ZAF

Zosteric Anti-Fouling

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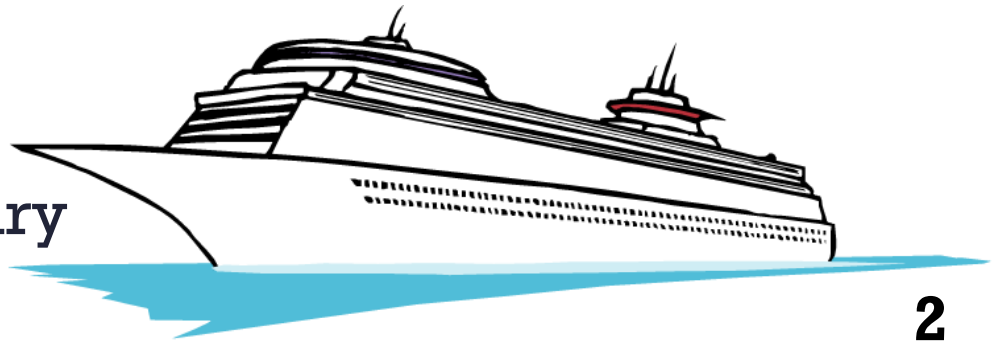
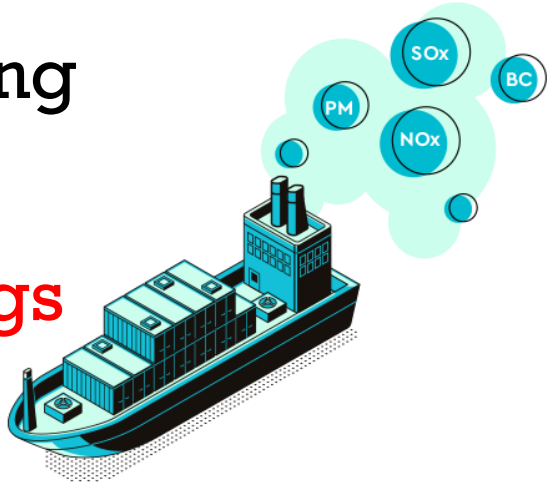
Importance of Ships

- 90% of all traded goods are delivered by ships
- Way of transportation for humans
- Sea border control, military

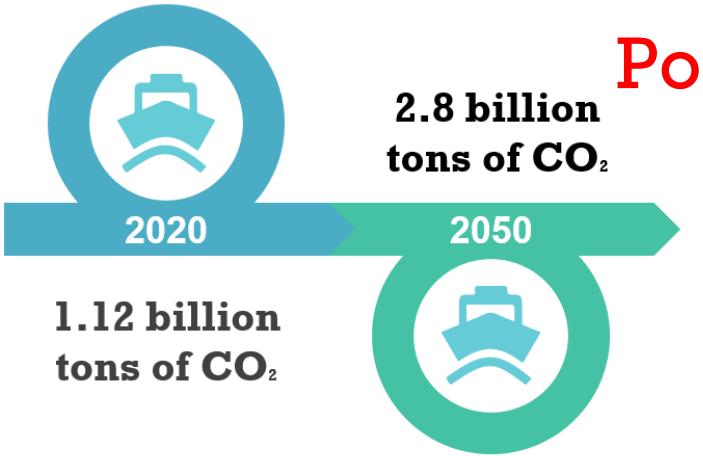


Challenges

Friction by biofouling



Pollution by coatings



CO_2 emissions

SOLUTION:

