# Studies of Potassium Polyanionic Cellulose as a Drilling Fluid Additive

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**Abstract.** Potassium Polyanionic Cellulose (K-PAC) is a widely used additive in water-based drilling fluids due to its excellent rheological and filtration control properties. This study investigates the effectiveness of K-PAC in enhancing the performance of drilling fluids under various conditions. Experiments were conducted to evaluate its influence on viscosity, yield point, gel strength, and filtration rate. Results demonstrate that K-PAC significantly improves drilling fluid stability, reduces fluid loss, and enhances lubricity, making it a suitable additive for challenging drilling environments.

**Keywords:** Potassium Polyanionic Cellulose, Drilling Fluid, Rheology, Filtration Control, Additives

**Introduction** Drilling fluids are critical in petroleum engineering for lubricating drill bits, carrying cuttings to the surface, and maintaining wellbore stability. Additives play a key role in modifying the properties of drilling muds to suit specific operational requirements. Polyanionic Cellulose (PAC) is a water-soluble polymer derived from cellulose and is commonly used for viscosity and filtration control.

Potassium Polyanionic Cellulose (K-PAC), the potassium salt form of PAC, offers advantages over sodium PAC, particularly in high-temperature and high-salinity environments. K-PAC enhances the thermal stability of drilling fluids and reduces filtration rates, preventing formation damage. This study focuses on analyzing the effect of K-PAC as a drilling fluid additive and determining its optimal concentration for field applications.

## 2. Materials and Methods

2.1 Materials

- Potassium Polyanionic Cellulose (K-PAC): Commercial grade, molecular weight ~250,000–300,000 Da.
- Base Fluid: Freshwater-based mud prepared with bentonite.
- Other Chemicals: Sodium hydroxide (NaOH), potassium chloride (KCl), barite (as weighting agent).

2.2 Preparation of Drilling Fluids Drilling fluids were prepared with varying concentrations of K-PAC (0.1%, 0.25%, 0.5%, and 1.0% w/w). Bentonite and other base components were mixed with water to form a uniform suspension, followed by gradual addition of K-PAC under continuous stirring. The pH was adjusted to 9–10 using NaOH or KOH.

2.3 Testing Procedures

1. Rheological Properties: Viscosity, yield point, and gel strength were measured using a standard rotational viscometer.
2. Filtration Test: API standard filter press was used to determine fluid loss under 100 psi pressure and ambient temperature.
3. Thermal Stability: Drilling fluid samples were aged in a high-temperature aging cell at 150°C for 16 hours and then re-tested for rheological and filtration properties.
4. Results and Discussion 3.1 Rheological Properties The addition of K-PAC increased the viscosity and yield point of drilling fluids proportionally to its concentration. At 0.5% K-PAC, the fluid exhibited optimal balance between flowability and suspension capability, ensuring efficient cuttings transport without excessive pressure loss. Gel strength measurements indicated improved thixotropic behavior, which helps maintain suspension during static conditions.

**Chemical Composition and Structure**

- **Chemical Formula:** Variable, but generally a cellulose backbone substituted with carboxylate groups (–COOK) in place of some hydroxyls.
- **Structure:** Polysaccharide (cellulose) chain with anionic (negatively charged) carboxylate groups.
- **Solubility:** Water-soluble due to ionic groups, forming a viscous solution.

**Physical Properties**

| Property | Description |
|---|---|
| **Appearance** | White to off-white powder or granular material |
| **Odor** | Odorless |
| **Bulk Density** | ~0.4–0.6 g/cm³ |
| **Particle Size** | Usually < 200 mesh for drilling applications |
| **Hygroscopicity** | Absorbs moisture from air; needs dry storage |

Table 1: Rheological Properties of Drilling Fluids with K-PAC

| K-PAC (%) | Plastic Viscosity (cP) | Yield Point (lb/100ft²) | Gel Strength 10s/10min (lb/100ft²) |
|---|---|---|---|
| 0.0 | 25 | 8 | 4 / 8 |
| 0.1 | 28 | 12 | 6 / 10 |
| 0.25 | 32 | 18 | 8 / 12 |
| 0.5 | 38 | 22 | 10 / 15 |
| 1.0 | 45 | 30 | 12 / 18 |

Filtration Control K-PAC significantly reduced fluid loss. At 0.5% concentration, filtration volume decreased by ~45% compared to the base fluid. The film formed by K-PAC on the filter medium minimized seepage and protected formation permeability.

Figure 1: Filtration Rate vs K-PAC Concentration (Insert bar chart here)

Thermal Stability K-PAC-modified fluids retained their rheological and filtration properties after high-temperature aging, indicating good thermal stability. This makes K-PAC suitable for deep-well and high-temperature drilling operations.

Discussion K-PAC improves water-based mud performance by:

- Enhancing viscosity and gel structure.
- Reducing fluid loss.
- Providing thermal and chemical stability in high-salinity and high-temperature environments.
- Being compatible with other common drilling fluid additives.

Optimal concentration was found to be 0.5% w/w, balancing performance and cost-effectiveness. Higher concentrations increase viscosity excessively, potentially leading to pumping issues.

Conclusion Potassium Polyanionic Cellulose is an effective additive for water-based drilling fluids, improving rheology, filtration control, and thermal stability. Its use enhances drilling efficiency, reduces formation damage, and provides operational flexibility in challenging well conditions. Further studies may focus on synergistic effects with other additives and performance in extreme salinity or ultra-deep wells.

**References**

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