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Solenis — World-class Wet Strength Resins for Tissue and Towel

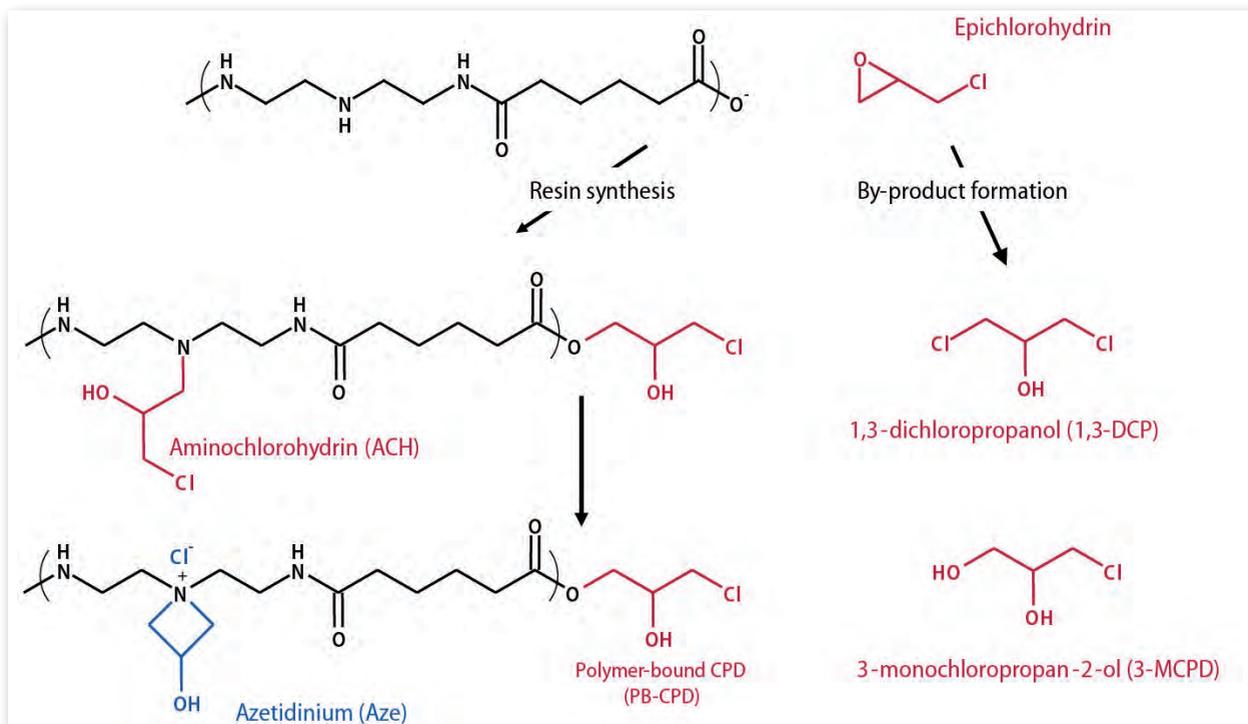
Solenis invented the modern era of wet-strength paper manufacturing with the introduction of Kymene™ wet-strength resin, the first polyamido-amine-epichlorohydrin (PAE) resin ever brought to the market. The product was an instant commercial success, both for its ability to function in neutral/alkaline papermaking processes and for its novel wet-strength capabilities. Today, Kymene™, is synonymous with wet-strength resin in the global paper markets.

In recent years, greater awareness of the hazards posed to human health and the environment by some of the processes and chemicals used when manufacturing paper products has resulted in various regulatory measures being imposed on the industry. To ensure business sustainability, papermakers must comply with these regulatory measures typically through operational changes. In addition, these same regulatory concerns have driven chemical suppliers to develop new products and technologies to help papermakers meet these ever-changing demands.

As these regulatory measures have evolved, newer generations of PAE resins have been developed. Typically, these regulatory measures are specific to a region, so the development of a single, standardized solution will not work globally. However, paper manufacturers that desire to produce for the global market must ensure that regulatory compliance for both grade and region are met.

In addition to external regulatory measures imposed in the industry, major producers of wet-strengthened paper products have corporate sustainability programs to ensure the long-term viability of their businesses. These programs often have a component for commitment to environmental sustainability by reducing the impact of their overall manufacturing footprint.

The final part of the manufacturing process, where a prepolymer made from adipic acid and diethylenetriamine (DETA), is reacted with epichlorohydrin under very precise conditions, can be outlined as below in Figure 1. It is this process that produces the final active wet strength resin and, as a consequence, some by-products that should be minimized.



[Fig. 1] Typical PAE resin manufacture and formation of epi by-products.