NATURE INSPIRED COATING

ZAF

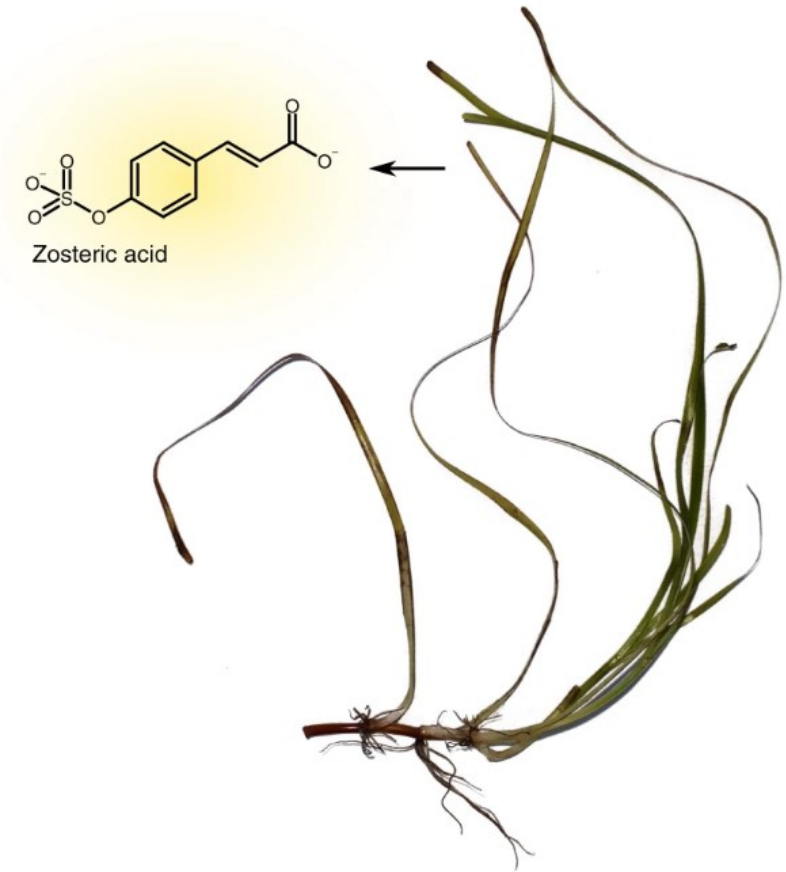
(Zosteric Anti-Fouling)

A hybrid mixture of silicone and zosteric acid, to ensure repellency of organisms at all times.

Eelgrass

- Zosteric acid is an anti-adhesive agent, **produced by eelgrass**

- Zosteric acid is natural, found to be less toxic than currently used antifoulants, such as TBT.



How is it made?

- Zosteric acid (ZA) is the product of sulfation of p-coumaric acid

- ZA and the silicone are mixed with catalysts and curing agents, such as pyridine, to ensure uniform distribution

- Methods of heating and disinfection are used to enhance the binding process of ZA and the silicone.

The Numbers

1. The average area of the cargo ship, in contact with the water, is 14,320 m^2

1. We need 52.27kg of Zosteric acid and 5,175kg of silicone to cover an average cargo ship for 10 years.

1. These amounts cost about 1,256,000$, but this investment would be an only 0.25% increase in annual costs.

Some more numbers

	Amount needed (kg)	Cost per kg ($)	Total cost ($)
Zosteric Acid	52.27	6,000	313,620
Silicone	5,175	187.5	970,312.5
Other chemicals	<0.1	<100	Not important
TOTAL			1,283,932.5

ZAF costs 1,283,932$ every 10 years -> it costs 128,393 $ every year

Why is it effective?

- Silicone alone won't be effective when the ship is docked at the shipyard. It ONLY works when the ship moves at certain speeds

- Zosteric acid alone dissolves in water very quickly, making it way too expensive

- In our case, we mix both zosteric acid and silicone - proven that it **dissolves very slow** and **is still effective when the ship docks**

