Unlocking Enhanced Oil Recovery for Harsh Reservoir Conditions

EOR-Grade Scleroglucan Technologies

Cargill®

Introducing Cargill's EOR-Grade Scleroglucan technologies

Designed for demanding EOR applications, when harsh reservoir conditions require performance in high salinity at 80-120°C

Companies are continually seeking ways to cost effectively increase production from known reservoirs before looking to higher cost options.

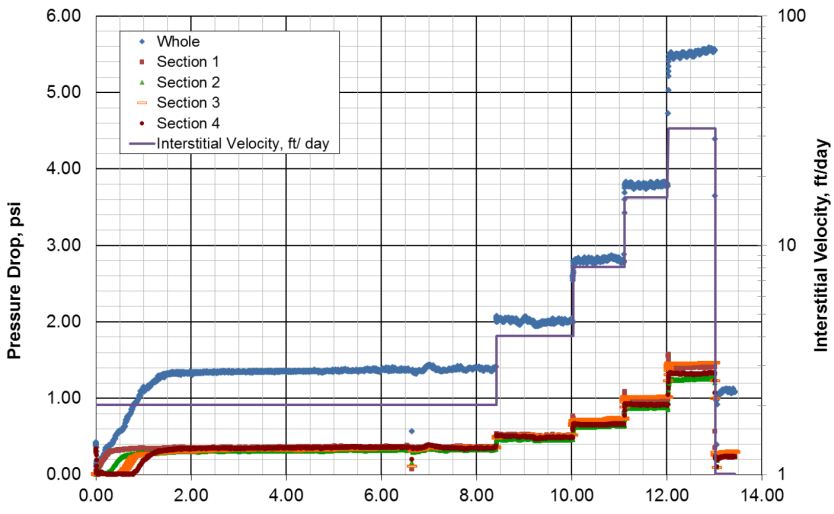
Many known reservoirs are hot and salty which makes enhanced oil recovery very challenging with existing technologies. The demand for a cost-effective polymer that withstands such harsh EOR environments has driven a number of emerging technologies, yet all have been limited in adoption to date because of poor functional performance, limited supply and/or high cost in use.

Until now.

Cargill's EOR-grade scleroglucan technologies have high active content and remain stable in high temperature and hard brines without losing viscosity or filterability. These characteristics make Cargill's EOR-grade scleroglucan well-suited for harsh environments; particularly in off-shore applications.

Cargill's EOR-grade Scleroglucan prototypes have demonstrated high viscosity yield, high shear stability, and high thermal stability compared to Polyacrylamides and Xanthan gum.

Furthermore, the viscosity and shear stability of scleroglucan biopolymer can afford at least a 6-fold product utilization advantage* over traditional synthetic polymers. Its high dosage efficiency not only makes tertiary recovery feasible but also economically attractive. Cargill's EOR-grade scleroglucan can be efficiently produced in large quantities and delivered worldwide, wherever our customers require.

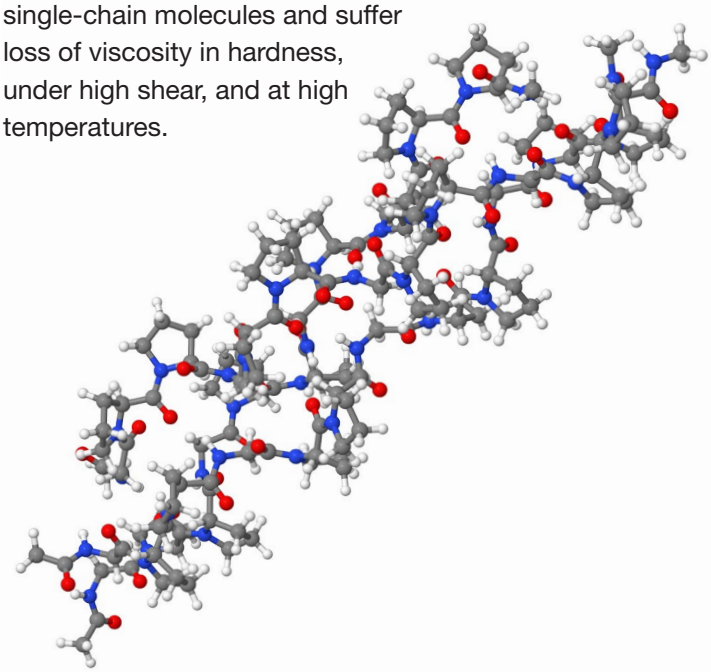


AD10-01 Coreflood, Pressure Drop Data during the Polymer Injection, plotted on a log scale.