Over the years, our researchers have modified the basic chemistry to make stronger-performing resins at higher solids, but with reduced by-products, such as the 1,3-dichloropropanol (1,3-DCP) and 3-monochloropropan-1,2-diol (3-MCPD), as well as aminochlorohydrin (ACH) and polymer-bound CPD (PB-CPD).

Solenis has led the industry in decreasing the organic chlorine content of its Kymene wet-strength resins without compromising their efficiency.

Our scientists have developed manufacturing processes with greater control to maximize the efficiency of how epichlorohydrin is used to generate

azetidinium chloride (AZE), the reactive portion of PAE resin, while minimizing the levels of 1,3-DCP and 3-MCPD formed.

Furthermore, Solenis has continuously invested and introduced innovative technologies that can be applied after the manufacture of the basic PAE resin to reduce harmful by-products, producing “cleaner” products with much lower levels of epichlorohydrin (epi) by-products and adsorbable organic halides (AOX). Additionally, higher solids and higher-efficiency PAE resins positively impact sustainability. The types of sustainability initiatives that need to be considered are summarized in Table I.

Table I – Types of Sustainability Initiatives.

Governmental Regulations	NGO's Eco-labels	Cost and Performance
Worker safety (e.g., GHS, OSHA, California Proposition 65, VOC) using PAE resins	Non-Governmental Organizations' guidelines for product and environment (e.g., EU Ecolabel, Blue Angel, Nordic Ecolabel, Green Seal)	Maximize solids to minimize transportation (reduce freight cost, carbon dioxide and pollutants), “fewer trucks on the road”
Consumer safety (e.g., FDA, BfR, GB 9685) using paper products made with PAE resins		Resin efficiency at time of customer usage. More efficient resin allows lower dosage, higher retention of PAE (less PAE resin in effluent)
Environmental safety (e.g., GHS, EPA, REACH) using PAE resins (AOX in effluent, aquatic toxicity, VOC)		

Today, PAE resins account for 90 percent of the wet-strength market, with very few producers using resins such as urea formaldehyde. Of this market, nearly half bears the Kymene™ brand name.

Solenis has introduced market-leading technologies into each of the widely used industry descriptors of G1, G2, G2.5 and G3 PAE resins, making it possible to address a full range of customer compliance needs while balancing cost-in-use on a global basis. One reason for the success of Kymene™ is its broad range of configurations that enable papermakers to customize their wet-strength programs to satisfy regional demands and regulatory requirements.

Technology Overview

Kymene™ wet-strength additives, based on polyamide-epichlorohydrin (PAE) resin chemistry, help papermakers improve the wet strength of grades intended primarily for the consumer market. These grades include tissue (facial, kitchen towel, wipers, napkins and tableware), packaging (liquid packaging, aseptic container, carrier board, and other forms of food packaging), and specialty (tea bag, coffee filter, labels, currency, laminating grades, etc.).

Like all PAE resins, the polymer in Kymene™ contains quaternary ammonium groups that adsorb onto negatively charged paper fibers and that continue to cross-link even as the paper dries and cures. That means the wet strength of paper treated with Kymene wet-strength resin continues to increase after it's been put into storage.

Designed to be used at neutral-to-alkaline pH, PAE resins have a high level of wet-strength permanence, help improve machine efficiency and do not adversely affect paper absorbency as do some other chemistries.

