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Lignin in Cosmetics: State of the Art

Discerning the value of lignin in the cosmetic industry

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Abstract

This study was carried out at the Department of Nanotechnology and Functional Materials, Uppsala University, one of several places where the interest of lignin in cosmetics is constantly growing. The functionalities of lignin have been studied to a great extent revealing its potential as a natural biopolymer to serve as a replacement for environmentally hazardous components in cosmetic formulations, namely UV-filters in sunscreens. Using ethnographic methods and qualitative interviews the lignin-cosmetic industry was observed and analyzed in order to discern how concerned the industry is with ecological and aesthetic value. Ecological value is a hallmark of the value proposition in the cosmetic industry, and leaders of the industry indeed share this view. The analysis further revealed that the actors of the lignin-cosmetic industry are at different stages of development and that as of this year we can expect the first product to be launched. Furthermore, the value chain of the lignin actors was identified and for the first time mapped out in detail from the qualitative analysis that was carried out targeting lignin actors within the lignin-cosmetic industry. Mapping the value chain revealed the actors included in the entire chain identified as biorefinery, manufacturer, modifier, formulator, distributor and retailer which together compose the lignin-cosmetic value chain. A qualitative, semi structured interview approach was used and adapted as we met with eleven actors interviewing them about ecological and aesthetic values in the lignin based product value proposition. The grounded theory was applied to analyze the data, generating eight categories representing the concepts comprising ecological and aesthetic values of the value proposition. The kernel category, Green Profile, explains the most important concepts valued by lignin actors in terms of what ecological and aesthetic value could be offered to be appealing to customers. The findings of this study reveals the current situation of lignin in the cosmetic market as of today, and discerns where the value of lignin lies. The understanding of lignin actors' values contributes to the current gray-area in biopolymer research, lacking information on the value chain of lignin in cosmetics. The findings therefore foster the advancement of sustainable innovative solutions for cosmetics and personal care.

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Populärvetenskaplig sammanfattning

Lignin är en omtalad komponent av biomassa som tillsammans med hemicellulosa och cellulosa utgör beståndsdelarna i träd och annan växtlighet. I pappersmassaindustrin har polymeren lignin länge varit en spillprodukt och dess fulla potential har inte utnyttjats då dess egenskaper förbisetts. Nyligen har dess egenskaper fått mer igenkänning då möjligheter att vara en god antioxidant och skydda mot UV-strålning gör att kosmetikaindustrin har ett större intresse för lignin. Att polymeren dessutom är av naturligt slag gör intresset extra stort eftersom ligninet i kosmetika kan byta ut syntetiska alternativ med sämre påverkan på miljö och människor.

Marknaden för ligninbaserad kosmetika har inte blivit kartlagd än och det är svårt att få en bild av vilka aktörer som är involverade eftersom det är ett så pass innovativt fält. I denna studie reder vi ut vilka aktörer som är aktiva och hur leverantörer inom industrin hänger ihop. Aktörer inom lignin-kosmetikaindustrin identifierades och kontaktades för kvalitativa intervjuer. Roller tilldelades de olika aktörerna allt eftersom ett mönster av beteende började synas och resulterade i att en värdekedja kunde presenteras. I denna värdekedja är bioraffinaderiet startpunkten för ligninets resa, följt av tillverkare, modifierare, formulerare, distributör och slutligen återförsäljare.

På världens största kosmetikmässa in-cosmetics® samlas industrins främsta, mest innovativa företag. Ett nav för industrins ledande aktörer. Genom att genomföra en fältstudie med grund i etnografisk metodologi studerade vi industrins syn på ekologiskt värde i stort, vilket visade sig ha en central roll i vad industrin värdesätter. Det framgick att det är omöjligt att tala om industrins värdebild utan att lägga stor vikt på hållbarhet och ekologiskt värde. Ett genomgående tema bland alla aktörer som ställde ut på mässan, seminarier vi deltagit vid, såväl som arrangörernas estetiska skildring av mässan, var att de alla försökte kommunicera vikten av att producera produkter som är hållbara i hela utsträckningen av processen. Från

ursprunget av materialet till uppföljningen av hur återvinning hanteras är det företags yttersta skyldighet att se till att de tar ansvar för hela produktionskedjan av en produkt, med alla omständigheter inkluderade. Nämnvärt var också att industrin jobbar hårt för att undvika Greenwashing, en illvillig marknadsföringsstrategi som missleder konsumenten att en produkt eller tjänst är miljövänlig när den i själva verket inte är det.

