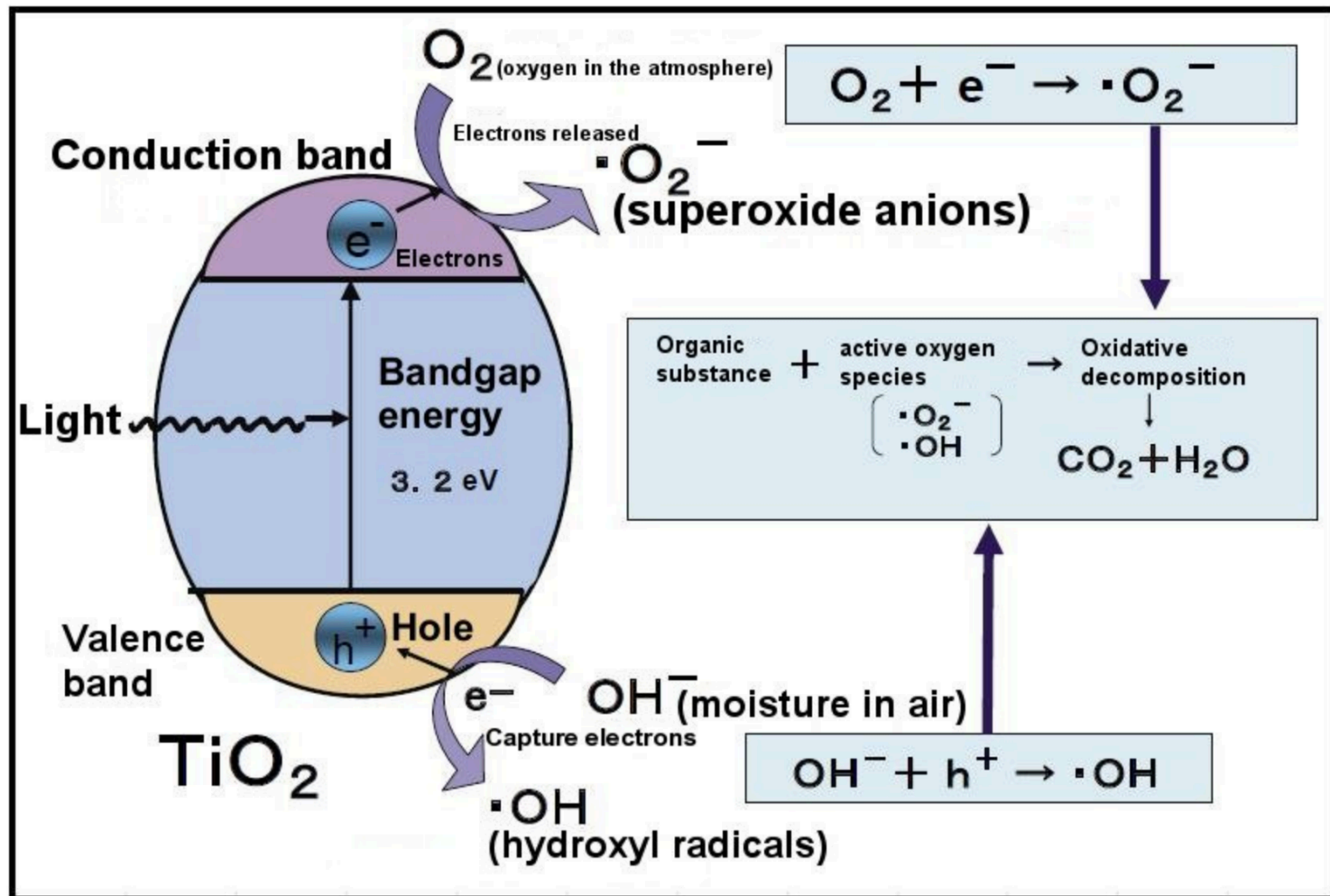
- White/Black HDPE geomembranes are now widely used in exposed applications and have the benefits of lower heat build up and less wrinkling.
- However recent failures have shown the white surface layer is difficult to properly UV stabilize and that microcracks can form in the brittle surface layer (BSL) which can then propagate into the black HDPE layer.