Source: "The Development and Evaluation of Polymers for Enhanced Oil Recovery", Vincent Lee, 2015, Master's Thesis, University of Texas at Austin.

Differentiating features of Scleroglucan deliver the viscosity retention required to perform in hot and salty environments

Scleroglucan's unique non-ionic, triple helix molecular structure enables the viscosity performance demanded in harsh conditions. The consistent high viscosity performance of scleroglucan won't drastically change with temperature, salinity and hardness. As a comparison, Polyacrylamides are typically ionic, single-chain molecules and suffer loss of viscosity in hardness, under high shear, and at high temperatures.



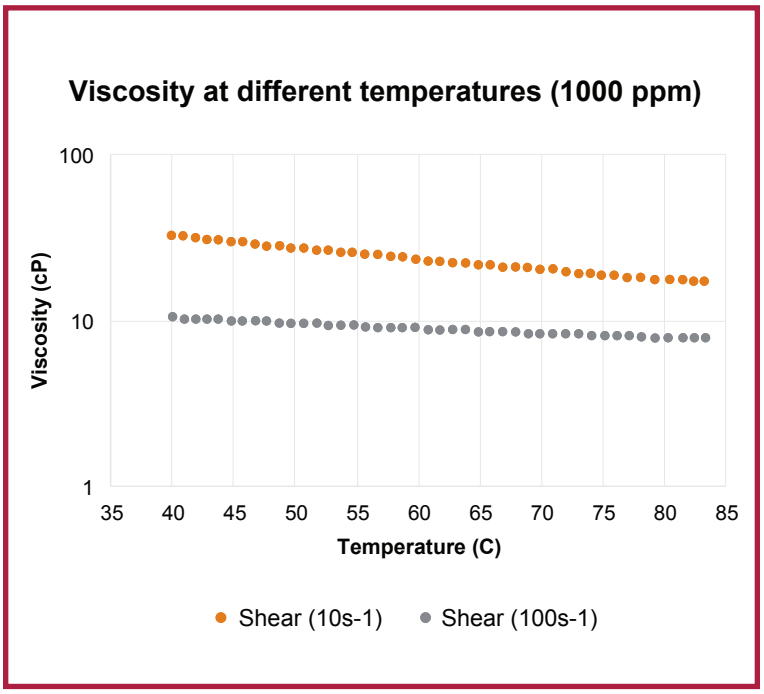
* Based on laboratory data demonstrating higher viscosity yield, less thinning at elevated temperatures, and less shear degradation.

1. Temperature – we can deliver EOR solutions for hot reservoirs (80-120C)
2. Viscosity – we can deliver viscosity independent of salinity and hardness
3. Filterability – we can deliver EOR solutions down to 250+ mDa permeability
4. Shear stability – our viscosity is stable up to 200,000 s-1
5. Rapid make down and retained viscosity – our solid can be put into a solution for injection in less than two minutes

