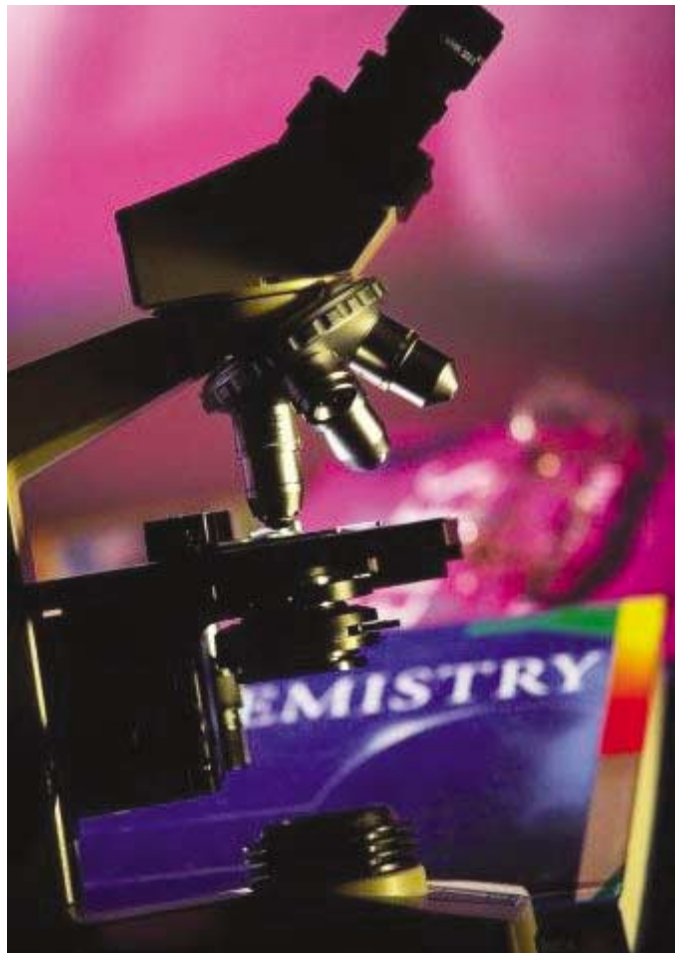


# Teaching Old Retention Agents New Tricks

Used with enhancers under the right conditions, polyethylene oxide provides highly effective retention for a Canadian newsprint mill using large portions of DIP in its mechanical furnish.

By Marco Polverari and David Aston



The trend toward higher percentages of deinked pulp (DIP) in newsprint furnishes, together with increased filler loadings and continuing efforts to close paper machine white water systems, are requiring more efficient retention and drainage aid technologies.

In this regard, a retention agent with a previously unreliable and problematic performance record—polyethylene oxide (PEO)—has been recently reevaluated and found to be highly effective with these types of furnishes when used with certain enhancers and applied at the proper rate.

This article examines studies conducted by Paprican and other independent researchers showing that PEO, despite its ignoble history, can indeed be a viable and efficient retention agent in modern mechanical furnishes containing high percentages of DIP. It also includes results from recent trials at Abitibi-Consolidated's Belgo mill in Shawinigan, Quebec, where four paper machines producing newsprint and book grade papers were converted to a PEO-based wet end retention technology.

## PEO HISTORY

Polyethylene oxide (PEO) has been around since the 1970s. Its bad reputation goes back to this period, mainly based on some disastrous mill trials. Typically, PEO worked only in about half of the cases, and with such uneven results, mills were understandably reluctant to endorse this seemingly fickle product—despite its highly touted potential.

Once perceptions form they are difficult to erase. However, subsequent research during the past decade has proved that PEO-based retention aid systems can live up to their high expectations. In fact, PEO programs are being used extensively today by papermakers in Sweden, South Africa, Japan, and Canada.

Among the main reasons for PEO's failure to achieve great expectations early on was the industry's incomplete understanding of wet end chemistry and chemical engineering. In essence, mills were applying too much PEO (e.g. 1,000 g/metric ton of newsprint) in an attempt to obtain

quick results. Unfortunately, they were also doing so with conventional make-down equipment, which not only offered imprecise chemical dissolution but caused havoc with the delicate chemical balance required in paper mills.