# Titanium Dioxide Pigments

Titanium dioxide (rutile) pigments come in three types of grades that have different durability in well-stabilized HDPE depending on the passivating coatings applied:

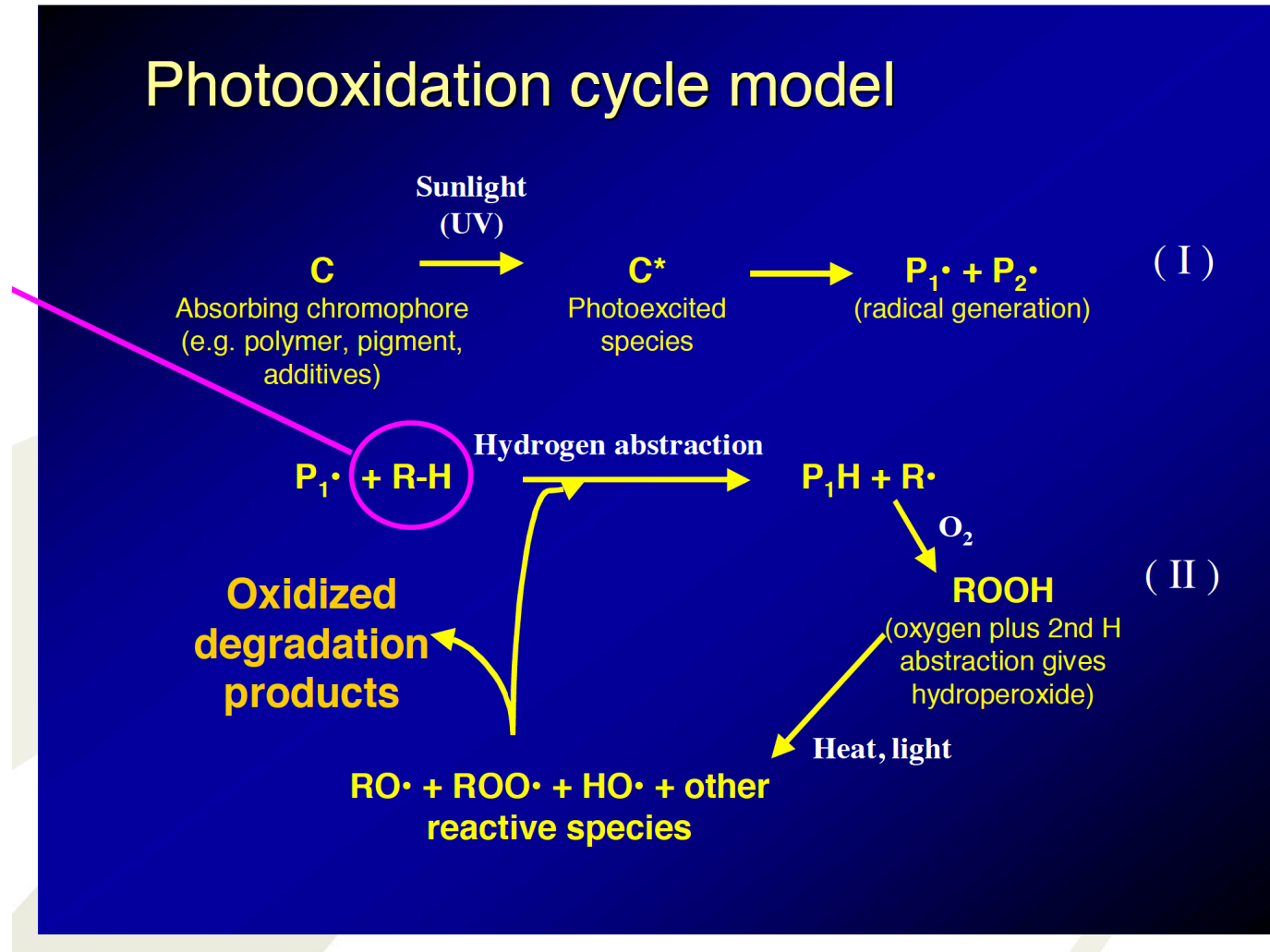
- Universal grade (10-15 years)
- Durable grade (15-25 years)
- Super Durable grade (25 years plus)

