Unlocking the green gold: maximising tall oil yield with chemical solutions

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INTRODUCTION:

As the global economy intensifies its transition towards sustainability, the pulp and paper industry is playing a pivotal role in optimising material efficiency and reducing environmental impact. The industry has long recognised the value of by-products such as tall oil, which is derived from the kraft pulping process. Traditionally underutilised and often burnt for energy, tall oil is increasingly recognised as a bio-based raw material of strategic importance and value. With applications ranging from biofuels and adhesives to pharmaceuticals, efficient recovery of this material is vital for both economic and environmental sustainability. Despite its potential, tall oil recovery remains suboptimal in many pulp mills. Losses due to process inefficiencies, foam formation, and inadequate separation methods limit the economic and environmental value that could otherwise be derived from this resource. In response, several technological advancements — including the strategic use of chemical additives — are helping mills significantly boost their recovery rates without major capital investments.

From by-product to bio-product

Tall oil, also known as pine oil, is a viscous, resinous liquid composed primarily of fatty acids, resin acids, and neutral compounds. It is formed during the kraft pulping process when softwood chips react with alkaline cooking liquors, leading to the formation of sodium salts of fatty and resin acids — collectively known as soap. This soap is skimmed from black liquor and later acidulated to yield crude tall oil (CTO).

Although the separation of tall oil in the pulping process has been known for decades, its wider exploitation has been limited by both raw material availability and underdeveloped markets. As a result, tall oil has traditionally been used mainly for energy production at pulp mills. Historically considered a low-value residue, tall oil has found renewed significance due to its unique chemical composition and bio-based origin. It serves as a precursor for numerous high-value products, including:

- Biofuels (e.g. biodiesel, renewable diesel)
- Lubricants and coatings
- Adhesives and inks
- Cosmetics and pharmaceuticals

With the adoption of new rules for renewable fuels worldwide, tall oil has never been as valuable as it is today. The rising interest in renewable fuels is a major factor driving the expansion of the tall oil market. Across the globe, governments are introducing mandates for biofuel usage and providing various incentives to encourage the shift toward sustainable energy sources. In this context, tall oil-derived fuels — particularly biodiesel and renewable diesel — are ideally suited to meet the increasing demand for eco-friendly alternatives. Having the right strategy for applying tall oil separation aids has therefore never been so critical to a mill's financial performance. Even a 1% increase in tall oil yield can translate to hundreds of thousands of euros in unrealised value for a mill. The global tall oil market is currently valued at approximately €2 billion and if production continues at the current pace, the market could grow to €3 billion by 2030.

The challenges of tall oil recovery

Despite the value it represents, tall oil recovery in kraft pulp mills is often inefficient. Studies and industry data show that, on average, only 80–90% of the available tall oil content in wood is recovered using conventional methods. Several factors contribute to this limitation:

- Foam formation during brown stock washing, leading to soap loss
- Incomplete separation of soap from black liquor during evaporation
- Inefficient separation processes at tall oil plants.
- Variability in raw material composition and process conditions

These factors result in typical losses of 5–20% of the potential tall oil, undermining both profitability and sustainability performance. Addressing these losses requires a multifaceted approach that combines process optimisation with targeted chemical solutions.

Traditional and emerging methods of tall oil recovery

There are several methods available for recovering tall oil in kraft pulp mills, each varying in complexity, efficiency, and implementation cost. These methods range from long-established mechanical separation techniques to more recent advancements involving chemical additives that enhance each step of the process. Key approaches used in the industry today are:

1. Soap skimming from black liquor

After brown stock washing, soap is present in the black liquor. During evaporation, soap is separated by skimming and collected in a tank. The efficiency of this step depends on parameters such as:

- Dry solids concentration
- Temperature
- Soap quality

This is a widely used and well-established method in most pulp mills. However, it is limited by physical process conditions and efficiency varies by mill and process stability. Typically, this method allows for recovery of up to 90% of the available soap, though losses of 1–5% are common due to incomplete separation. It requires continuous process monitoring and adjustment. Without effective soap skimming, tall oil recovery is compromised.

2. Acidulation of soap to produce crude tall oil

In this step, the skimmed soap undergoes acidulation, where it is mixed with an acid to convert the sodium salts into free fatty and resin acids. This phase separation produces crude tall oil and an aqueous by-product. Acidulation can be performed using:

- Batch reactors (common in older facilities)
- Continuous systems, such as the HDS (Hydro Dynamic Separator) process

This is an established process with known parameters and enables production of crude tall oil with high value. However, these systems can be slow and labour-intensive and phase separation can be inefficient without additives. It requires careful pH and temperature control to ensure separation. The performance of this phase separation determines the final tall oil yield and quality and there is a risk of quality variation if not optimally managed.

