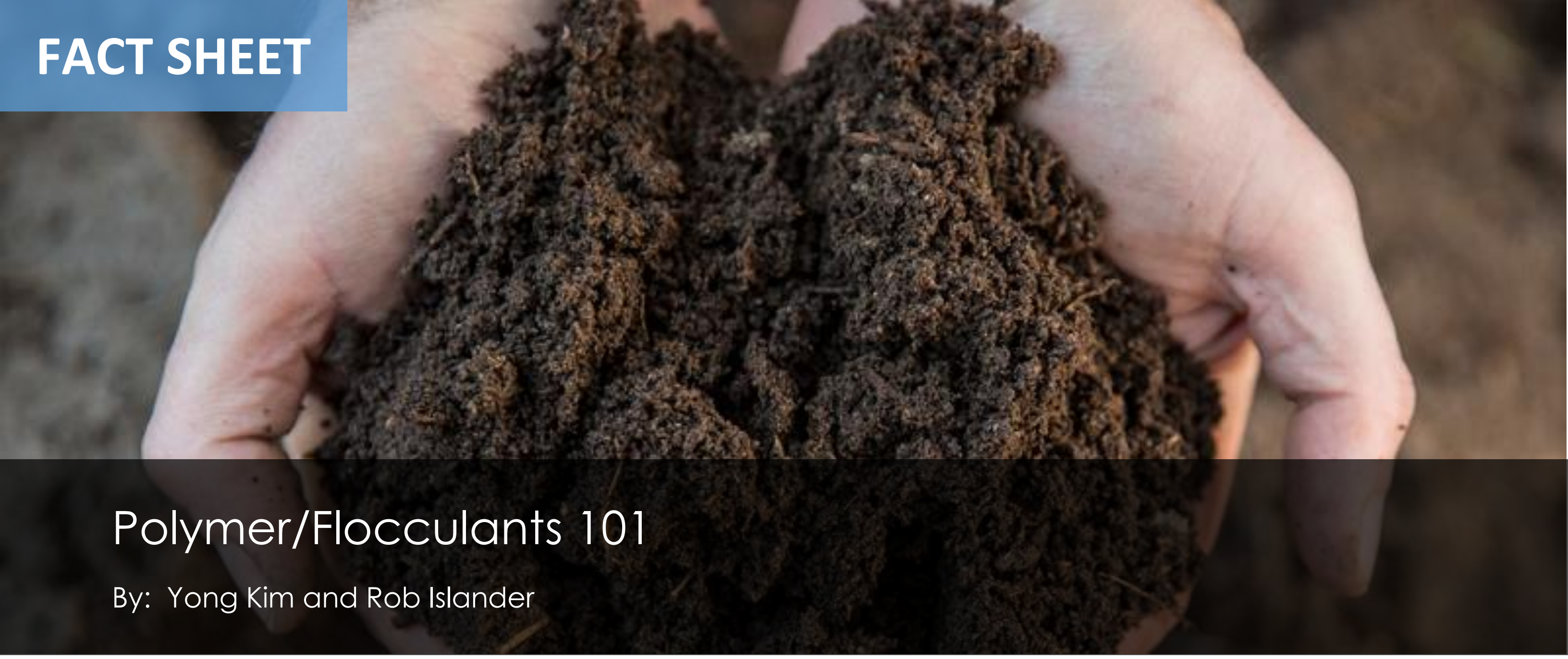

FACT SHEET

Polymer/Flocculants 101

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The aggregation of particles into larger and more easily removable forms by employing coagulants or flocculants is necessary for efficient separation by clarification, sedimentation, filtration, or dewatering processes. The terms "coagulant" and "flocculant" are often used interchangeably. However, the discussion in this fact sheet will be focused on high molecular weight, cationic polymeric flocculants used for thickening and dewatering solids separation processes where they operate through bridging or similar mechanisms.

Polymer Type

Polymer comes in three different forms – dry, solution (Mannich), and emulsion polymer. Most polymers used in wastewater industries are acrylamide-based and often called PAAM (polyacrylamide).

- Dry: When the polymeric flocculant was first developed, the only type available was a dry powder form. Dry forms typically contain greater than 90% active polymer and need more time for complete dissolution and activation than emulsion polymers. Dry polymers can be delivered in 50 lb bags or "Super Sacks" as large as 2000 lb.

- Mannich: Mannich polymer is a high molecular weight, very viscous solution polymer that was widely used in wastewater treatment plants in 1990s. Its usage has sharply decreased due to the low active polymer content of 4% - 8%, short shelf life, difficulty in pumping, and unique unpleasant odor. Mannich polymers, due to their low activity, are typically delivered in 3000 to 5000 gallon tanker loads.

- Emulsion: Emulsion polymers used for solids separation processes are hydrolyzed, of high molecular weight, and have very high viscosity. One of the most important characteristics of emulsion polymers is their fluidity and micron-sized polymer gels that enable operators to utilize in-line polymer mix/feed systems. They consist of polymer gels emulsified in 30% hydrocarbon oil. Depending on the content of water in the polymer gels, the active polymer in emulsion polymer ranges from 20% to 55%. Therefore, emulsion polymers cost more than dry polymer on a per pound basis. The polymer as delivered to a site is "neat" and includes water, oil, surfactants, and active polymer. However, the active content is the portion of the emulsion that actually conditions solids in downstream processes and it is the active content that should be considered when assessing appropriate polymer doses for solids processing systems. Emulsion polymers can be delivered in small 55-gallon drums, 270-gallon totes, or 4000 to 5000-gallon tanker loads.