Under intervjuer med leverantörer av lignin dök några specifika termer upp oftare än andra. Deltagarna nämnde ofta hur aspekter såsom att lignin är naturligt, biobaserat och inte kemiskt modifierat är viktigt för vad de väljer att leverera till sina kunder. En sammanställning av intervjuerna genererade olika kategorier som förklarar hur leverantörerna ser på produkten som erbjuds till kunder i termer av ekologiska fördelar såväl som estetiska. Vi fann att en Grön Profil, med andra ord ett erbjudande av bland annat ovan nämnda fördelar, är absolut viktigast för vad som erbjuds till kund.

Definitions and Abbreviations

Definitions and abbreviations are presented below in alphabetical order.

Category - One or several concepts that have been processed to an extent that they together can represent a phenomena of reality (Strauss, Anselm L. and Corbin, Juliet M., 1998; Bryman and Bell, 2011).

Concept - Are created through open coding and serve as labels of phenomena that are recurrent in data (Strauss, Anselm L. and Corbin, Juliet M., 1998; Bryman and Bell, 2011).

Green Cosmetics - "are referred to as natural and organic cosmetics: products that contain natural and organic plant-based ingredients and avoid synthetic.."- (Rodrigues *et al.*, 2018)(Sheehan, 2014)

Greenwashing - Intentionally misleading marketing strategy portraying a product or service as more environmentally friendly than it is (*Green claims*, 2023-05-10).

IARC - International Agency for Research on Cancer

Natural cosmetics - Incorporation of natural extracts in cosmetic formulations, such either have natural origin or/and are developed considering sustainability aspects (Rodrigues *et al.*, 2018).

NDA - Non Disclosure Agreement

REACH - Registration, Evaluation, Authorisation and Restriction of Chemicals

SCCS - Scientific Committee on Consumer Safety

SPF - Sun protection factor

UV - Ultra Violet

Value chain - Companies together compose a chain of actors, cosmetic companies, distributors and customers, which is referred to as value chain and/or value chain (Kumar, Massie and Dumonceaux, 2006)

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1. Introduction

Sourcing waste stream biomass for usage as ingredients for cosmetic applications is frequently suggested, especially as of today, as the interest for natural ingredients increases (Schieber, Stintzing and Carle, 2001; Barbulova, Colucci and Apone, 2015). Lignin, a natural biopolymer with origin from plants, is a by-product from pulp and paper industries (Sadeghifar and Ragauskas, 2020). Several properties of the molecule motivates its applicability in cosmetic applications (Sadeghifar and Ragauskas, 2020). Cosmetic customers are motivated to purchase green cosmetics based on factors such as the origin and production process of the product, as well as how safe it is for their body (Hsu, Chang and Yansritakul, 2017). The attention that green products and ecological sustainability is receiving is increasing globally (Jan, Ji and Yeo, 2019). Consumer attitudes towards buying green cosmetic products seem to correlate with the product origin, production process and environmental safety of the product (Hsu, Chang and Yansritakul, 2017). Indeed, Consumer attitudes towards buying green cosmetic products were shown to correlate with the product origin, production process and safety of usage, one such factor being that the product is organic (Jan, Ji and Yeo, 2019).

Lignin has many times been proposed to be applicable as a cosmetic ingredient especially due to the SPF and antioxidative properties that it carries (Ugartondo, Mitjans and Vinardell, 2008; Zhang *et al.*, 2019; fGordobil *et al.*, 2020; Widsten, 2020; Arruda *et al.*, 2021; Antunes *et al.*, 2023). To our knowledge, little is declared about the status of commercialization of lignin products. However lignin nanoparticles are predicted to be a part of the future of cosmetics (Bajwa *et al.*, 2019). Furthermore, the Norwegian company Borregard produces vanillin based on lignin (Kaushik, 2014), which can be used in cosmetics as a fragrance (Kaushik, 2014)(Wong J.T, 2012).

The cosmetic industry's value chain is composed of actors, cosmetic companies, distributors and customers (Kumar, Massie and Dumonceaux,

2006). However, an extensive mapping of the lignin-cosmetic value chain is to our knowledge not available as of today. The management of the value chain is vital for the success of all parties involved (Kumar, Massie and Dumonceaux, 2006), and thus the recognition of its composition is important for its prospects.

Cosmetic companies deliver value, that is the performance of the product, its aesthetics, innovative initiatives and incorporation of technology in the formula (Kumar, Massie and Dumonceaux, 2006a). As the attention towards green consumerism increases, understanding how communication of value affects purchasing behavior of customers becomes important (Todd, 2004; Jan, Ji and Yeo, 2019). As previously mentioned, aesthetic values are offered in cosmetic products (Kumar, Massie and Dumonceaux, 2006), where the goods deliver a feeling of pleasure or the opposite through its holdings (Plato and Meskin, 2014). Aesthetic values meet environmental values in the delivery of natural cosmetic products, as producers need to deliver in terms of both environmental sustainability and product effectiveness (Todd, 2004). As why the interest of understanding what aesthetic and ecological values should be delivered by lignin ingredient actors targeting the cosmetic industry arises.

