

Microencapsulation Technology

Advancing compliance
and safety of biofouling
management

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Arxada awarded Ecovadis Silver Medal 2025

Arxada Sustainability Report



Planet

- Net Zero by 2050
- 50% reduction of Scope 1 & 2 by 2030
- 28% reduction of Scope 3 by 2030



Preservation

- Protecting the wellbeing of people, improving the longevity of infrastructure, while supporting the health of our planet
- Advancing the UN SDGs through sustainable preservation
- Advocacy leadership for science-based decision-making
- Responsible sourcing



People

- World-class operations health and safety
- Creating an inclusive culture where all employees thrive and grow
- Community engagement and positive impact through volunteering

A recognized leader in carbon management

SBTi Approved GHG targets



Ecovadis Silver Medal
Recipient Top 15%



Biocides in antifouling paints today

Biocidal solutions power performance and protection today

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01

Why biocides remain essential

- >90% of vessels rely on biocidal coatings
- Cu_2O : Proven efficacy for over 100 years
- Organic co-biocides: Copper Pyrithione, Zineb, DCOIT, Zinc Pyrithione

02

What defines an effective antifouling biocide

- High performance and formulation compatibility
- Cost-effective with favorable price/performance ratio
- Low risk to non-target organisms, environment, and human health

03

Non-biocidal alternatives

- Require specific in-use conditions (e.g., foul-release coatings)
- Currently single digit market share
- May complement but not replace biocidal solutions

Effective biofouling control relies almost exclusively on biocidal solutions

Effective and regulatory compliant biofouling management is increasingly challenging.

Regulatory Challenges for Antifouling Biocides in South Korea

- Antifouling biocides (e.g. CuPT, Cu₂O, ZnPT, etc) are designated as toxic substances with 1% threshold (NIER Notice No. 2022-63)
- Antifouling paints containing >1% of these substances are also classified as toxic
- Increased compliance burden with government approvals, labelling, and facility management standards needed
- On August 7th 2025, Korean National Institute of Chemical Safety (NICS) updated the toxic substance list and introduced hazard-specific thresholds (NIER Notice No.2025-19)
- CuPT and ZnPT are now: >1% acute human tox, >10% chronic human tox, environment tox >1%
- Cu₂O is now: environment tox >1%
- New grace periods announced for newly designated and existing toxic substances with changed thresholds apply (see below)
- It is unclear if grace period applicable to CuPT, ZnPT and Cu₂O, as their original 1% thresholds remain

Regulatory Compliance Timeline

Requirement	Original Deadline	New Deadline
Chemical Substance Confirmatory Statement	Jul 1, 2023	Jul 1, 2026
Toxic Substance Labeling	Jul 1, 2023	Jul 1, 2026
Toxic Substance Import Notification	Jul 1, 2023	Jul 1, 2026
Handling Standards for Hazardous Substances	Jan 1, 2024	Jan 1, 2027
Chemical Accident Prevention Management Plan	Jan 1, 2025	Jan 1, 2028
Business Approval for Hazardous Chemical Substances	Jan 1, 2025	Jan 1, 2028
Installation & Management Standards for Handling Facilities	Jan 1, 2027	Jan 1, 2030

Arxada TIME Microencapsulation: response to regulatory pressures and efficacy expectations

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K-REACH tightening biocide limits

- Korea's Ministry of Environment is reducing the maximum permitted concentrations of biocides in marine paints

02

Toxicity classification risk

- Common antifouling biocides (e.g., Cu_2O , CuPT) are being designated as environmentally hazardous and toxic under K-REACH if present above thresholds in the mixture

03

Microencapsulation solution

- Encapsulated biocides containing <1% free active, minimizing both occupational and environmental exposure
- Product MSDS Approved by K-OSHA as non-toxic