# Photocatalytic Behaviour of Titanium Dioxide

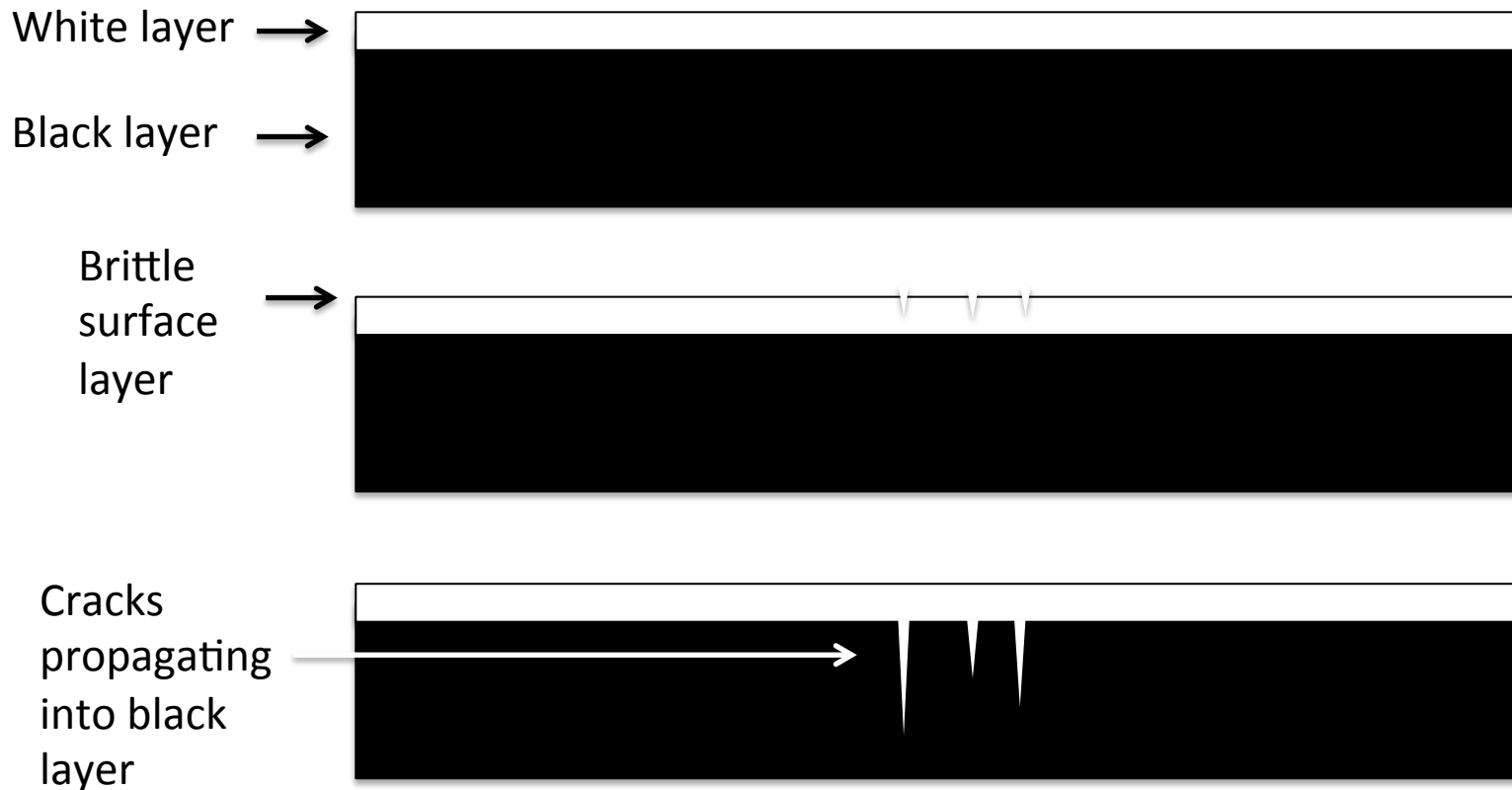


# Photooxidation Cycle in White HDPE

Rate of -OOH formation is related to the concentration of most abstractable Protons in the HDPE