1.1 Background

Utilization of lignin for cosmetic application is a possibility (Zhang *et al.*, 2019; Sadeghifar and Ragauskas, 2020). Studies have been carried out to investigate UV protection properties of the polymer, indicating that the SPF boosting effects are indeed there, and that the absorption spectrum is broad (Zhang *et al.*, 2019; Sadeghifar and Ragauskas, 2020). A reason behind the interest in lignin for cosmetic applications arises from the need to replace or limit the use of synthetic substances found in sunscreens (Zhang *et al.*, 2019; Sadeghifar and Ragauskas, 2020). Organic filters were used before mineral filters entered the market and have been proven to be harmful to both users, and the environment. A natural polymer, as lignin, is thus in the lime-light (Zhang *et al.*, 2019; Sadeghifar and Ragauskas, 2020). Furthermore, the industry is predicted to see large growth as according to Statista (2020) the global sales of organic cosmetic products is estimated to see a growth from $USD 34.5 billion in 2018 to $USD 54.5 billion in 2027.

Pulp and paper industries and biorefineries produce lignin as a consequence of other activities (Sadeghifar and Ragauskas, 2020). The lignin can be further modified as a next step, for instance for pigment purposes (Zhang *et al.*, 2019) or for enhanced UV blocking properties (Widsten, 2020). However, actors' enrollment in the industry has not been declared to any greater extent in scientific studies, to our knowledge. This is theorized to be because lignin has carried a negative connotation due to its unpleasant odor and dark color (Guggenberger *et al.*, 2023). Neither does literature provide the means to understand the construction of the value chain in the lignin-cosmetic industry. The effectiveness of actions incorporated in a cosmetic value chain determines the amount of profit the actors can make (Kumar, Massie and Dumonceaux, 2006a). Thus, there is in our view a need for a proper mapping of the lignin-cosmetic industry.

Ayadi and Lapeyre (2016) state that environmentally aware customers are inclined to purchase a product that possesses ecological benefits and recognizing such green attributes increases their will to purchase a product (Ayadi and Lapeyre, 2016). However, this inferring was counterproved by

Jan, Ji and Yeo (2019) as they in a study found ecological benefits not to correlate with the customers' purchasing attitude. However, values of safety did correlate, where customers were affected positively by the exclusion of synthetics (Jan, Ji and Yeo, 2019). In yet another study, Todd (2004) concludes that advertisements of cosmetics generate sensory experiences which include ethics related to the environment (Todd, 2004). Hence, there is an interplay between the aesthetics of the cosmetic product and that of nature (Todd, 2004). Furthermore, these customers recognize themself as wanting to do good for the environment, as why they consider environmental aspects of the product that they purchase (Todd, 2004). Here the interest of ecological and aesthetic value delivery within the lignin-cosmetic industry rose. By declaring what ecological and aesthetic value actors of the lignin-cosmetic industry could offer customers, one can better understand the market opportunity.

1.1.1 The Department of Nanotechnology and Functional Materials, and the interest in lignin

At the Department of Nanotechnology and Functional Materials, Uppsala University an innovative extraction process for Organosolv lignin is being explored, and various industrial applications are investigated for lignins viability. One of the applications currently investigated is understanding the areas of use for Organosolv lignin in the cosmetic industry. Organosolv is the product of an industrial process for solubilizing lignin and hemicellulose in an organic solvent producing a pulp which is more easily distilled than conventional kraft pulp, and additionally eliminates the odor often obtained with kraft pulping (Johansson, Aaltonen and Ylinen, 1987).

1.2 Problematization

Lignin for high-value applications is a recurring term in scientific literature and vernacular contexts. A number of actors are developing such high value applications towards the cosmetic industry already, and the properties which are to be of special interest for cosmetic products seem to be UV blocking and antioxidant properties of the natural biopolymer (Pan *et al.*, 2006; Sadeghifar and Ragauskas, 2020).

Aesthetics does indeed play an important role in cosmetics, however environmental values have too come to be important for the cosmetic industry (Todd, 2004). The companies investigated in Todd's (2004) work were all very motivated by environmental concerns. As of today when environmental concerns are turning more heads there is a need to elaborate on how values related to environmental concerns are apparent (Jan, Ji and Yeo, 2019). In this analysis we aim to investigate the general view on ecological values in the cosmetic industry as well as specific companies working with lignin, not necessarily characterized by such initiatives. This to further engage in whether lignin actors offer such value and how their value proposition is composed of for lignin biopolymer products.

The upcycled material travels from nature to a final product, a journey where a lignin based cosmetic product takes shape from what was once waste. We wish to elaborate on this journey, in terms of what actors are involved, how they are intertwined and what their efforts are. This, to understand what this innovative industry looks like so that the ecological and aesthetic value incorporated in the industry can be understood.