Handling and Storage

Dry polymer is very hygroscopic (moisture-attracting), so care should be taken to store it in a cool and dry area (neither above 40 °C nor humid). Dry polymer has a shelf life of over 1 year

WSEC-2019-FS-007, RBC Solids Separation Subcommittee

if properly stored. Mannich polymer must be used within 4 weeks and should be kept away from both freezing and overly warm environments. Since emulsion polymer tends to be stratified (separation of hydrocarbon oil and polymer gels) during storage, a drum/tote mixer or recirculation pump should be used before connecting polymer container to feed equipment. Emulsion polymer should be stored at the temperature range of 5 °C - 30 °C and dry conditions, preferably inside a building. If properly stored, emulsion polymer has a shelf life of 6 months. Should freezing occurs, the product should be allowed to thaw thoroughly in a heated area and mixed well before use (1).

Polymer solutions, when spilled, present a slip hazard and system design should include provisions to maintain safe working spaces in polymer rooms. Material Safety Data Sheets and Product Data Sheets typically contain information on how to safely handle each type of polymer.

Polymer Make-Down (Solution Preparation)

Emulsion and dry polymers as delivered to a site must be activated in a dilute solution that can then be added to a solids stream for conditioning. Dilution water is mixed with polymer to produce this dilute solution in a "make down" process. Emulsion and dry polymers are typically diluted to 0.2% to 1% active solutions. Mannich polymers, which are delivered as activated compounds, already have relatively low activity and are typically diluted down to 0.2% to 0.5% active base. Care must be taken to avoid breaking polymer chains through excessive mixing once activated. Damaged polymer chains can result in increased polymer demand for the process.

While polymers with higher molecular weights are more efficient in flocculation, they also present greater technical challenges in solution preparation than lower molecular weight polymers. The concept of two-stage mixing is well established in the polymer make-down process (2).

- First Stage: Very high energy mixing at the initial wetting stage to prevent "fisheye" formation
- Second Stage: Low energy mixing to minimize damaging the polymer molecules as they "uncoil" out of polymer gels/particles. Much longer residence time is required for the second stage than the first stage (3).

Since emulsion polymer consists of polymer gels emulsified in hydrocarbon oil, it is also important to make-down at a higher concentration (> 0.5% by weight which is equivalent to 1.0% - 1.5% by volume) in the feed equipment mix chamber. This ensures a sufficient content of inverting/breaker surfactant in the activation of emulsion polymer (1, 4). If the final feed concentration of polymer solution needs to be lower than 0.5% by weight, it is necessary to have an additional post-dilution stage.

Polymer Make-Down System (Equipment)

Although there are numerous polymer make-down systems available in the market, they can be classified into two types - mechanical and non-mechanical systems depending on how mixing energy is delivered for effective polymer activation.

An advantage of mechanical systems includes the ability to provide high energy mixing regardless of the fluctuation of plant water pressure, while they may require more maintenance than non-mechanical systems. Non-mechanical or hydraulic polymer make-down systems are easy to operate with less moving parts than mechanical systems. However, they may require a dilution water booster pump to maintain the consistent incoming water pressure which is directly related to the applied mixing energy.

Whether employing mechanical or non-mechanical mixing, polymer make-down systems should be designed based on the following principles:

- Two-stage mixing
- Provision of sufficient residence time
- Production of a high solution concentration during primary mixing with post-dilution as needed for emulsion polymer activation.

Aging after the make-down system can improve polymer performance, but the required aging time may be significantly reduced by a well-designed mixing chamber. Polymer manufacturers are also introducing products with advanced inverting surfactants that reduce the need for aging.

Polymer-Solids Mixing

Injecting and dispersing a polymer solution into a solids stream is critical for achieving efficient thickening and dewatering. Polymer solutions can be very viscous and difficult to inject and disperse rapidly into solids streams, especially if the solids stream is thick. There are many commercially available polymer-solids mixers with either static or mechanical mixing, so careful evaluation is required. Parameters to be considered include the type of dewatering equipment, solids content in the feed, solids to polymer contact time, and polymer solution viscosity. For example, if the feed contains higher than 4% solids, the static polymer-solids mixer may not be able to disperse polymer solution rapidly and uniformly into the stream. This can cause over-dosing or under-dosing of polymer, ultimately leading to inefficient dewatering.

Dilution Water

The quality of dilution water has a tremendous impact on the efficiency of a polymer solution. Hardness which represents a major portion of the ionic strength of dilution water plays an important role in polymer activation. If hardness exceeds a certain level (such as 400 mg/L), it is strongly recommended to add a softening device to minimize the negative effect of hardness. Considering the increasing trend of utilizing reclaimed water for polymer mixing at wastewater treatment plants, it is essential to reduce the chlorine level of dilution water to below 4 mg/L to avoid damaging the structure of polymer molecules. Additionally, when reclaimed water is used for polymer mixing, aging must be carefully evaluated. Chlorine, suspended solids, turbidity, and dissolved ions in reclaimed water react with polymer molecules. During aging, these reactions can last longer, resulting in degradation of the polymer solution. There is a need for more research on this particular subject.

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Further Reading

1. Polyacrylamide Emulsions Handbook, SNF-Floeger 1197-01/10-99.
2. Y. Kim and B. Hawley, How to Maximize the Value of Polymers at Wastewater Treatment Plants, Proc. 2016 WEFTEC, 2845, 2016.
3. Solenis Product Data, PYM-PDS-NA-Cationic Polymers.
4. ANSI/AWWA B453-06 Standard for Polyacrylamide, April 2006.

Additional Resources

- Yong Kim, Coagulants and Flocculants: Theory and Practice, Tall Oaks Ventures, Littleton CO, 2015.

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