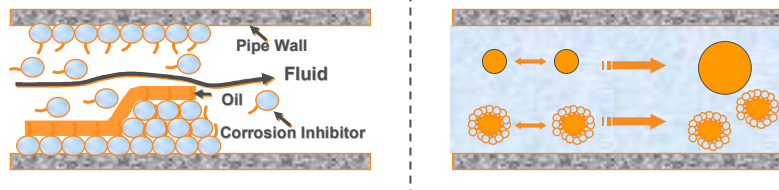


Green Corrosion Inhibitor as Solution to the Environmental Challenges

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Corrosion Inhibition Mechanism



- ▶ Works by forming a protective film on the metal surface that prevents water - metal communication.
- ▶ Residue of corrosion inhibitor in produced water will form a laminary film that surround the oil droplets → hardly to conjugate, and harder to separate. As the result, we will face the problems in our produced water quality.

Corrosion Inhibitor can give bad impact to the environment due to;

- ▶ **The hazardous characteristics of it's component (solvent, additives, and active ingredients), or**
- ▶ **It's ability to create stable oil in water emulsion**

Environmental Challenges



- ▶ As a good example, North sea region is one of the most prominent region which has imply the environment requirements for its production chemicals
- ▶ Any chemical in this region must meet at least two of the following three criteria:
 - Biodegradation greater than 70% in 28 days (OECD 301A, 301E) or greater than 60% in 28 days (OECD 301B, 301C, 301F or 306)
 - Toxicity greater than 10 mg/l (LC50 or EC50)
 - Bioaccumulation log Pow less than 3 (unless mol wt >600 then not applicable and bioaccumulation will be 0)
- ▶ If a product does not meet the above criteria,
 - then it will be given a substitution warning, and
 - permission to use the product will not be granted or temporary permission will be given.

3 - Reference, date, place



Green Corrosion Inhibitor



- ▶ Green Chemistry: “The invention, design, and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances.”
- ▶ At minimum the following principles shall apply
 - Less Hazardous Chemical Syntheses
 - Design Safer Chemicals
 - Safer Solvents and Auxiliaries
 - Design for Degradation
- ▶ conventional inhibitor chemistry (i.e. amines/imidazolines/quats) is recognized to be toxic to marine organisms,
- ▶ modification of this chemistry can result in actives of lower toxicity without compromising performance.
- ▶ A wealth of information now exists on chemical actives that display more favorable environmental properties.
- ▶ Green corrosion inhibitor is becoming a serious point that keep developing and improving

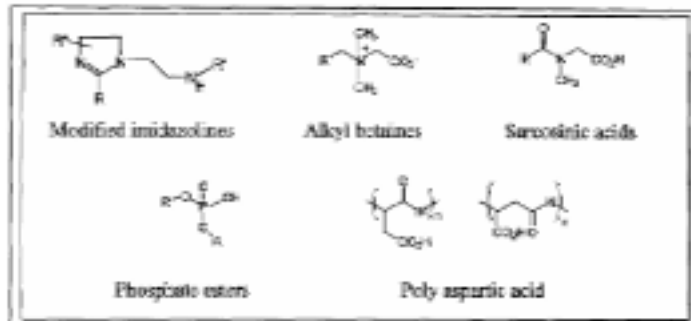
4 - Reference, date, place



Green Corrosion Inhibitor



Green Components



- ▶ **Chemical's Manufacturers have reported a lot of success stories on the application of Green Corrosion Inhibitor**
- ▶ **The success is based on it's ability to protect pipelines from corrosion and keep maintaining the produced water quality within the required specification**

5 - Reference, date, place



Selection of Corrosion Inhibitor



- ▶ **Corrosion Inhibition Performance**
 - Static Corrosion/Bubble Test → pass criteria is 90% of corrosion protection Efficiency
 - Galvanic Corrosion → pass criteria is 80% of corrosion protection Efficiency
 - Jet Impingement
 - Thermal Stability
- ▶ **Impact to the Produced Water Quality**
 - Emulsion Tendency
 - Foaming Tendency
 - Mini Wemco (Floatation) Test
- ▶ **Environmental Selection**

6 - Reference, date, place



Environmental Selection of Corrosion Inhibitor



- ▶ **TOTAL E&P INDONESIA** has adopted the North sea policy for selecting the chemicals based on given information
 - Eco Toxicity
LC50, EC50, NOEC, PNEC on 3 relevant species (shrimp, fish, sediment species)
 - Biodegradability
28 days biodegradation test
 - Bioaccumulation
Log de Ko/w + molecular weight
 - Hazardous Components composition
- ▶ **Requirements for Vendor:**
 - Data must be reliable (certified lab, origin identified)
 - Data on whole mixture or ALL hazardous components
 - HOCNF is a recommended format