04

Maintains efficacy

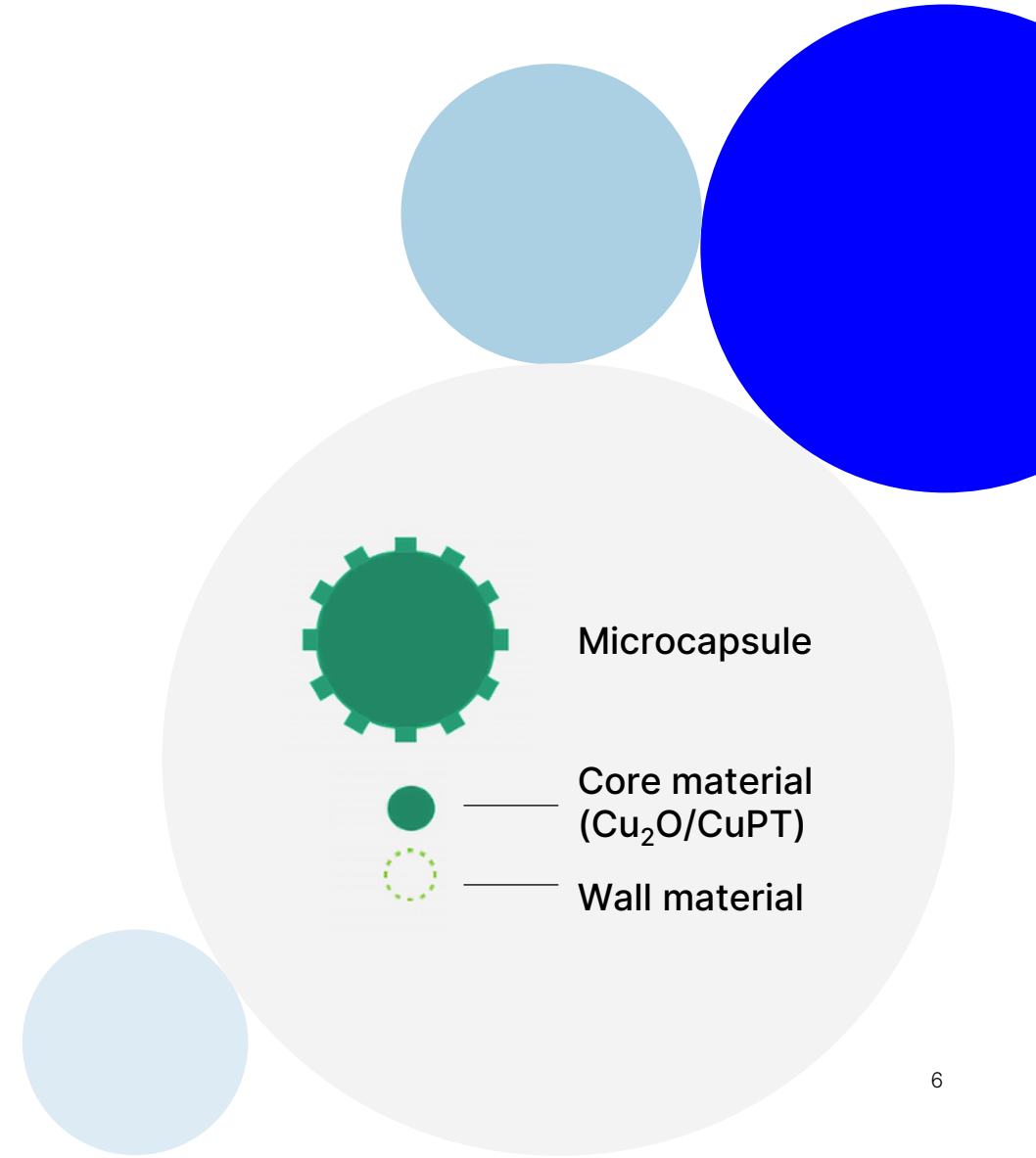
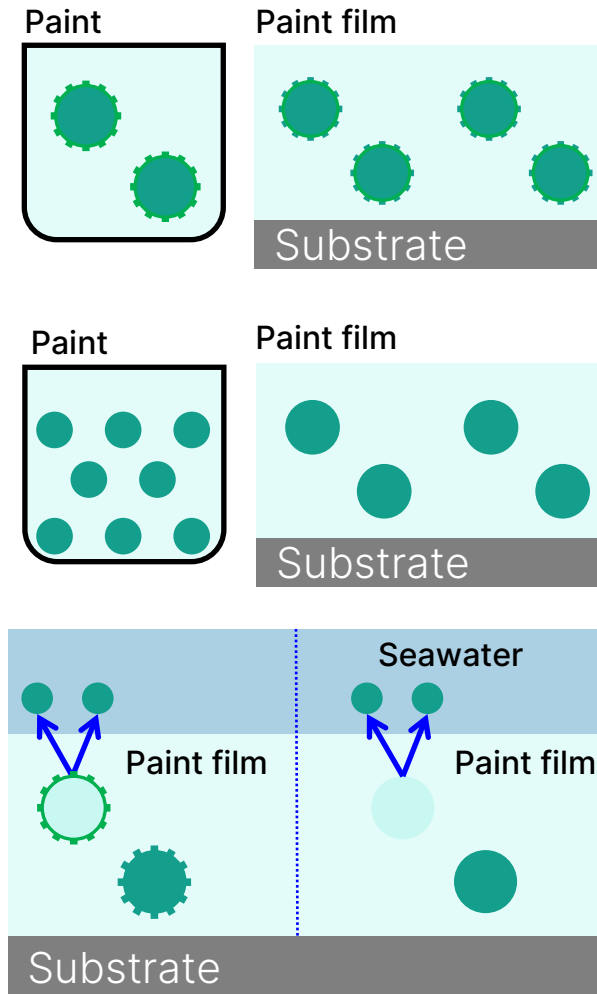
- Static panel testing shows comparable performance to traditional formulations, ensuring IMO-compliant biofouling protection.