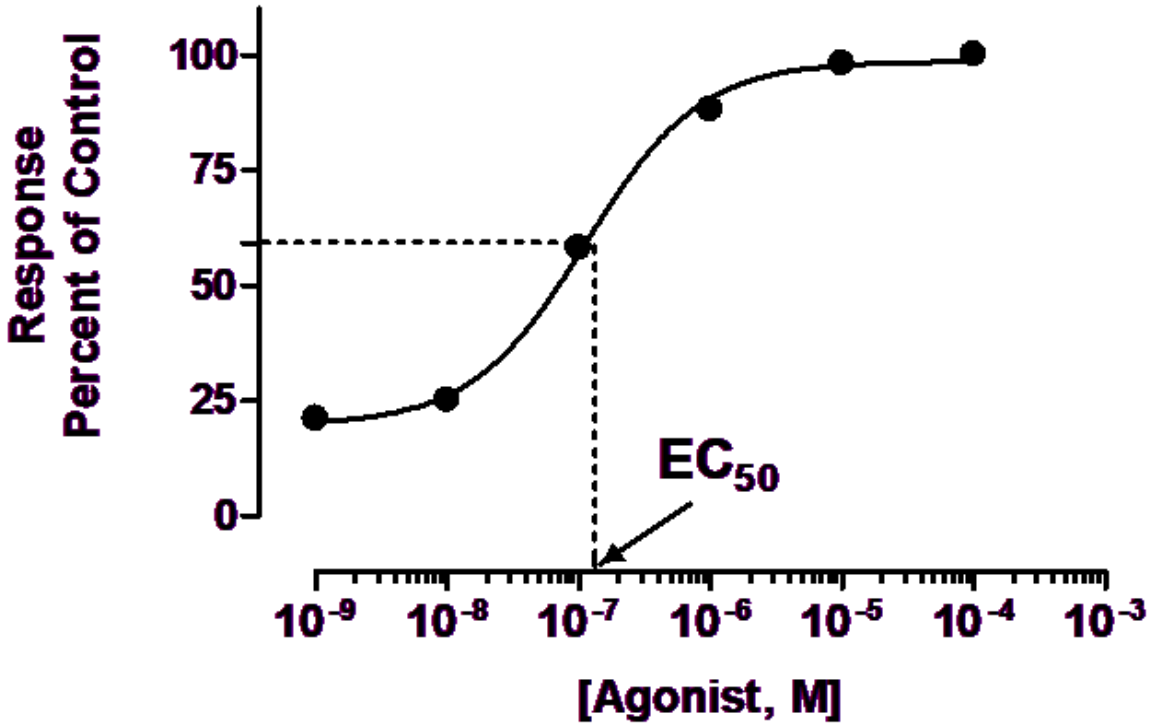
Promising results

Harmless to the environment or humans

Repells 90% of bacterias, fungi, algae, etc.

0.25% increased annual expenditure ($128K per year)

Lasts 5 times longer (~10 years)



EC50 of currently used coatings:

0.3-4 mg/L

EC50 of zosteric acid:

440 mg/L

CONCLUSIONS & IMPACT

- Current anti-fouling solutions are **hazardous, expensive** and **wasteful**
- We offer ZAF – **eco-friendly**, fuel and money **saving**, new way of antifouling painting

THANK YOU

Do you have any questions?

SOURCES

https://www.nature.com/articles/s41467-019-12022-x

https://www.researchgate.net/publication/226101299_Zosteric_acid-An_effective_antifoulant_for_reducing_fresh_water_bacterial_attachment_on_coatings

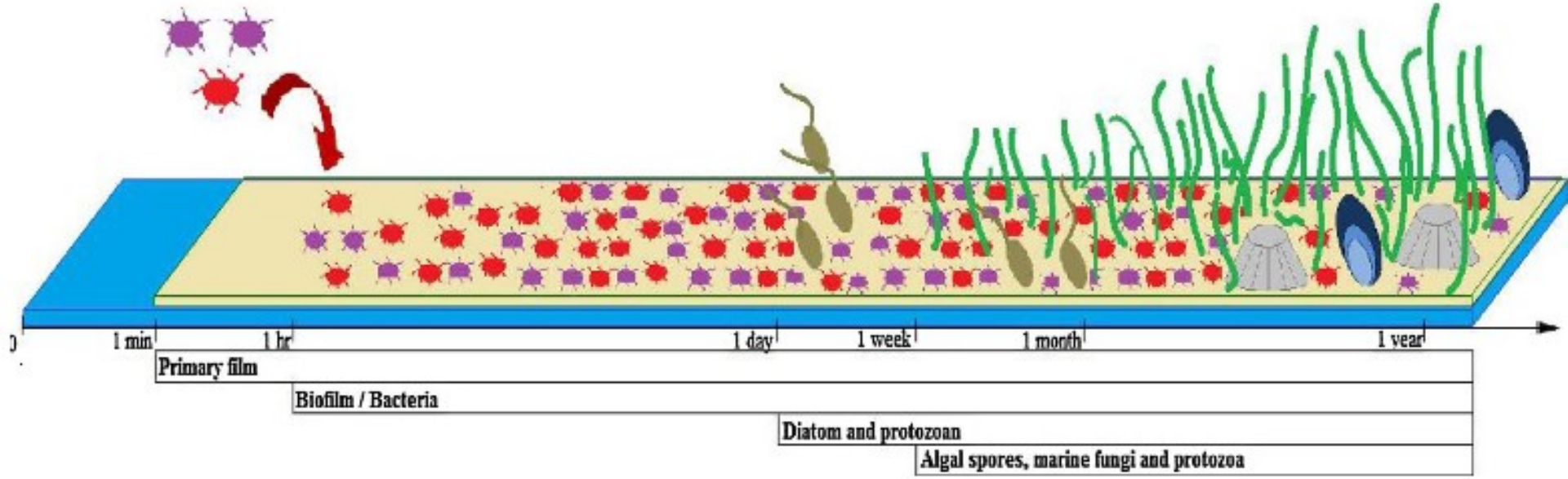
https://www.theguardian.com/environment/2008/feb/13/climatechange.pollution