Not considered were such parameters as injection velocity, dilution rates, and delivery points. It's no wonder that mills complained about consistency problems in the newsprint. Another major problem was either inadequate cofactor (enhancer) technology or the lack of any enhancer at all.

Around 1990, fundamental research at the University of McGill and Paprican broke new ground. Researchers found that PEO alone was generally an ineffective retention aid, but when combined with certain enhancers or cofactors formed a highly efficient retention system. Cofactors used in these studies, supplied by Kemira, were found to be highly efficient and stable. In fact, current products have a shelf life 10 times longer than phenolic resin and are not affected by calcium ions found at headbox concentrations. Furthermore, PEO in combination with these stable cofactors is no longer affected by detrimental substances carried over by DIP, such as sodium silicate.

At the same time, the advent of new technology has solved the problem of how to precisely deliver PEO-based chemicals. For example, a make-down system known as Equiwet III, developed by Kemira, monitors a host of parameters, including mix times, equilibrium dosage, polymer dispersion, and total dilution rates.

Both bench tests and mill studies show that PEO-based retention aids increase first-pass retention by 5% to 20%. Achieving ideal results requires the selection of the right PEO/enhancer blend for each specific machine at optimum dosages, which typically range between 50 and 70 g/metric ton with cofactor ratios of 5:1 to 10:1.

## PEO RETENTION AID THEORY

In mechanical pulps, high levels of anionic contaminants, both soluble and insoluble, make neutralizing a wet end with coagulants more difficult. As mill water systems are closed and treated effluents recycled, dissolved and colloidal solids (DCS) in the white water increase. Further, in many mills, increased use of recycled fiber introduces contaminants, both soluble and colloidal, into the water.

PEO retention aid systems have been shown to work better than charged polymers because they do not require charge neutralization to function effectively. These flocculation mechanisms imply a direct reaction of the first component (PEO) with the second one (cofactor). Fines and filler retention occurs by entrapment in a molecular "net."

This net is made by the PEO attached to naturally occurring and added cofactors. Under optimum conditions, the flocculation can be powerful, even at low dosages. The suggested bonding mechanism of this retention aid system is hydrogen bonding, as shown in Figure 1. The same reaction is why PEO is excellent for bonding and retaining pitch, fatty acids, and ray cells.

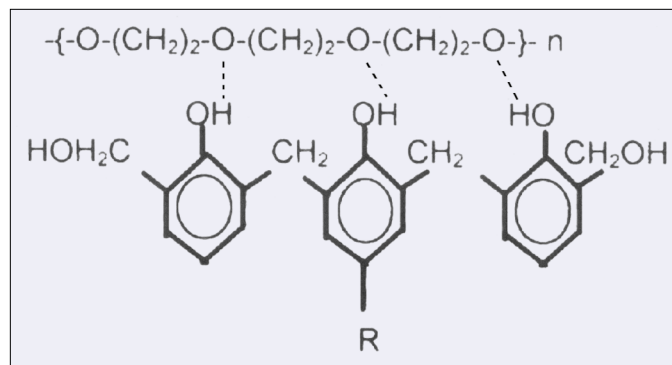


Figure 1. Reaction with phenol formaldehyde cofactor and PEO

Working together, Paprican and Kemira have developed cofactors based on this mechanism. Each mill's white water requires a specific cofactor because all mechanical furnishes have anionic trash containing lignin, pitch, and often colloidal contaminants from recycled fiber and deinking processes (some which are themselves natural cofactors for PEO).

## SUCCESS AT BELGO

Beginning in 2001, the Belgo, Shawinigan Division of Abitibi-Consolidated launched a review of its entire wet-end program, with the objective of reducing white-water consistency variations and increasing paper machine productivity, while simultaneously reducing operating costs.

Belgo decided to go with the PAPEO™ system, which combines Kemira's new enhancer chemistry with PEO, because this chemistry would not affect cationic demand of the overall mill process. Conclusive trials had demonstrated that PAPEO chemistry would fulfill the criteria and objectives set forth by the mill.

The Belgo mill produces 1,040 metric tpd of paper. Some 70% is standard newsprint (Abinews) and 30% is controlled thickness paper (Abibook). The mill has four paper machines, three TMP lines, a deinking unit, and most importantly a common white water system.