Microencapsulation technology for marine antifouling

Concept: Microencapsulation limits exposure to free, non-encapsulated fractions

- **CR versions** of the active substances in paint film are very similar to the non-encapsulated Cu₂O/CuPT, the amount of capsule shell material (organic polymer) is minimal
- **CR products** are stable in the paint/xylene and amounts of free Cu₂O/CuPT remains low at temperatures up to 40°C
- The non-encapsulated fractions remain at <1%
- Limited exposure to occupational workers and environment



TIME - Arxada Technology for Innovative Microencapsulation

Innovative technology to meet performance challenges

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Arxada's encapsulated biocides are storage and temperature resistant

The capsules remain intact during long storage times or at higher storage temperatures (up to 40-50 °C), with very limited migration of the biocide from inside the capsules into the carrier phase during storage, i.e. there is no time- or temperature related loss of the capsule performance (= leach resistance)

The biocide microcapsules are shear resistant

High-shear mixing conditions are used to produce these capsules! Mechanically the biocide capsules can only be damaged by grinding (media mill) and chemically by treatment with strong acids (nitric acid) at high temperatures of 90°C (very slow, time-consuming process)

The rate of diffusion is dependent on the properties of the biocides and properties of the capsule

Capsule properties and "tightness" are aligned to biocide properties to deliver best performance

Stable in most of organic solvents incl. Xylenes and Toluene

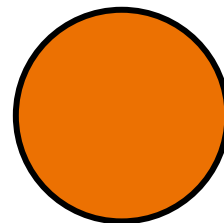
No significant capsules deterioration during long storage times and higher temperatures