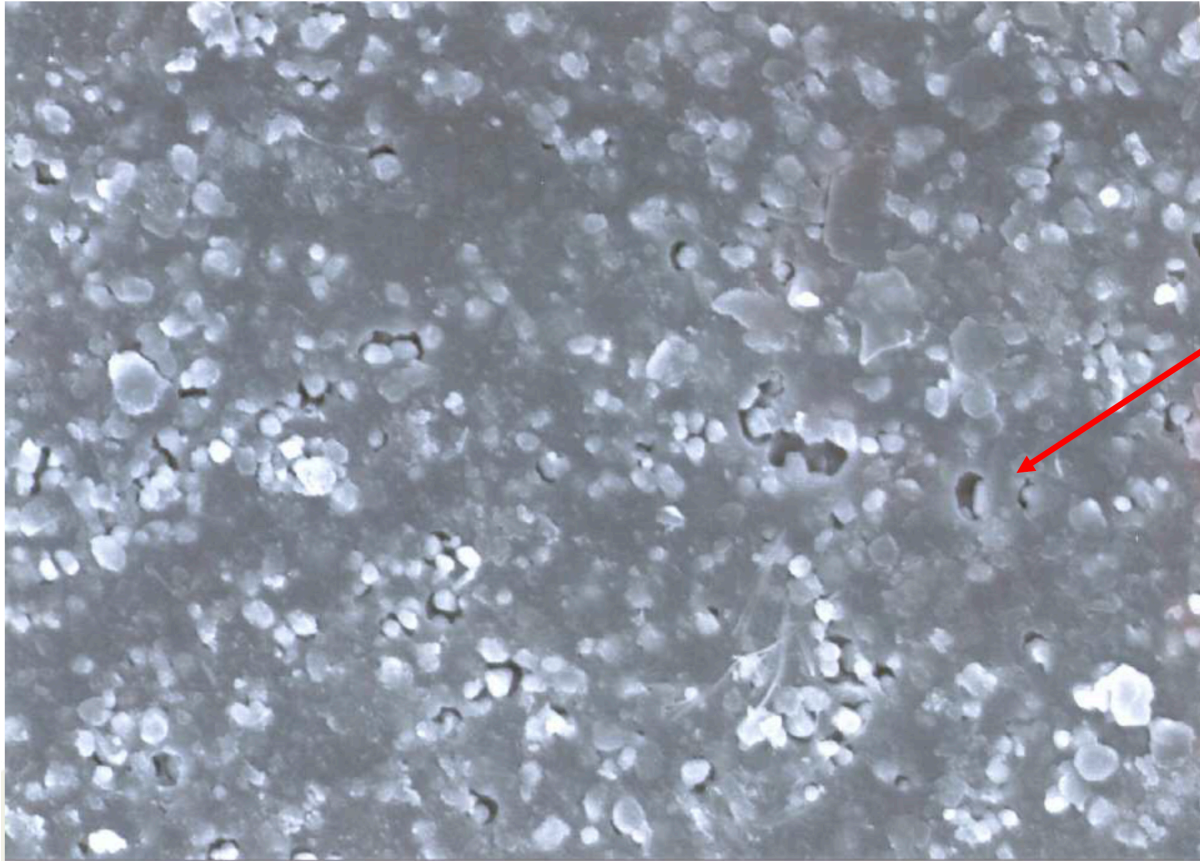
# Mechanism of Crack Initiation and Propagation in White HDPE