Prior to the PAPEO trials, the mill was using a standard coagulant-polyacrylamide (PAM) technology. This type of chemistry had a critical shortcoming—it was constantly and severely affected by the varying cationic demand of the

stock. This variation was a consequence of the varying percentage of hydrosulfite pulp added to the stock and the varying hydrosulfite bleaching agent added to achieve the desired brightness.

Many other cationic chemistries were tested to overcome the effect of the varying cationic demand of the process, but the PAPEO system was found to be most effective for several reasons. First, the cationic PAM-coagulant chemistry Belgo was using is known to function well only within a small, defined window of cationic demand. If the cationic demand of the process goes outside of the defined interval (which will depend on the coagulant type and flocculant charge density), system performance diminishes. The role of the coagulant is to neutralize the anionic charge of the DCS and reduce repulsion between fines and fibers (see Figure 2).

Once the anionic charge is reduced, fines are attached to the larger fibers through bridging flocculation to form flocs that can then be retained to form sheets. When the cationic demand of the process increases outside of the window, the cationic coagulant is mostly consumed to reduce the anionic charge rather than to reduce repulsion between the fines and fibers. This leads to a decrease in the flocculant efficacy and, as a result, to an increase in white water consistency.

PEO chemistry, on the other hand, functions through a non-charge dependant hydrogen bonding mechanism. The enhancer creates H-bonding sites on the fines and fibers, which the PEO molecule can use as anchors when bridging the fines and fibers together.

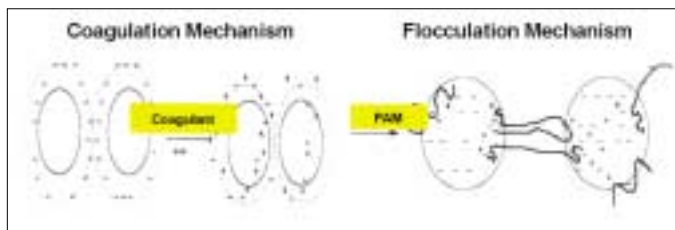


Figure 2. Coagulation and flocculation mechanism

### ON-MACHINE TRIALS

The first on-machine PAPEO trials were conducted on Belgo’s PM 6, a fourdrinier machine with a “top-flyte” former. Trial criteria were:

- Maintain white water consistency of the bottom wire at or below a set target by varying the PEO dosage
- Keep white water consistency stable regardless of deink content in the furnish (deink furnish was found to affect cationic demand and increase pitch and stickies)

- Maintain or increase machine productivity
- Have no negative impacts on sheet physical properties
- Reduce retention program costs.

As can be seen in Figure 3, white water consistency was much more stable with the PAPEO system than with the incumbent cPAM-coagulant system. The objective was to maintain white water consistency at or below 0.48% throughout the trial. This objective was respected throughout the trial regardless of stock cationic demand and/or deink furnish content. Furthermore, machine speed was increased by 30 m/min. Figure 4 shows that the cationic demand of furnish had an effect on machine runnability or retention aid efficacy.

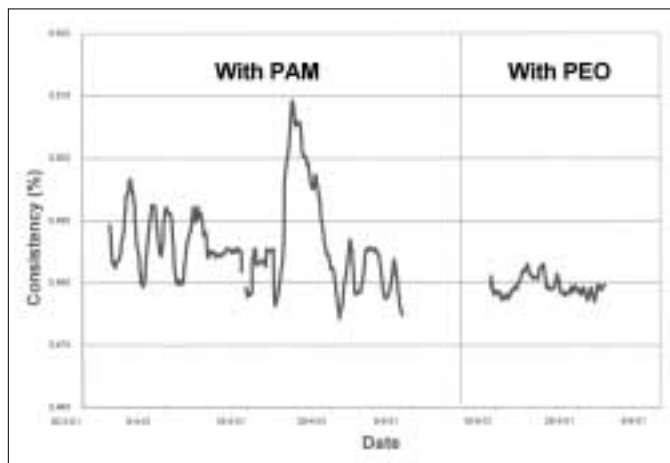


Figure 3. Variation of white water consistency



Figure 4. Variation of headbox cationic demand

The Belgo mill produces its own deink furnish, which has a free drainage value lower than that of the TMP or sulfite furnish. It also has a cationic demand lower than these pulps but higher in dissolved calcium levels.