Mechanism of release is simple diffusion

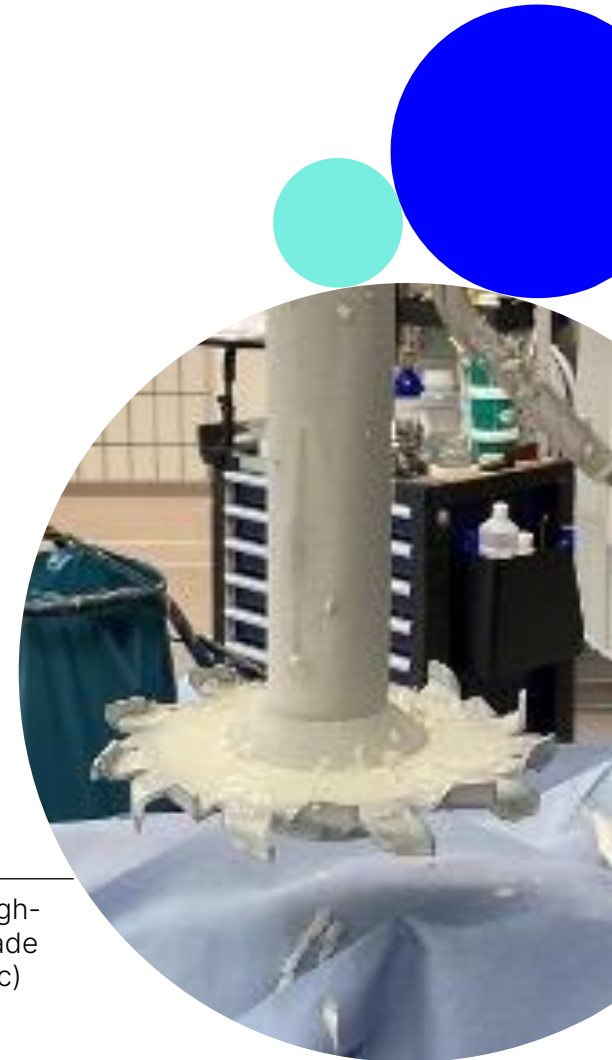
The driving force for the active substance migration through the capsule wall is the concentration gradient (inside/outside the capsules). Migration takes places in dissolved form, i.e. requires water or solvent.

Arxada TIME Technology - sustainable dry film solutions delivering superior fouling control

Encapsulated biocide



Production equipment: high-shear mixing dissolver blade (tip speed: up to 26 m/sec)



Arxada TIME – innovative biofouling control

Novel marine antifouling products to meet most stringent regulatory challenges

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Innovative antifouling solutions based on Arxada TIME technology

- Analytically proven encapsulation efficacy of CuPT and Cu₂O of 99.5-99.9%
- Very low “free” active substance content (<1%)
- No compromise on antifouling efficacy*



