Lab Evaluation of the product Greenzyme®

Nature of the product.

Apollo Greenzyme 280, as provided.

Action Mechanism.

- Acts on the wettability of the rock. Adsorbs grains and expels the oil that is adhered to them. Would make the rock strongly wet by water.

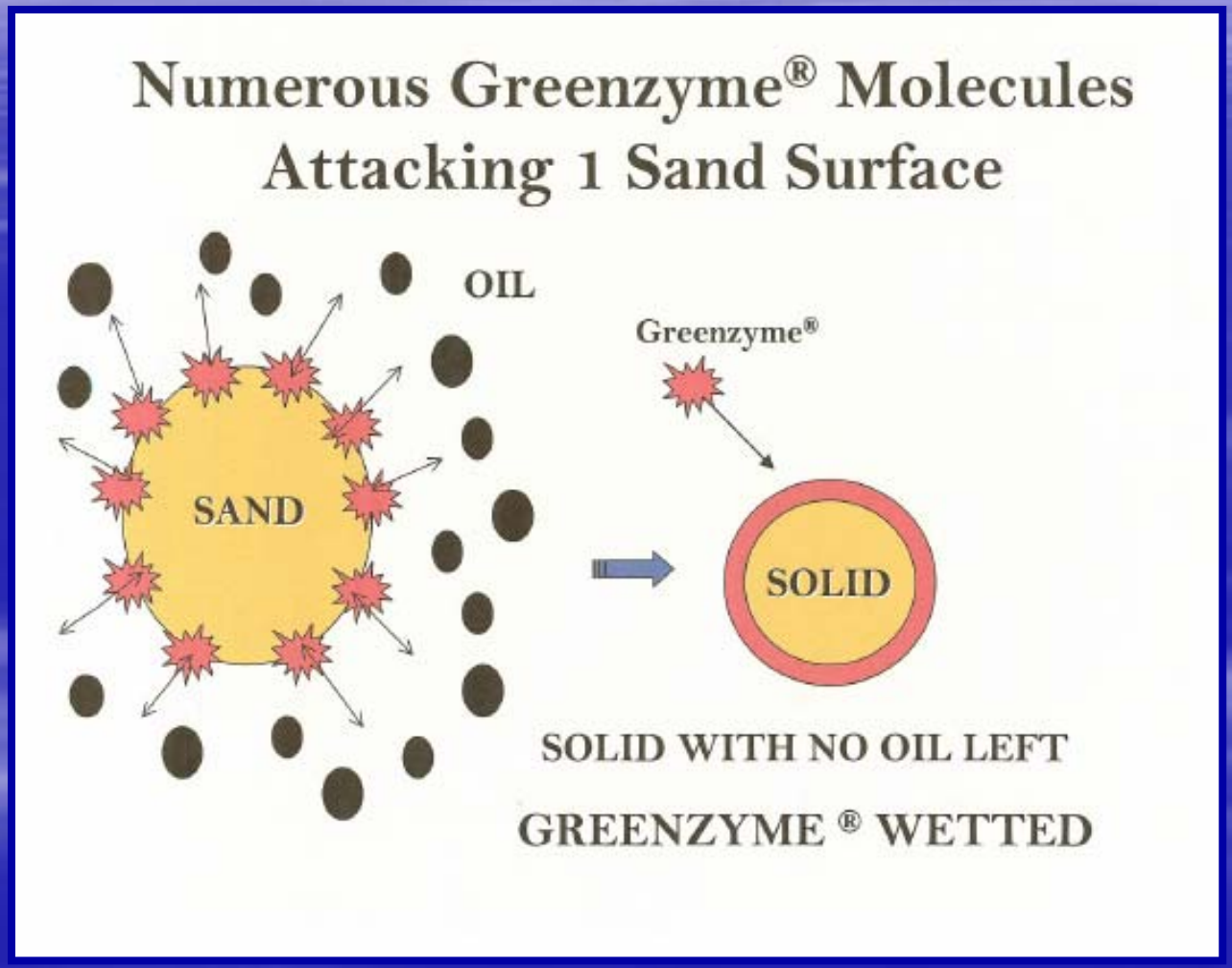
- The oil stuck to the rock has to have *mobility*. It may not be in the solid state, otherwise the product can not evict it from the surface of the grains.