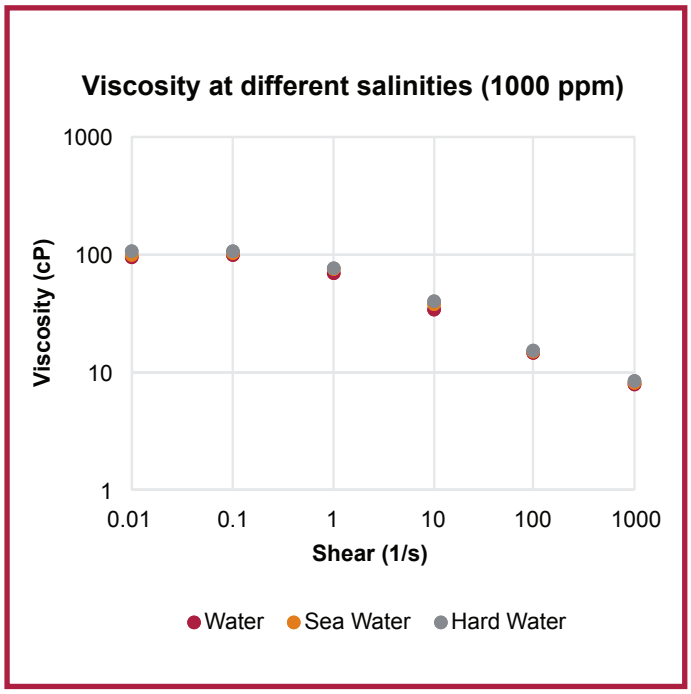
CARGILL'S EOR-GRADE SCLEROGLUCAN PROTOTYPE PERFORMANCE

Key Application Requirement	Functional Behavior
Very High Viscosity	350ppm polymer gives 10cPs at 7.3 s-1
High Thermal Stability	Viscosity is stable up to 120° C (in anaerobic conditions)
Rapid Solubilization (no dwell time needed)	Dissolution time less than 2 min in salt water
Filterable to 0.8 um	Filterability Ratio <1.1 at 0.8µm or higher
Excellent Shear Stability	No viscosity loss at 200,000 s-1 shear (API RP63 test)
Not sensitive to salinity or hardness	No viscosity loss at 250,000 TDS & 15,000ppm hardness
Core Flood Performance	Core flood with 80 cP apparent viscosity scleroglucan on 1.8 Da Bentheimer rock in Arabian gulf sea water at 95 °C produced stable pressure, undetectable levels of adsorption, and comparable breakthrough to the brine solution.
Environmental Compatibility	EOR-grade scleroglucan is a bio-based, non-hazardous polysaccharide with no special handling requirements
High Active Content Provides Improved Logistics	Pure solid form

Scleroglucan offers high viscosity at a low dosage rate and remains stable in harsh conditions.



Source: Cargill lab tested.



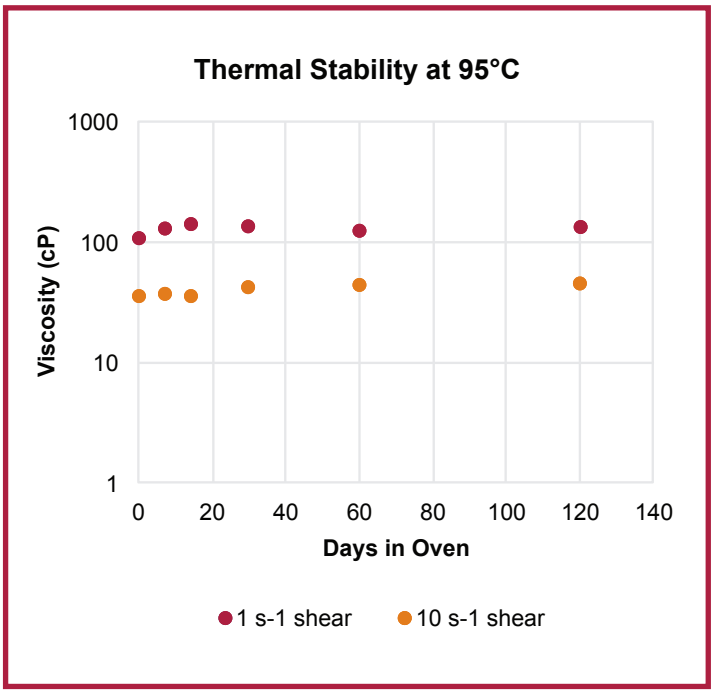
Source: Cargill lab tested.

Cargill is a global leader in industrial-scale fermentation and technology development

Cargill has more than 30 years of scleroglucan production expertise supplying customers in oilfield, personal care and other industrial applications. We are a leading producer and supplier of hydrocolloids including biopolymers.