Copper Omadine™ CR



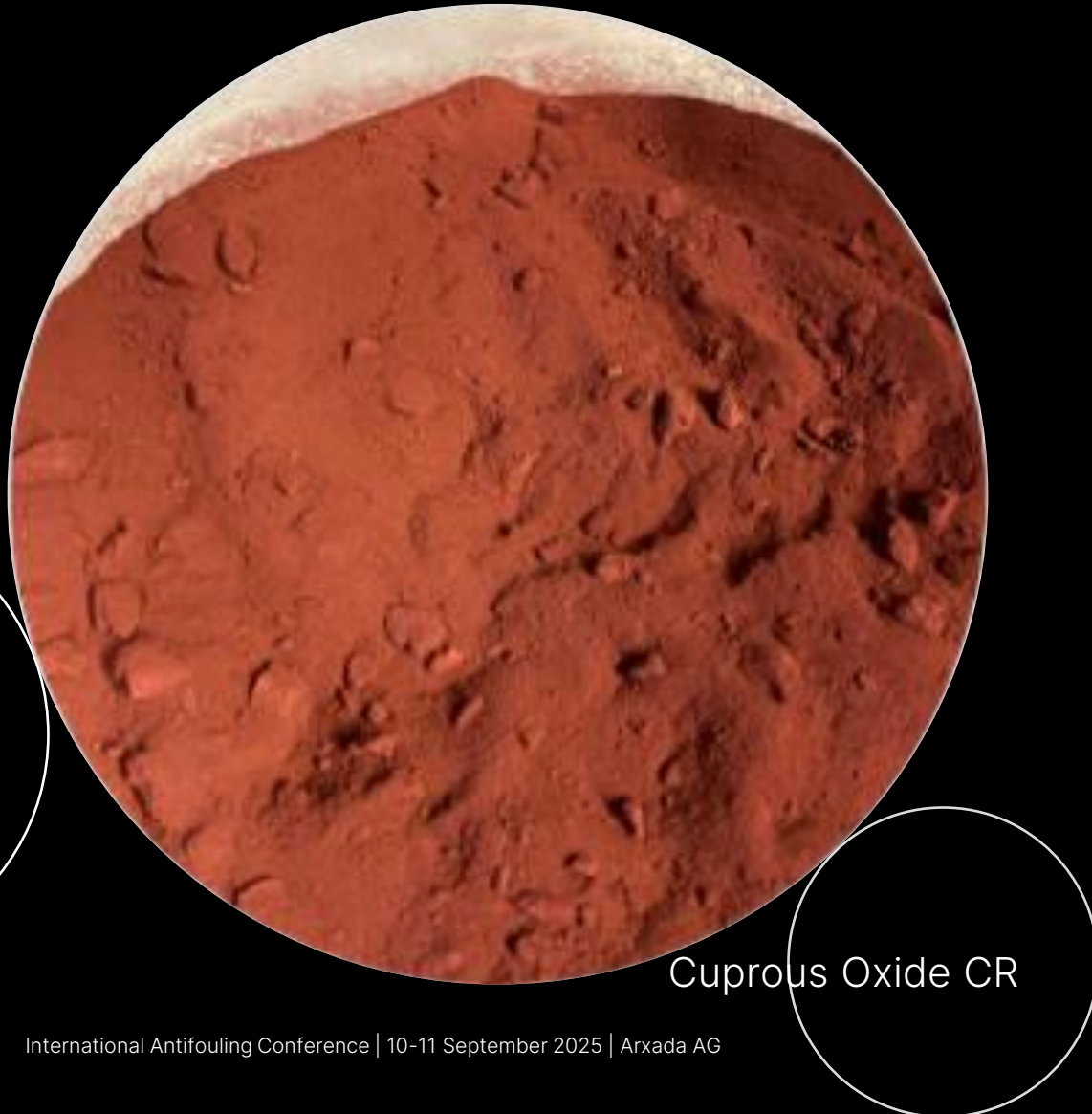
Sustainability advantage

- Leaching is controlled to a level that is desired
- Improved safety and handling, reduced emission and environmental impact
- **SDS's for Copper Omadine™ CR and Cuprous Oxide CR approved by KOSHA**
- **Products categorized as non-toxic substances**

Arxada TIME – innovative biofouling control

Novel marine antifouling products to meet most stringent regulatory challenges

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Cuprous Oxide CR

Arxada technology advantage

- Easy to formulate as dry capsules or solvent-based building blocks
- Manufacturing sites in APAC region, existing manufacturing process and infrastructure
- Cost-efficient encapsulation process, high throughput multi-ton scale
- Ability to “tune” the release rate and concentration in leaching layer of active component by altering capsule wall characteristics (chemistry, thickness, porosity etc.)

Controlled Release Testing Programs ongoing

Interim Results: Static Panel Efficacy Tests

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01

Performance testing ongoing at Arxada and with several customer accounts

- Ongoing efficacy tests with current 12-months data

02

Inhouse test overview:

- Ongoing efficacy tests at multiple sites globally (Florida, US and Japan)
- Various fouling conditions assessed

03

Comparison of formulations:

- **Paint Types:**
 - Rosin-based ablative
 - Silyl polymer
- **Tested antifouling biocides:**
 - Copper Omadine™ CR and Cuprous Oxide CR vs. non-encapsulated formulations (reference samples)

Key findings:

- No significant difference in antifouling efficacy between encapsulated and non-encapsulated Cu₂O/CuPT across both paint types
- Paint erosion tests also show no notable difference between the tested samples and the reference