- In case of the oil condition is *immobility* it will be necessary to heat the formation or to inject solvents.

- According to the supplier, it does not crack hydrocarbons.

The product does not form emulsions and is insoluble with the oil

Action Mechanism.



Evaluation of the Effectiveness

Heavy oil – Dynamic test *

White (water) ; 48 h

Gzyme 4% v/v ; 3 h

Gzyme 4% v/v ; 48 h

* Agitation in the Shaker 30°C

Evaluation of the Effectiveness

Heavy oil – Static Test*

White (water) ; 6 days

Gzyme 4% v/v ; 6 days

* Without stirring and temperature controlled at steady 30°C

Evaluation of the Effectiveness

The vacuum residue (asphaltic material)

The solid material was transformed into a viscous paste, with xylene.

Evaluation of the Effectiveness

The vacuum residue (asphaltic material) – Dynamic test.

White (water) ; 3 h

Gzyme 4% v/v ; 3 h

Evaluation of the Effectiveness

The vacuum residue (asphaltic material)– Static Test

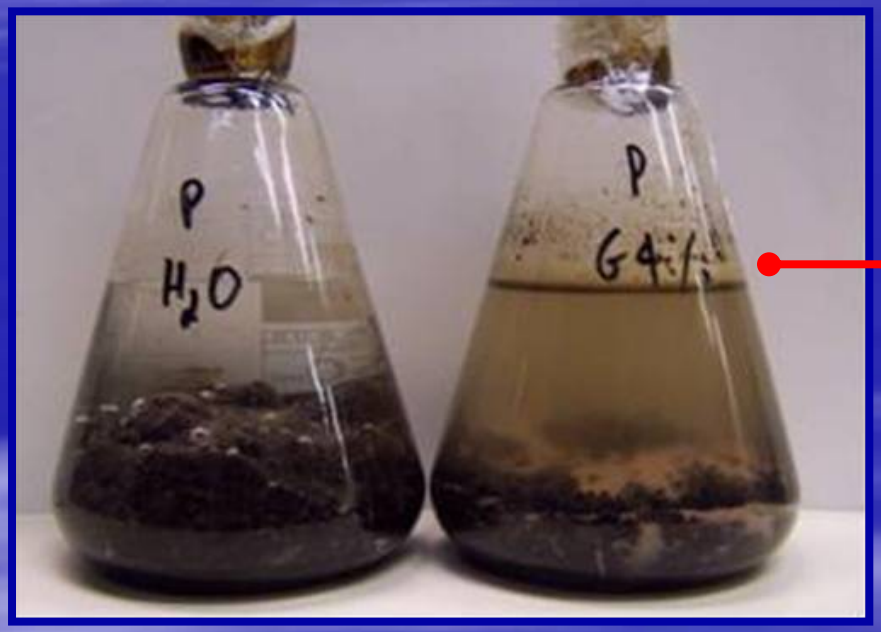
White (water) ; 72 h Gzyme 4% v/v ; 72 h