http://www.diva-portal.org/smash/get/diva2:1073109/FULLTEXT01.pdf

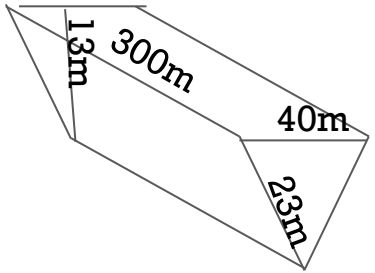
https://pubs.acs.org/doi/abs/10.1021/bm049962e

https://www.sciencedirect.com/science/article/abs/pii/S0927776504003418

https://www.nature.com/articles/srep42424


0
1 min
1 hr
1 day
1 week
1 month
1 year
Primary film
Biofilm / Bacteria
Diatom and protozoan
Algal spores, marine fungi and protozoa

Additional data



average cargo ship size

$$S_{ship} = 2\ triangles + 2\ \text{rectangles}$$

$$= 2 * \left(\frac{1}{2} * 40 * 13\right) + 2 * (300 * 23) = 14{,}320_{m^2}$$

$$\frac{0.1_{\mu g}}{day}\ for\ 1_{cm^2}$$

$$\frac{0.1x_{\mu g}}{x_{days}}\ for\ 1_{cm^2}$$

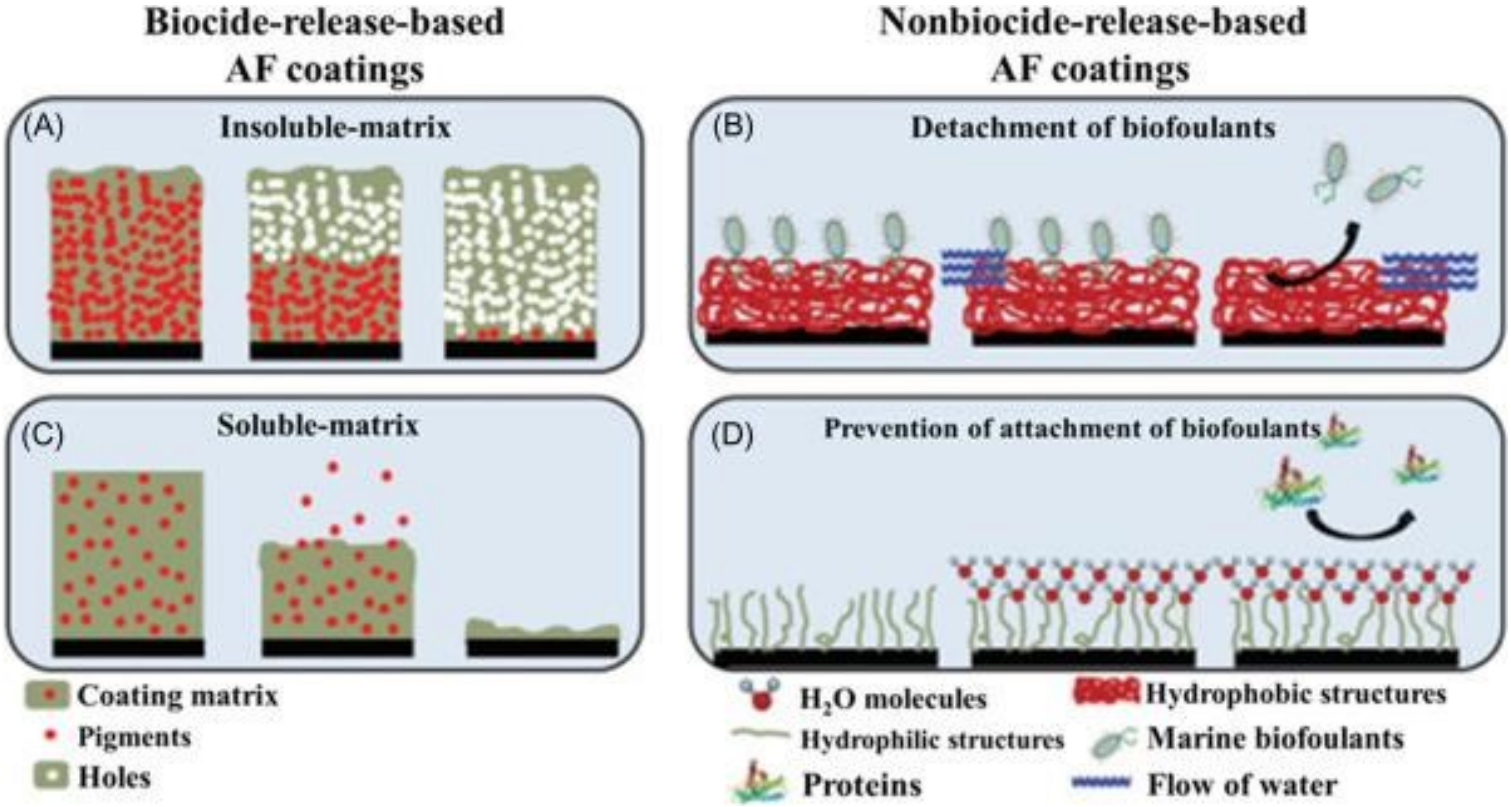
$$\frac{0.1x * 14320 * 100^2{}_{\mu g}}{x_{days}}\ for\ 14{,}320_{m^2}$$

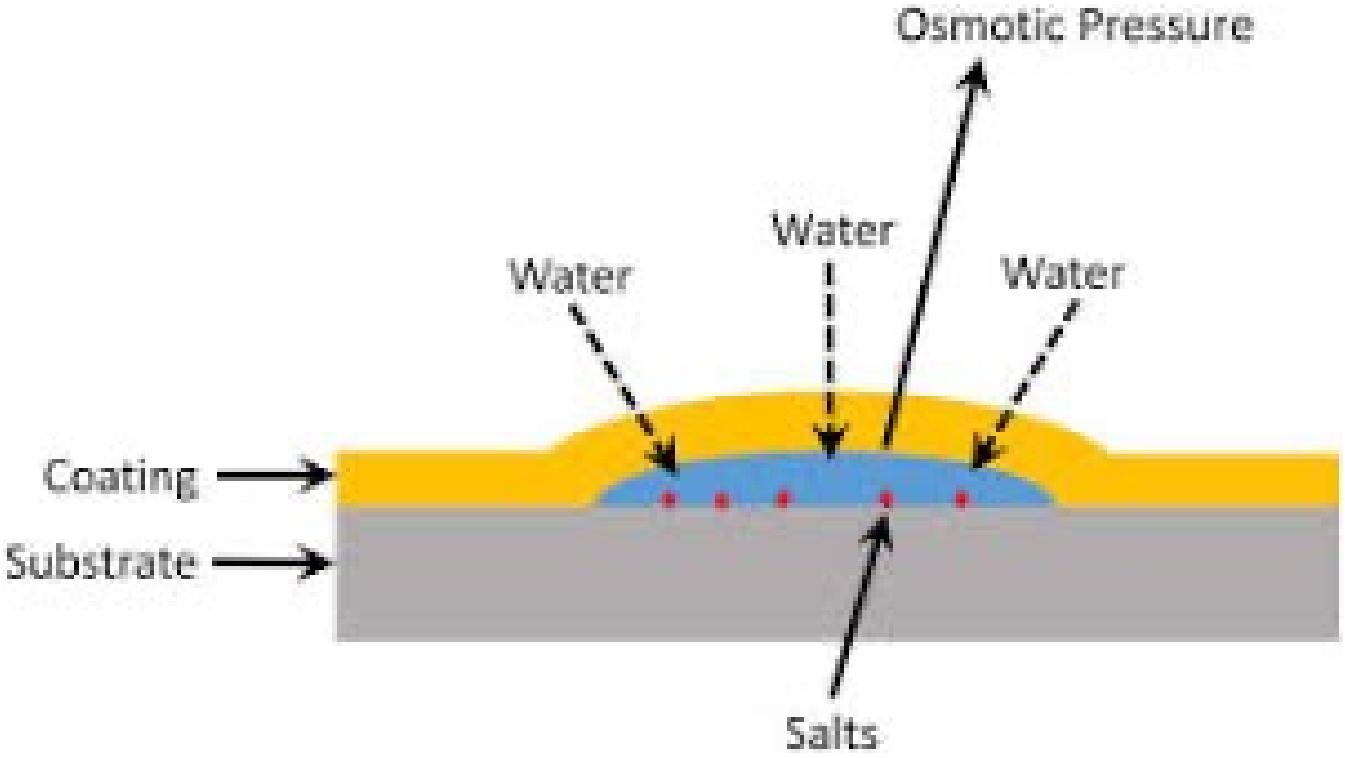
$$\frac{0.01432x_{kg}}{x_{days}}\ for\ a\ ship$$