3. Advanced chemical additives and process optimisation

Recent innovations have introduced chemical solutions to improve each stage of the tall oil recovery process, using targeted chemicals. These additives enhance separation efficiency without requiring capital investment or shutdown and are customisable to each mill's unique process.

Chemical additives require expert knowledge for dosing and implementation, which is why good cooperation with the chemical supplier, combined with process understanding and on-site support, can unlock significant value from existing operations. When used strategically, they significantly improve yield, reduce losses, and ensure consistent product quality.

A chemical-based approach to maximising tall oil yield

Developed by BIM Kemi, the BIM Talloil Maximisation concept, BIM TOMAX, is a comprehensive, three-part approach designed to improve tall oil yield through targeted chemical applications. According to field data, it can increase tall oil yield by up to 20% without requiring major capital investment. The concept improves yield at critical stages of the pulp process — during brown stock washing, recovery, and at the tall oil plant.

1. BIM Antifoam – reducing washing losses

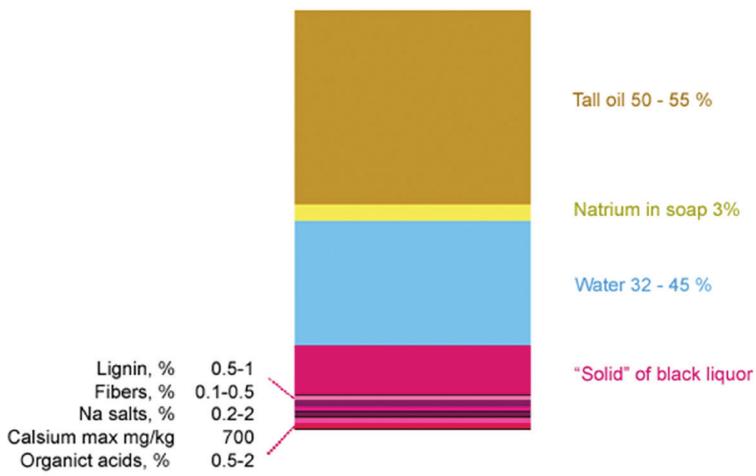
Foam formed during brown stock washing introduces air into the system, disrupting the transport of soap and causing losses as some soap moves to the bleaching stage instead of black liquor. The average washing loss is around 5%.

BIM Antifoam, a silicone-based formulation, is designed to reduce foam and promote efficient soap dissolution into the black liquor. With its application, washing losses can be reduced to as low as 1%, thereby preserving more soap for later recovery. The dosing method, dosing point, and specific product used for BIM Antifoam are tailored to each mill, and no shutdown of the process is required for its implementation.

Key benefits:

- Reduction in foam formation
- Improved soap transport
- No shutdown required for implementation
- Customised dosing per mill conditions

Figure 2: Composition of good quality soap, containing up to 55 % of tall oil.



Source: KnowPulp

2. BIM Soap Booster – enhancing soap skimming

At the evaporator, the soap is separated from the black liquor by skimming it into a soap collection tank. Even after effective brown stock washing, a portion of soap remains dissolved in the black liquor. The efficiency of this separation is affected by factors like dry solids content, temperature, and the quality of the soap.

The BIM Soap Booster enhances the skimming process by accelerating the separation of soap from the liquor, leading to up to a 20% increase in soap yield and a 10% increase in tall oil yield. As the separation is enhanced and improved, the crude tall oil is of better quality and contains fewer inorganic particles. The BIM Soap Booster is very similar to a scale inhibitor and will also reduce inorganic deposits. Further benefits of this concept are less soap carryover to the recovery loop, less fouling in the evaporation plant and smoother load on the recovery boiler.

This method is the result of ten years of product development and has undergone extensive field testing.

3. BIM Talloil Booster – accelerating phase separation

At the tall oil plant, where acidulated soap separates into aqueous and organic layers, phase separation can be slow and incomplete. The BIM Talloil Booster facilitates faster and more complete separation by interacting with the phase interfaces, effectively pushing the layers apart. (Image 4a and 4b below)

Advantages include:

- Faster processing times
- Higher tall oil quality and purity
- Better product consistency
- Capacity increase: Recovery boiler capacity freed up and less inert looping around