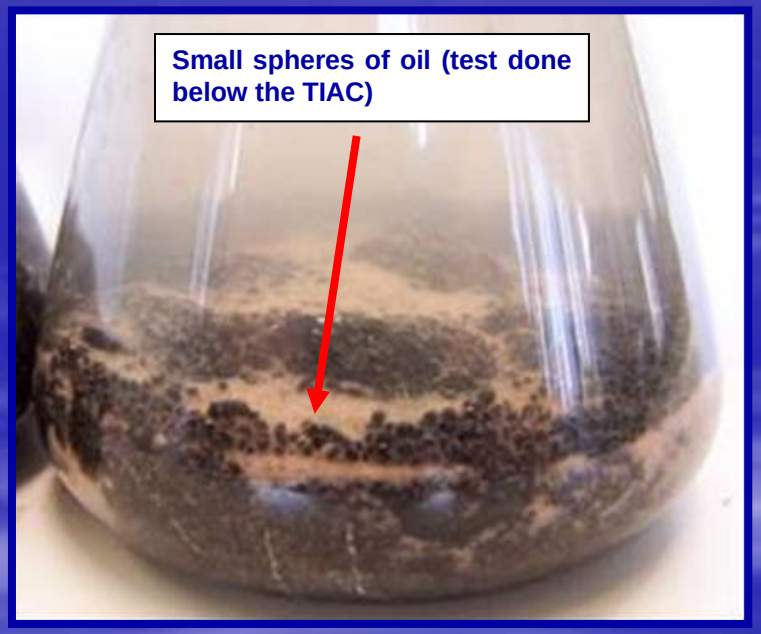
Evaluation of the Effectiveness

Paraffinic Oil

Evaluation of the Effectiveness

Paraffinic Oil – Dynamic Test





White (water) ; 3 h Gzyme 4% v/v ; 3 h

Evaluation of the Effectiveness

Paraffinic Oil - Static Test

Small spheres of oil (test done below the TIAC)

White (water) ; 72 h

Gzyme 4% v/v ; 72 h

Evaluation of the Effectiveness

Bleached Paraffin - Dynamic Test

White (water) ; 3 h Gzyme 4% v/v ; 3 h

White (water) ; 72 h Gzyme 4% v/v ; 72 h

Evaluation of the Effectiveness

Bleached Paraffin – Dynamic Test

A (sand + water) ; 72h

Grains with paraffin

B (sand + Gzyme 4%) ; 72h

Grains without paraffin

Evaluation of the Effectiveness

Bleached Paraffin - Static Test

White (water) ; 72 h Gzyme 4% v/v ; 72 h

White (water) ; 72 h Gzyme 4% v/v ; 72 h

Evaluation of the Effectiveness

Comparison with surfactant - Dynamic Test

Anionic Surfactant; 24 h

Gzyme 4% v/v ; 24 h

Evaluation of the Effectiveness

Comparison with surfactant- Static Test

Anionic Surfactant ; 3 days

Gzyme 4% v/v ; 3 days

Evaluation of the Effectiveness

Comparison with Cationic Polymer - Dynamic Test

Non-ionic surfactant + Cationic Polymer ; 5 days

Gzyme 4% v/v ; 5 days

Evaluation of the Effectiveness

Comparison with Cationic Polymer - Static Test

Non-ionic surfactant +
Cationic Polymer; 5 days

Gzyme 4% v/v ; 5 days

Evaluation of the Effectiveness

- The product is itself unstable, forming an off-white precipitate which returns after a few days of its removal.
- The instability seems to worsen in the presence of divalent cations such as Ca+2.
- However, this instability seems not to undermine its action.
- The product has been stable under extreme conditions of pH (pH = 1 and 12) temperature (200C), shearing and salinity.
- His performance, however, was slower after these treatments.

Evaluation of the Effectiveness

Original
GreenZyme

Greenzyme
After centrifugation

Original Greenzyme after 3 Weeks

Greenzyme + Ca+2 1 kppm after 3 weeks

Evaluation of the Stability

Water

Gzyme 4%

Gzyme 4% ; pH=1

Gzyme 4% ; pH=12

Gzyme 4% ; Salt

Gzyme 4% ;
Temp. 200C

After 6 days

Conclusion.

- The product can effectively move oil from the surface of grains of sandstone, provided that these hydrocarbons are above the point of fluidity.
- The mechanism of operation seems to be a reversal of wettability, making grains strongly wet by water.
- The product diluted to 4% v / v Tuesday showed satisfactory performance in sand contaminated with heavy oil, both paraffinic and asphaltenic.
- Submitted to extreme conditions of pH, temperature, salinity and shearing, the product continues to run that, albeit slower. The temperature limit tested was of 200C.
- The product presents instability, a forming a precipitate after resting for a few days. The presence of divalent cations seemed to have aggravated the problem.

Recommendations

- It is recommended to make field tests, with preliminary laboratory experiments being able to demonstrate the effectiveness of the Greenzyme performance with the oil, the rock and, especially, the formation and dilution waters of the product that will be specifically used in the targeted-field . The composition of the water was the factor that most impaired the performance of the product in these preliminary tests, more than extremes changes of temperature and pH.

- The selection of the targeted-fields should follow the recommendations of the supplier.

- Because of their unstable nature (formation of hasty), it is recommended that the product be filtered immediately prior to injection in the reservoir.