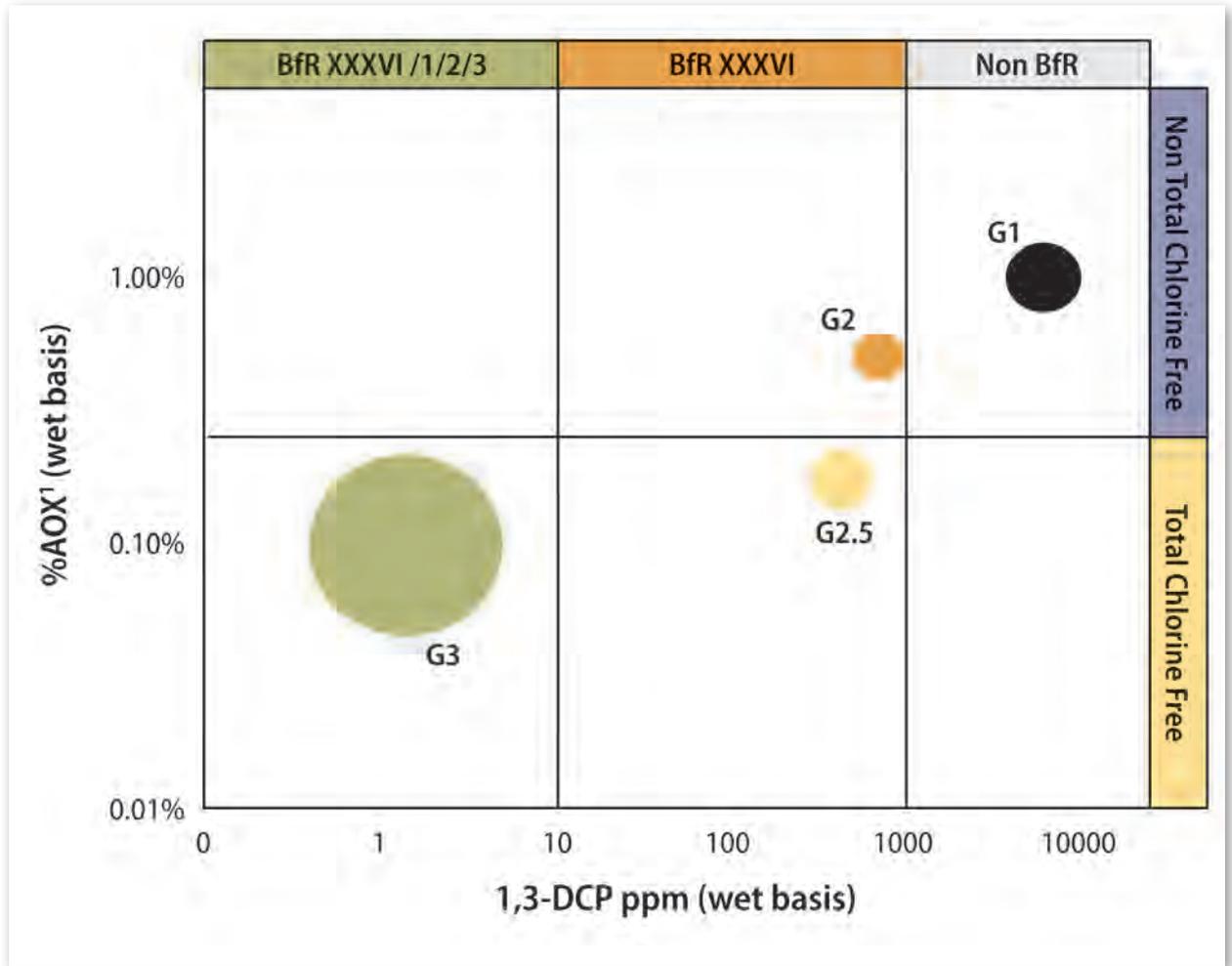
Membrane Separation Technology

Solenis pioneered a bio-dehalogenation process to effectively remove free epi residuals, without creating additional waste streams. This process has been in place now for many years.

Further research has led to our revolutionary membrane separation technology (see Figure 2), which can help paper mills decrease levels of both 1,3- DCP and 3-MCPD and overall AOX, while not impacting resin functionality.



[Fig. 2] The reduction of epi by-products utilizing a patented membrane technology.



[Fig. 3] Paper compliance matrix for PAE resins with recommended generation definitions based on customer drivers.

Compliance and Sustainability

Solenis’ wet-strength resins can be supplied in a variety of product configurations to accommodate stringent compliance and regulatory standards. We offer solutions that help mills comply with environmental labeling established by Nordic Ecolabel and recommendations issued by the German Federal Institute of Risk Assessment (Bundesinstitut für Risikobewertung, or BfR). And we can deliver products to papermakers with very specific manufacturing needs, such as total chlorine-free grades with very low-OX-in-paper requirements. One way to represent this is in a matrix, as shown below in Figure 3.

Supply Chain

Solenis is the only true global supplier of PAE wet strength resin, with 12 manufacturing sites globally and two licensees with facilities for wet-strength resin production. This puts us close to any customer,

reducing freight distances and, as a result, freight costs. It also gives us the necessary manufacturing backup to ensure that we can serve our customers even if one facility encounters a production problem.

Solenis is a leading global manufacturer of specialty chemicals for the pulp, paper, oil and gas, chemical processing, mining, biorefining, power and municipal markets. The company’s product portfolio includes a broad array of process, functional and water treatment chemistries as well as state-of-the-art monitoring and control systems. These technologies are used by customers to improve operational efficiencies, enhance product quality, protect plant assets and minimize environmental impact. Headquartered in Wilmington, Delaware, the company operates 30 manufacturing facilities strategically located around the globe and employs a team of 3,500 professionals in 118 countries across five continents. For additional information about Solenis, please visit www.solenis.com. ■