# Role of TiO<sub>2</sub> in White HDPE Oxidation

- TiO<sub>2</sub> particles both protect the HDPE matrix (polymer continuous phase) by blocking UV, **AND** initiate binder degradation through photocatalytic sites on the particle surface
- Grades designed for exterior applications have low photocatalytic activity, but residual photoactivity can still be a significant contributor to HDPE matrix degradation over long periods of time in full sun
- For HDPE, adding TiO<sub>2</sub> therefore tends to accelerate the rate of surface photooxidation leading to a brittle surface layer

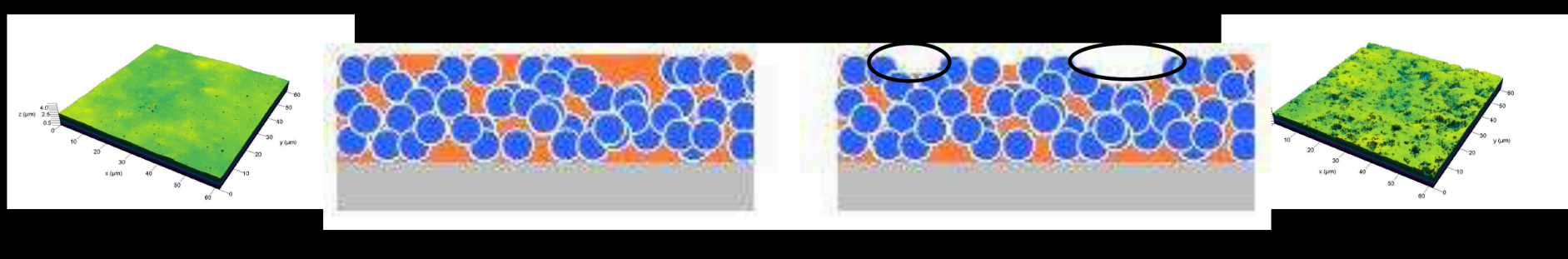
# TiO<sub>2</sub> Grades & Photocatalytic Activity



- The more durable the HDPE, the less important is the TiO<sub>2</sub> protective effect, but the more one needs to worry about residual photocatalytic activity from the pigment.
- Water plays an important role in photoradical generation
- Photoradical generation rate scales not linearly with light intensity but rather like  $I^{0.5}$

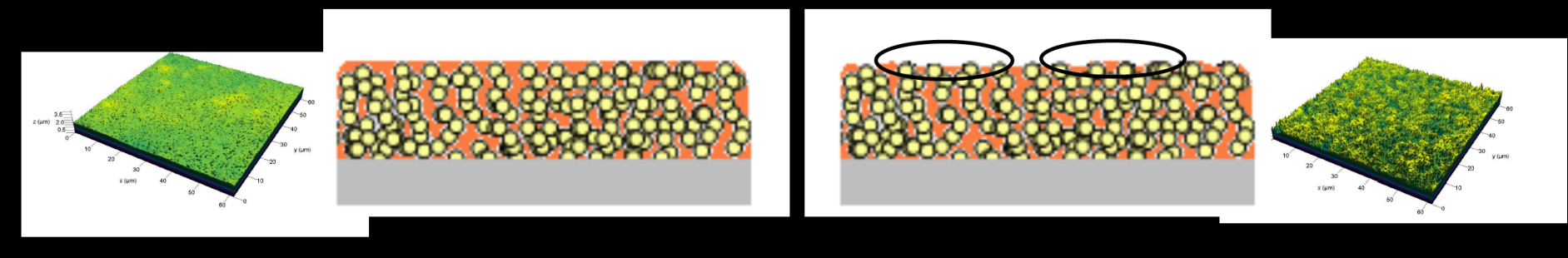


# Pigment-Induced Pitting in White HDPE



**FRESH**

**DEGRADED**



HDPE Matrix



Pigment Cluster  $\varnothing \sim 5\mu\text{m}$



Pit, loss of material



TiO<sub>2</sub>

## DEFORMULATION OF WHITE GMB TO DETERMINE *FITNESS FOR PURPOSE* FOR SPECIFIC SERVICE ENVIRONMENTS

