E-Seal Technology

A new paradigm for leaky well remediation

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Value Proposition

E-Seal Technology from Los Alamos National Laboratory offers a transformative answer to the world's aging wells. E-Seal is a liquid sealant that flows like water until an applied electric field steers its engineered micelles directly into the sub-millimeter cracks where cement and polymer treatments physically cannot reach, then transforms into a durable, jammed plug that holds even after the power is switched off. E-Seal has the ability to mitigate galvanic corrosion of well casings and an AI-guided control system that adjusts voltage in real time as the seal forms.

Technology Readiness Level 3

IP Information for S-197080

U.S. Patent pending

Contact Information

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Overview

E-Seal begins as a low-viscosity, water-like fluid carrying specially engineered surfactant micelles and stabilized colloidal particles. When an electric field is applied across the target zone, three electrokinetic forces act in concert: Electrophoresis pulls the charged micelles toward the fracture, electro-osmosis drives bulk fluid flow into tight constrictions, and dielectrophoresis uses non-uniform field gradients to push larger micelle clusters into the narrowest gaps. As the micelles concentrate inside the crack, the dispersion transitions from a flowing liquid into a jammed, high-viscosity network that bridges the fracture wall-to-wall and resists pressure-driven flow even after the field is removed.

Advantages

- Reaches sub-millimeter microfractures and microannuli that cement squeeze jobs cannot penetrate because of particle bridging at the fracture mouth
- Maintains sealing performance under the high temperatures, high pressures, and aggressive brine chemistries where polymer and resin sealants typically break down
- Delivers an estimated tenfold cost advantage over contemporary sealing approaches
- Mitigates galvanic corrosion of well casings as a built-in secondary benefit of the applied electric field
- Uses an AI-guided control system that tracks sealing progress and adjusts voltage dynamically for a smarter, more reliable repair
- Applies broadly beyond wellbores to concrete, containment, and subsurface infrastructure wherever micron-scale leak paths drive failure

Technology Description

At the molecular scale, surfactant molecules in the E-Seal fluid self-assemble into micelles above the

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Technology Description continued

critical micelle concentration, and cement surfaces in downhole brine naturally develop an electrical double layer that interacts with these approaching charged carriers. In high-salinity brines containing divalent cations such as calcium and magnesium, the double layer compresses, inter-particle repulsion drops and micelles aggregate and adsorb onto the cement face; silica or alumina nanoparticles then reinforce the network as physical anchoring points, producing a mechanically robust plug that maintains low permeability over time. Optional additives further tune the sealant to site conditions. Trivalent cations of lanthanum and cerium raise ionic strength, accelerate micelle aggregation and can react with carbonate species in carbonate-bearing brines to precipitate low-solubility mineral phases as a secondary plugging mechanism. Crosslinked polyacrylamide derivatives, sodium polyacrylate and sulfonated polyacrylamide gel particles also can be incorporated to reinforce the seal through polymer crosslinking or by swelling on contact with the leaking fluid.

Layered on top of the chemistry is an AI/ML-based real-time control pipeline that monitors sealing progress and dynamically recommends voltage adjustments as conditions evolve in the wellbore, positioning E-Seal as an actively steered rather than passively injected treatment. The applied potential difference carries a second benefit beyond transport: It helps mitigate galvanic corrosion of the well casing, addressing a long-standing integrity concern in parallel with the primary sealing function. Because the underlying transport mechanism is electrokinetic rather than pressure-driven, the same chemistry is well suited to micron-scale defects in any cementitious, porous or fractured medium, including concrete infrastructure, dams, tunnels, underground vaults, waste containment structures, clay and bentonite engineered barrier systems, repository backfill, corroded metallic interfaces, leaky caprocks, fault damage zones, abandoned mine workings and underground storage caverns.

Market Applications

- **Oil and Gas Recovery** (legacy well plugging and abandonment, sustained casing pressure remediation, methane leak compliance)
- **Geothermal Energy** (well integrity repair, asset life extension for high-cost geothermal wells)
- **Carbon Capture** (caprock and wellbore integrity for long-term CO2 containment)
- **Critical Infrastructure** (dams, tunnels, underground vaults, reservoirs)
- **Mining and Subsurface Storage** (abandoned mine workings, underground storage caverns, fault zones)

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