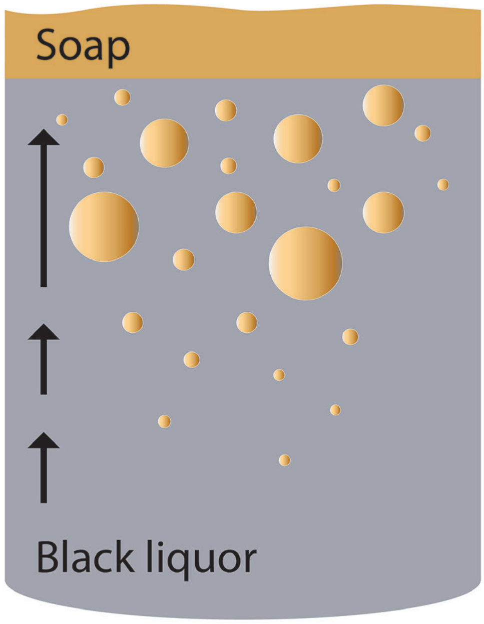


Figure 3: Soap separation efficiency is dependent on several factors such as dry solids content, temperature, and the quality of the soap.

One of the standout features of the BIM TOMAX concept is its flexibility. Each component — BIM Antifoam, BIM Soap Booster, and BIM Talloil Booster — can be applied independently, based on the specific needs of a pulp mill. BIM experts conduct on-site evaluations to determine which solution(s) will deliver the best results. Moreover, the implementation of these solutions does not require process shutdowns or major equipment changes, making them low-risk and cost-effective.

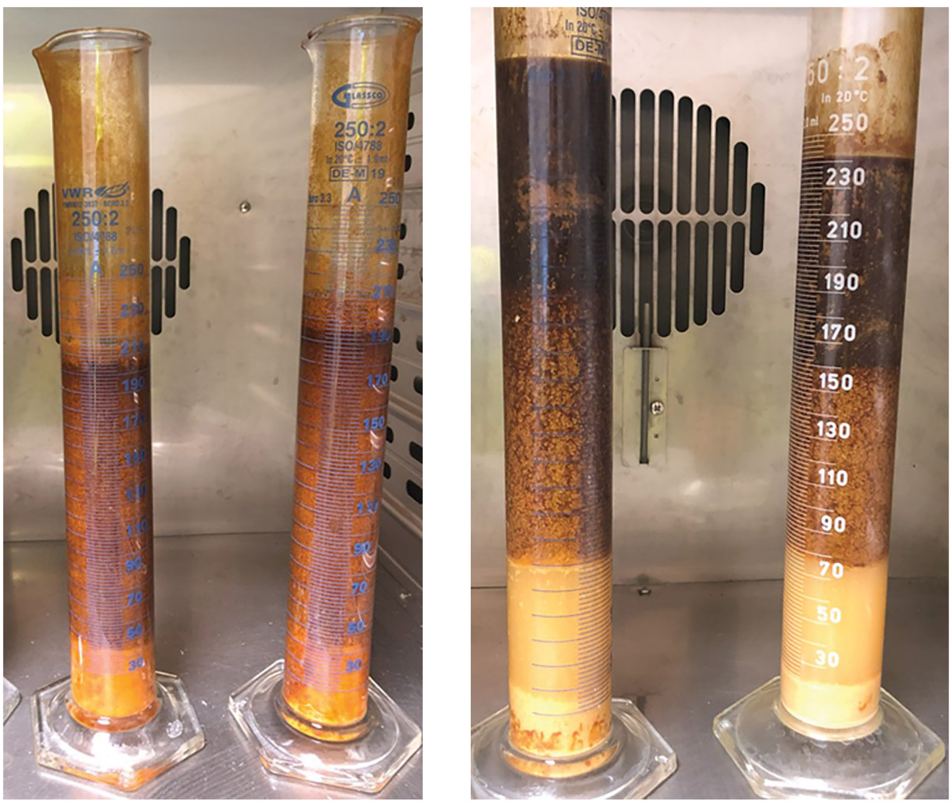


Figure 4a and 4b: Reference sample (left) vs sample with BIM Talloil Booster (right). After 10 min of separation of acidulated soap with BIM Talloil booster, a clear phase separation between the oil and lignin phase is visible compared to the reference sample without dosage.

Optimising process control for improved tall oil yield

Another challenge impeding full tall oil yield has been the lack of proper analysis and process control measures throughout the process. Starting with brown stock washing, where the soap chemistry is complex and typically not monitored, and continuing through soap skimming tanks often controlled mostly manually or semi-manually, it is not surprising that some yield losses can be attributable to suboptimal process control.