Among the main reasons for PEO's failure to achieve great expectations early on was the industry's incomplete understanding of wet end chemistry and chemical engineering.

In essence, mills were applying too much PEO in an attempt to obtain quick results.

Past experience at the mill had shown that as deink furnish percentages varied in the headbox, white water consistency also varied. If the percentage of deink furnish increased in the headbox, machine retention would increase, *i.e.*, the white water consistency decreased. This was due to natural retention of the paper machine increasing in proportion to the percentage of deink furnish.

Thus, during the first trial the proportion of deink furnish was decreased from 20% to 0%, in 5% intervals (see Figure 5). With each 5% decrease, an increase in white water consistency was observed. As a result, more PEO was needed to maintain the consistency at 0.48%. This showed that the PAPEO system was very responsive to stock variations. Note the very low PEO dosages in Figure 5.

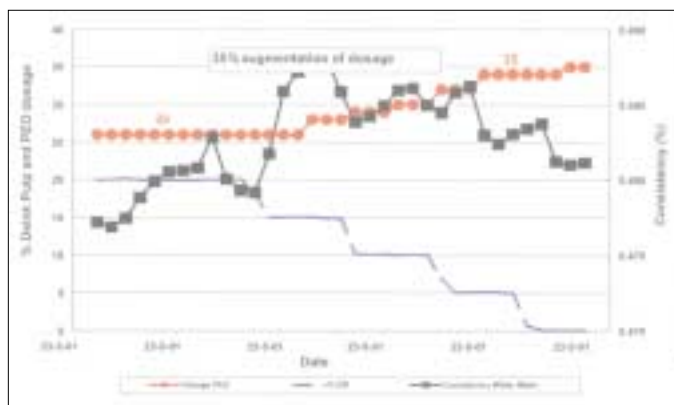


Figure 5. Impact of deink pulp on the consistency of white water as a function of PAPEO dosage

One of the most important criteria of this trial was to maintain paper machine efficiency (*i.e.* uptime/productivity) at 90% or above. Use of the PAPEO system had no effect on steam consumption, wire cleanliness or life, and white water chemistry. However, on the positive side, culled tons of paper due to specks and spots decreased significantly, on the order of 3.5 metric tpd. Furthermore, overall machine drainage improved and sheet draw decreased, resulting in fewer sheet breaks.

The fourth success criteria was sheet quality. In addition to decreased spots and specks, Table 1 shows that burst and cross directional tear improved while all other parameters remained the same. This was an important result, as improvements in these parameters have been correlated with decreased printing press breaks at Belgo's most important customers, The New York Times and The New York Daily News.

Parameter	Coagulant-PAM	PAPEO System	Difference
Porosity	515	504	Same
Formation	8.1	8.0	Same
Burst	87.6	90.6	Positive
Tear (CD)	335	348	Positive
Curl	9	7	Same
Linting	40	38	Same

Table 1. Comparative results for sheet quality

The overall PAPEO program cost, at equilibrium values, was found to be 40% less expensive than the incumbent coagulant-PAM system. Also, an unexpected increase in brightness occurred during the trial. Sheets from PM 6 (PAPEO trial) had 0.5% higher brightness than those from the structurally identical PM 9 that was still running on the PAM system.

The gain in brightness was due to the enhancer not only acting as a cofactor for PEO but also having chelating properties for metallic ions such as calcium. The enhancer is able to "coat" calcium carbonate colloidal particles and thus prevent or retard their dissolution in acidic medium. This causes higher amounts of calcium carbonate colloidal particles to be retained in the sheet, resulting in a brightness gain with no loss in opacity.

After all four paper machines at Belgo were converted to the PAPEO system, a significant decrease in pitch and stickies was noted on the wires and felts. PEO is known to have a strong affinity for hydrophobic material due to its hydrophobicity. However, the new PAPEO enhancer also has hydrophobic moieties that attach themselves to hydrophobic particles and allow the PEO molecule to bridge them and retain them in the sheet. Thus the enhancer also passivates the pitch/stickies particles by coating them and rendering them hydrophilic. With the PAPEO system, the amount of pitch/stickies going out with the sheet increased from 0.4% to 0.9%. ■

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