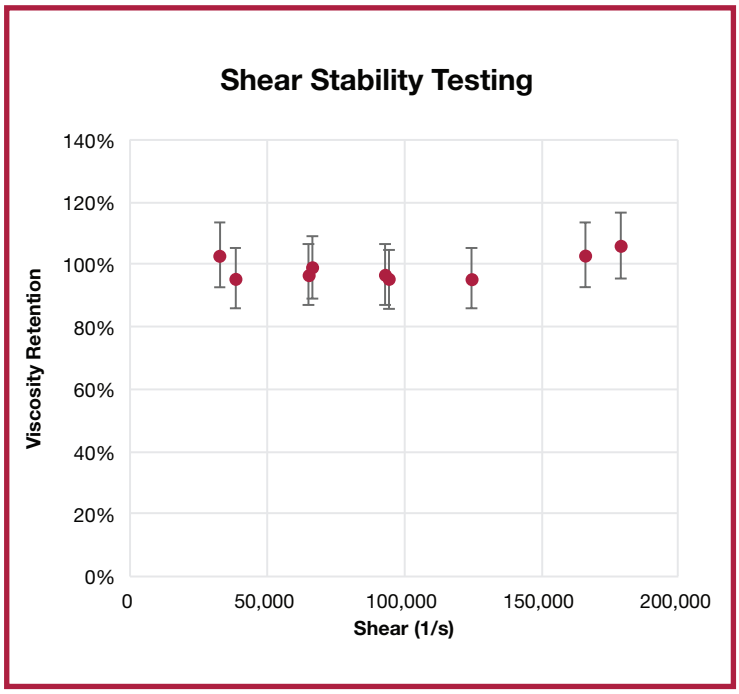
Cargill is the only current commercial producer of scleroglucan worldwide and operates many large-scale industrial fermentation plants around the globe to service our customers' demands for innovative solutions.

Scleroglucan retains functionality in high temperatures 80-120°C.



Source: Cargill lab tested.

Scleroglucan is stable in high shear environments common in many EOR projects, especially off-shore. Solid scleroglucan can be re-solubilized in less than two minutes.



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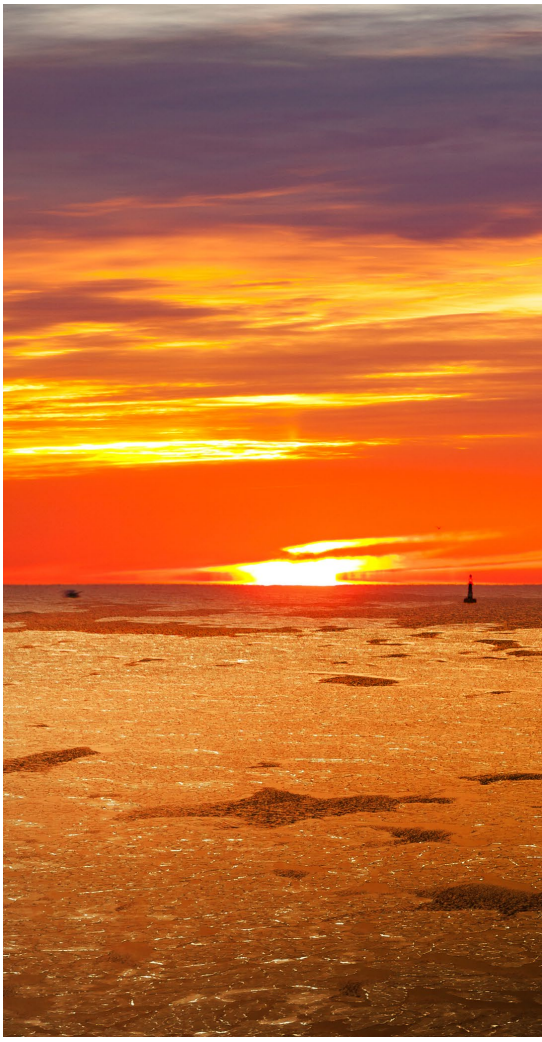

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