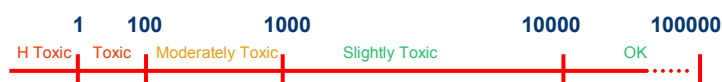
7 - Reference, date, place



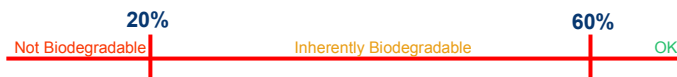
Environmental Selection of Corrosion Inhibitor



▶ Toxicity (LC 50, 96 h, in ppm)



▶ Biodegradability (after 28 days)



▶ Bioaccumulation (log Ko/w)

- MW > 600 for ALL hazardous components **OK**
- MW < 600 and mean Ko/w < 3 **OK**
- MW < 600 and mean Ko/w > 3 **NO**

8 - Reference, date, place



Environmental Selection of Corrosion Inhibitor



Forbidden Substances List

organohalogen compounds, organophosphorus compounds, organotin compounds, carcinogenic properties in or via the aquatic environment, mercury, cadmium and their compounds, persistent synthetic polymers and plastics, arsenic, lead, copper, zinc, nickel, chromium, antimony, tin, uranium, vanadium, cobalt, thallium, tellurium, silver; and their compounds, toxic or persistent organic compounds of silicon, and substances which may give rise to such compounds in water, cyanides.

9 - Reference, date, place



Environmental Selection of Corrosion Inhibitor



Environmental Risk Assessment Principle

Assessment depends on Nature of the Hazard, Quantity released to the Environment and Sensitivity of the Environment :

► Is the chemical Hazardous or not ?

- 1) It is going to be released in the environment, if YES how much ?
- 2) What is the sensitivity of the concerned Environment ?

- A)Swamp – HIGH sensitivity
- B)Onshore – HIGH sensitivity
- C)Offshore – MEDIUM sensitivity

10 - Reference, date, place



Environmental Selection of Corrosion Inhibitor



1st Round rules

Chemical reaching the Environment

AND

- ▶ NO DATA – Chemical is not considered – **REJECTED**
- ▶ Some Data Missing – Chemical is considered – **missing data are assumed negative**
- ▶ Not validated data are considered missing– Chemical is considered – **data are assumed negative**
- ▶ Presence of forbidden substance > 5 % – **REJECTED**
- ▶ All data available and validated – **considered for further evaluation**

11 - Reference, date, place



Environmental Selection of Corrosion Inhibitor



2nd Round rules

Chemical	Toxicity	Biodeg.	Bioacc.	Forbid. Comp.	Results
Chem 1	High	<20%	>3		REJECTED
Chem 2	OK	<20%	>3		REJECTED
Chem 3	High	OK	OK	BTEX	REJECTED
Chem 4	Medium	OK	Medium		Further Study
Chem 5	Medium or HIGH	OK	OK		OK or Further Study
Chem 6	OK	OK	OK		OK

12 - Reference, date, place



Environmental Selection of Corrosion Inhibitor



Last round Criteria

- ▶ **Evaluate possible concentration released in the Environment :**
 - Ko/w
 - Usage concentration
 - Total Quantity used

- ▶ **Evaluate precise Hazardousness of the Chemical :**
 - Determination of NOEC and PNEC needs precise and multiple ecotox data

- ▶ **Evaluate Risk :**
 - Take into account sensitivity of the Environment
 - Subjectivity of the Environmentalist

13 - Reference, date, place



TOTAL E&P INDONESIE EXPERIENCE



- ▶ **Selection Result (2004); Based on three selection categories, TI have the best product which gave**
 - Corrosion Protection Efficiency higher than 90%
 - Galvanic Corrosion Protection Higher than 80%
 - Emulsion completely break on ?? Minutes
 - Biodegradability ~ 97.31%
 - Bioaccumulation; Kow ~ 2.23
 - Eco-toxicity LC50 96h : Panaeus monodon (21.71)

- ▶ **Field Application Result**
 - Total Petroleum Hydrocarbon content in water is less than 20 ppm
 - Corrosion rate is kept below 1-4 mpy

14 - Reference, date, place



CONCLUSION



- Green corrosion inhibitors are available - and by having proper selection process - could provide the same protection performance as conventional inhibitors
- User Company must socialize the environmental requirements to Vendor. Vendor must supply the complete and proper data for the evaluation
- More stringent requirements are needed to ensure all submitted products during the selection are met with the environmental requirements

15 - Reference, date, place