The key issue lies in the complex nature of soap in black liquor, which makes real-time analysis and tracking difficult. To address this, BIM Kemi uses a series of innovative analytical methods to evaluate soapy liquors, which reinforces the BIM TOMAX concept. These methods include:

1. Visual glass flask separation tests.

This is a visual method used to observe the separation process. A black liquor sample is collected and placed in an oven to allow natural separation, see images top right.

2. Heat centrifugal separation.

This is a volumetric analysis to measure the amount of soap that is separable from the black liquor and the quantity of tall oil that can be produced. The method, which is based on the Pinola analysis method, uses specific centrifuge glasses for soap separation and tall oil production.

3. A new camera-based image analysis method.

The camera image analysis method can detect and visualise soap particles in black liquor, measuring their count, size, and shape to provide quantifiable, actionable data in a new, unique way. Thanks to this methodology, the effect of chemistry changes can be more reliably observed, documented, and adjusted. This leads to significantly improved process control, reduced variability, and ultimately, higher tall oil yields.

Environmental and economic benefits

Improving tall oil recovery brings a twofold benefit: it reduces waste/operational costs and adds value. Improved tall oil recovery reduces organic load in recovery cycles, leading to lower maintenance needs in evaporators and recovery boilers, and improved mill energy efficiency. For pulp mills, the economic returns from even modest yield improvements are significant, considering the scale of production and the market price of tall oil.

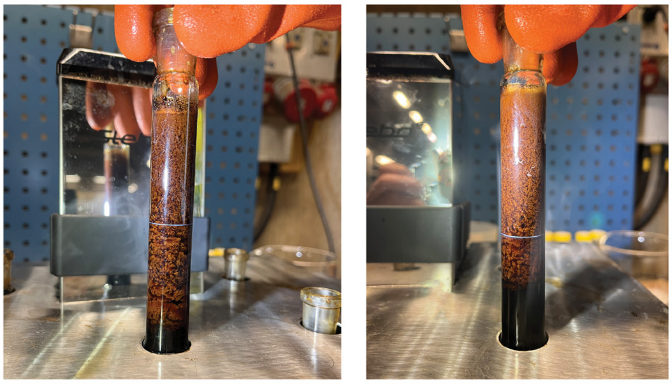


Figure 5a and 5b: Separation of soap from black liquor without dosage of BIM soap booster. 5b: Separation of soap from black liquor with dosage of BIM soap booster. A more compact layer of soap with less black liquor in the soap.

Key advantages include:

1. Higher profitability

- Increased tall oil yield translates directly to higher revenue
- Reduced energy use and less waste disposal costs

2. Sustainability gains

- Lower reliance on fossil-derived chemicals
- Higher utilisation of renewable resources
- Reduced greenhouse gas emissions by using tall oil-based biofuels

3. Regulatory compliance

As governments mandate stricter sustainability and circular economy measures, efficient by-product recovery will be critical for compliance and future-proofing industrial operations.

As demand for renewable raw materials continues to grow, the strategic importance of tall oil will only increase. The market is set for expansion, and mills that optimise their recovery processes now will be better positioned to capitalise on this growth.

Conclusion - unlocking value from a hidden resource

Tall oil recovery represents a significant, yet often underexploited, opportunity for pulp and paper mills to enhance both their economic and environmental performance. By moving beyond traditional methods and embracing advanced chemical solutions, mills can unlock the full potential of this once-overlooked by-product. Chemical innovations such as those in the BIM TOMAX concept provide scalable, cost-effective methods to boost recovery rates, reduce losses, and align with the broader push towards sustainability. By adopting such solutions, mills can convert what was once considered waste into a valuable resource, transforming the economics and impact of pulp production in a bio-based future.

Figure 6: Centrifuge test to analyse separable soap content.

BIM Kemi is a family-owned entrepreneurial company that has been developing and producing specialty chemicals for the global pulp and paper industry with a focus on sustainable solutions since 1973. *Over the years, BIM Kemi has been listed four times among Europe's top 500 rapidly growing entrepreneurial companies and received several awards for its dedication and contributions to the business world and the industry. With a global workforce of dedicated professionals, BIM Kemi operates across the world, with production units located in Sweden, Norway, Finland, the UK, and South Africa, and local operations in Germany, Poland, Belgium, the Czech Republic, Portugal, and France and agents and distributors in most other countries with pulp and paper manufacturing. The headquarters are located in Stenkullen, outside Gothenburg, Sweden, and house the central research and development department, customer service lab, and one of five production facilities. BIM Kemi are members of the UN Global Compact and have a gold rating by Ecovadis. We are your dedicated partner in innovative and green chemistry solutions for the pulp and paper industry.* ***To learn more, visit: https://www.bimkemi.com***