Conclusions



- **Arxada offers solution that complies with new stringent Korea Chemical Control Act (CCA)/K-REACH regulations** limiting the content of free active substances to <1%
- **Encapsulation** significantly reduces exposure to biocides during paint preparation and hull application
- **For Copper Omadine® CR**, Arxada's microencapsulation technology is implemented using existing manufacturing processes and infrastructure, and is fully prepared for launch and commercialization—this is not an early-stage development, but a market-ready solution
- **Arxada's TIME microencapsulation technology** serves as a versatile platform capable of encapsulating a wide range of biocidal active ingredients including Oxides and Pyrithiones, enabling safer and compliant marine antifouling solutions tailored to evolving regulatory demands

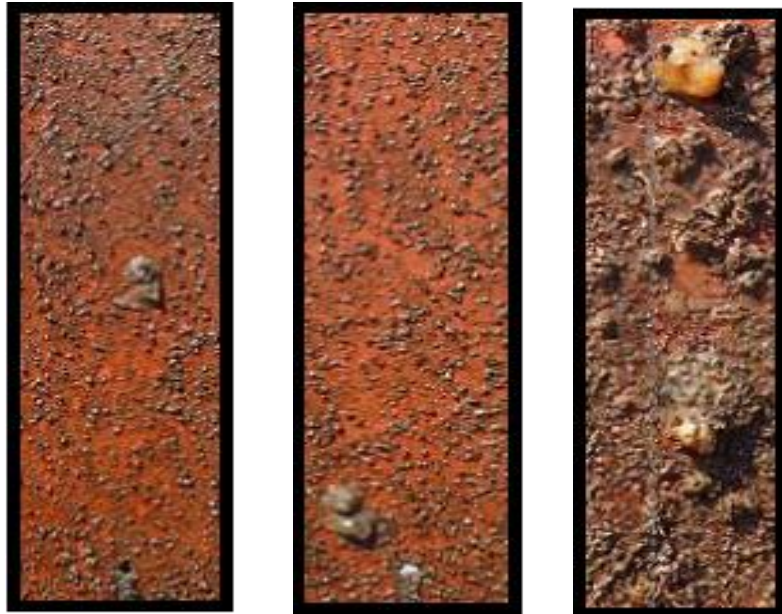
Thank you

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Interim Results: Static Panel Efficacy Tests

(12 months data)

Rosin-based paint

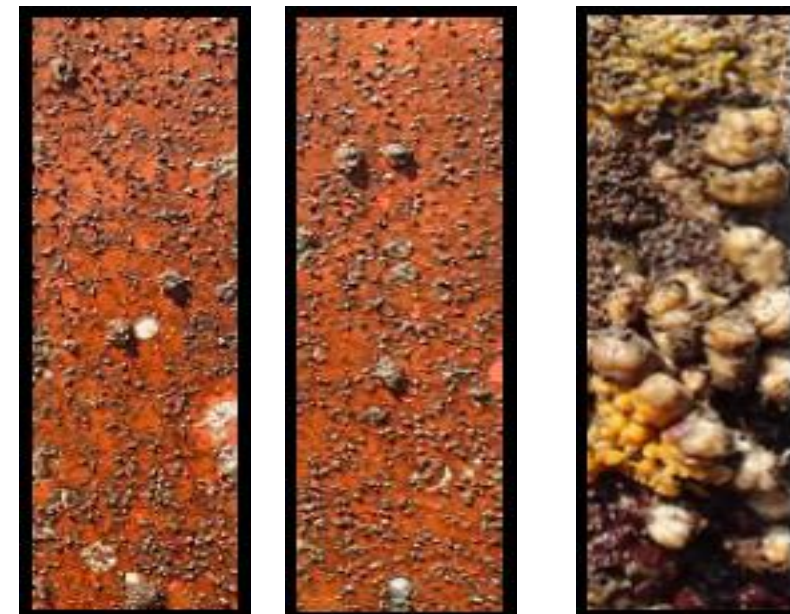


Cu₂O/CuPT
40%/4%

CR-Cu₂O/CR-
CuPT
40%/4%

Cu₂O/CuPT
0%/0%

Silyl Acrylate-based paint



Cu₂O/CuPT
40%/4%

CR-Cu₂O/CR-
CuPT
40%/4%

Cu₂O/CuPT
0%/0%