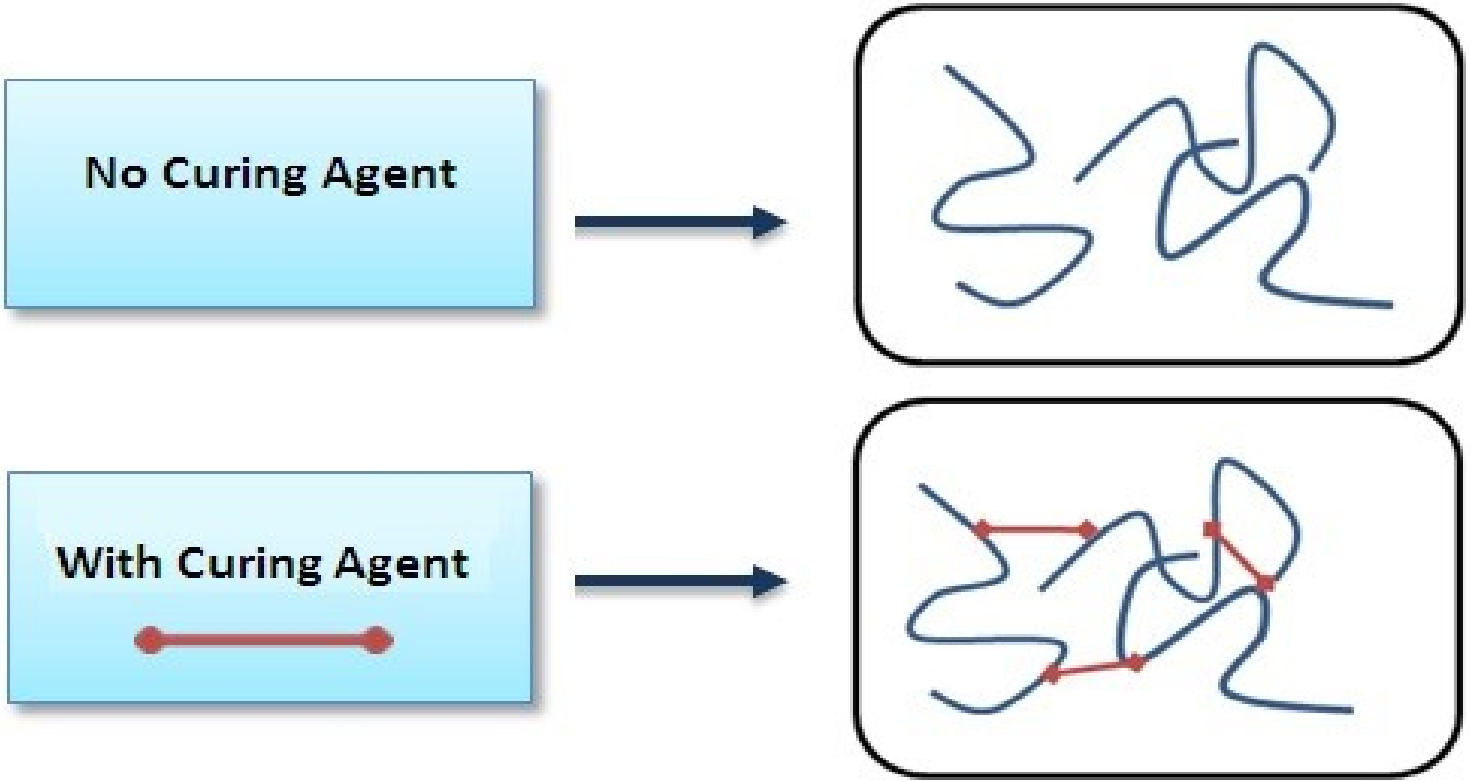
To make it last for 10 years (5 times more than average coating),

