1. Introduction

The forest industry has been for decades one of the corner stones for Finland's economy. One of the first export products was burnt tar, which was used specially to protect the surfaces of wooden ships. In addition to exports, wood has been used in construction, heat and energy production, and manufacturing of various necessities. The forest industry developed and thus, the production diversified in the middle of 19th century when paper and board production began with wood fibers (Lamberg, 2012).With digitalization and change in consumer behavior, demand for traditional forest industry products such as paper and board has been declining, leading to a transition in the industry towards replacing fossil materials with wood-based end products. Nevertheless, the forest industry is still important to the Finnish economy and its share of all Finnish good exports was about 20 percent in 2018 (Ministry of Agriculture and Forestry, 2019).

With environmental pollution and the reduction of fossil fuels, more sustainable solutions have replaced oil-based raw materials. (Sarika, Nancarrow, Khansaheb, & Ibrahim, 2020) In recent years, wood has been used in new applications such as the production of biofuels and chemicals. Wood is a heterogeneous material, which is why its use in new applications requires more accurate understanding of the structure of wood and its components. Lignin is the most potential component to replace aromatics in many different applications, for example, as a substitute for phenol in the production of phenolic resins. The availability of lignin is good, with up to 50 million tonnes of lignin produced each year as a by-product of pulp and paper processes. However, its main use is currently energy production (Klett, Chappell, & Thies, 2015) because applicability of lignin in value-added products has been limited by the lignin's intrinsic heterogeneity and complex structure. Therefore, more research is needed about its different properties such as reactivity and solubility to optimize the properties of the ligninbased resin and its end-products.

In this bachelor's thesis, the correlations between the molecular weight distributions (MWD) of lignin-phenol-formaldehyde resin (LPF) and its properties measured from the resin were investigated. The development and properties of the LPF resin can be studied by measuring, for example, its viscosity, pH, alkalinity and free formaldehyde content. The aim of this work is to identify the effects of different manufacturing parameters on the MWD and on the other hand the effect of MWD on the LPF resin properties. The research method used are a literature review and computational processing of MWD data. The literature part focused to find information about the MWD of the LPF- and PF-resins, resin polymerization and how MWD are affected the resin properties. The work was done in collaboration with UPM, where the data for this bachelor thesis was obtained.

The theoretical part of the work deals with the production of LPF resins, characteristic production parameters, as well as the properties of lignin and the formation of the polymer structure of the resin. The results of the work are presented and interpreted at the end. Based on the results, the summary provides suggestions for heading future research.

1 Introduction

World hunger is a constantly rising issue in multiple developing countries. As the world population grows, there is a high demand for environmentally friendly and efficient food production methods to ensure food security. Blue food, meaning fish, bivalves, seaweed, and other aquatic foods, is an overlooked category of food sourcing. It has excellent potential to be an option for environmentally friendly, sustainable, and healthy eating. (Gephart et al. 2021.) The fish industry has grown to be a significant industry over the past 30 years. In 2018, about 156 million tonnes of blue food were consumed globally. Expanding and advancing onshore aquaculture methods is required rather than expanding marine and freshwater fishing for this growth to continue sustainably. (FAO 2020.) Due to problems caused by commercial fishing, such as overfishing and the disturbance in food chains, recirculating aquaculture systems could come in as a potential option (Marsh 2020). Recirculating aquaculture systems (RAS) are operated by purifying the water used in the cultivation tanks to be used again (Blue Ridge Aquaculture 2022). RAS waters tend to have issues with off-flavors and odors that affect the quality of the fish (Helmer 2020).

Research has shown that the off-flavors and odors are mainly caused by two compounds, geosmin (GSM) and 2-methylisoborneol (MIB). These compounds cause earthy, muddy, and musty tastes and odors in aquaculture waters. The off-flavors and odors are then accumulated in the fatty tissue of fish. (Zimba et al. 2011.) Since GSM and MIB are hard to remove from RAS waters, the fish are placed in a different tank with clean water, where the impurities accumulated in their fatty tissue diffuse into the clean water. This method is called depuration. Depuration requires separate facilities and uncontaminated water reserves, making this method impractical and expensive. (Lindholm-Lehti and Vielma 2018.) However, there have been some promising results with utilizing advanced oxidation processes (AOPs) as removal methods. (Antonopoulou and Konstantinou 2017.) A study on removing GSM and MIB with UV photocatalysis using titanium dioxide found it effective on spiked laboratory water and actual aquaculture water. Up to 90 % reduction in taste and odor compounds was reached in RAS waters. (Pestana et al. 2014.) Ozonation has been another possibility for the purification of RAS waters since it has already been used for municipal water treatment. It was found that low-dose ozone addition of 0.25 – 0.8 milligrams per liter did not reduce the compounds remarkably. It was also stated that a higher dose might work better. (Schrader et al. 2010.) Similarly, Yuan et al. (2013) found that using an ozone dose of 4.19 milligrams per liter reduced the amount of both GSM and MIB by 90 %. These findings are consistent with Schrader et al. (2010). While current research has shown potential, more research is still needed to utilize these methods on a larger scale effectively.

This bachelor's thesis investigated the practicality of GSM and MIB removal from water with titanium dioxide photocatalysis and ozonation. It was also explored whether these methods differed performancewise. The focus of the literature review is on getting a general understanding of the topic before diving into the experimental part of the thesis. The practical part involves removing GSM and MIB from spiked laboratory waters with UV photocatalysis using titanium dioxide as a catalyst and ozonation. The GSM and MIB levels are determined by pre-treating the samples with liquid-liquid extraction and analyzing them with gas chromatography-mass spectrometry (GC-MS).