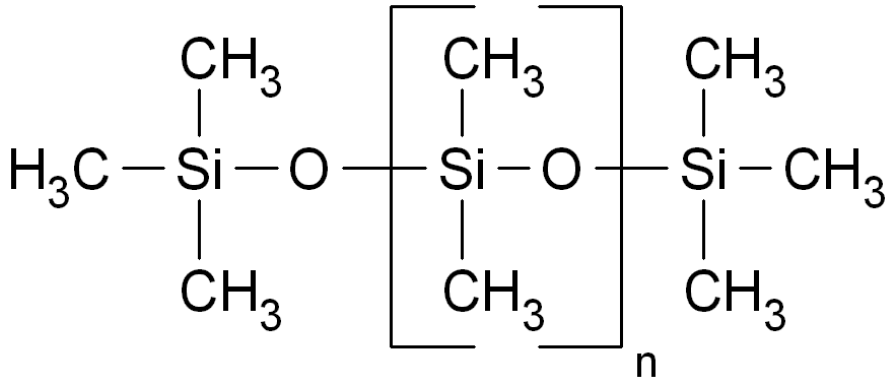
we need to assume $x = 10 * 365 = 3650_{days}$

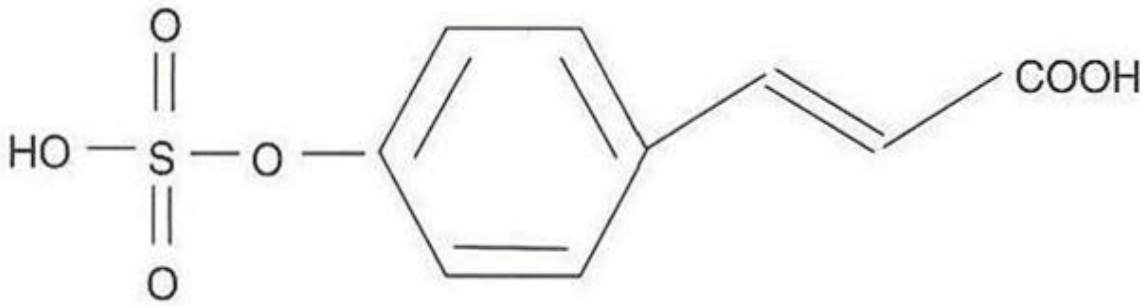
Eventually we get that 52.27_{kg} are needed for 1 ship for 10_{years}


Biocide-release-based
AF coatings
Nonbiocide-release-based
AF coatings
(A)
Insoluble-matrix
(B)
Detachment of biofoulants
(C)
Soluble-matrix
(D)
Prevention of attachment of biofoulants
Coating matrix
Pigments
Holes
H2O molecules
Hydrophilic structures
Proteins
Hydrophobic structures
Marine biofoulants
Flow of water


Osmotic Pressure
Water
Water
Water
Coating
Substrate
Salts


No Curing Agent
With Curing Agent


CH3
H3C
Si
O
Si
O
Si
CH3
n


O
HO
S
O
O
COOH