Lignin, described as a heterogeneous molecule with a lot of potential by the actors within the field, carries properties that are of "high value". What has not yet been detangled however is how actors view upon value within this field. We are interested in understanding what terms are used to describe high value and what is essential for the ingredient to be seen as an ingredient possessing such. What can be noted is how some minds describe high value applications as something which generates economic profit. The

opinion of what value lignin has in the cosmetic industry however has not been properly mapped, to our knowledge.

In the most rudimentary form, the cosmetic industry needs to deliver a sensory experience to the end customer which fulfills him or her, allowing the consumer to experience the aesthetic attributes, such as smoothness, of the final product. Perhaps the cosmetic industry is a good example since it differentiates from other fields where the aesthetic experience is not the main scope. Even so, when the aesthetic aspect is of importance to a customer, it seems as if this comes with a more comprehensive responsibility towards ecological sustainability. One may suggest that this field of cosmetics and their actors in some way are very aware of ethical aspects and that these values guide the industry as a whole. Lignin applications in cosmetics may be very economically profitable as it is an upcycled by-product which is inexpensive as feedstock and as a product which can be sold for much.

In order to have the entirety of the cosmetic industry understand the value of using lignin based ingredients rather than alternatives which are potentially harmful to the environment and make the switch to using biobased polymers instead of traditional alternatives, one needs to investigate what the value creation is composed of and to what extent it is being met between already established relations between actors and customers. This has to our knowledge not been further investigated and therefore is of interest for us. This elaborates on the understanding of customer needs and validates what can be further improved in the delivery.

1.3 Purpose

This study focuses on the investigation of 1) actors involved in the lignin-cosmetic industry, 2) the importance of ecological value recognized by the cosmetic industry, and 3) what ecological and aesthetic value that is offered by actors in the lignin based products that they produce. The practical context of this research is the main driving force of the study advancing the analysis forward.

The purpose of this study is to discern the value chain of lignin polymer actors and what role ecological and aesthetic value play in the value proposition of lignin based cosmetics. Without identifying this value proposition and the industries' organization it is impossible to answer where the potential lies for a lignin based product and explain the value of biobased polymers.

The theoretical context of this master thesis will be the minor driving force of scientific curiosity. However, theoretical context will still be of large importance both to understand the chemical characteristics of lignin which gives it its properties, available for utilization in personal care and cosmetics, as well as various current businesses how lignin is utilized in personal care and cosmetics. Analyzing current business opportunities with lignin, elucidates the question on how feasible it is to introduce a novel lignin based product on the market. It produces theoretical ground on which new theories can be postulated. Simultaneously theoretical context on lignins chemical properties creates understanding of use cases for lignin based products, with regards to its possible characteristics e.g. UV-blocking effects, and deflocculating properties.

1.3.2 Research Questions

With regards to an interest in understanding the potential of lignin polymers in cosmetics we will investigate what the current status of the industry is, the importance of ecological value in the cosmetic industry overall and what ecological and aesthetic value is offered by current lignin actors of the cosmetic industry.

The field of actors involved in lignin based cosmetics has not been properly mapped, nor has the view upon value delivery been investigated. To understand how actors of lignin biopolymers can offer value one needs to understand how the industry is constructed as a first step. Leading up to the research question;

- What does the industry of lignin-based cosmetics look like?

Furthermore, we will elaborate on the importance of ecological values that are present in the cosmetic industry, answering the following question.

- How important are ecological values in the cosmetic industry?

Finally, we will investigate what current lignin biopolymer actors offer within aesthetic and ecological value. We will turn our focus toward existing lignin biopolymer actors to answering the central question:

- How can actors within lignin biopolymer production offer ecological and aesthetic value in lignin for the usage of cosmetic product formulating?

1.4 Delimitations

The project aims to conduct a rigid analysis delivering confident results and therefore withdraw from analyzing all aspects which affect the organizations involved.

1.5 Limitations

lignin in cosmetics is a fairly new field and as a consequence the quantity of companies involved in the subject is limited. For the analysis of the offered ecological and aesthetic value of lignin cosmetic products, this may affect the theoretical saturation of less commonly occurring data. Thus, certain concepts that have been brought up by merely one interviewee does not qualify as important for the industry as a whole given that it is not significant. Whereas if more actors were available, for a larger industry, the contextual importance for a less frequent recurring concept may have been further understood.

We can not disregard how the matter of confidentiality, and Non Disclosure Agreement, NDAs, can dictate the data obtained for the analysis, as numerous factors of interest will be hidden away behind confidential documents and trade secrets. Thus, some data that would be of relevance for our research might not be within our reach and as a consequence can not be addressed.

1.6 Disposition

Starting of section *2. The Literature Review* introduces the reader to the cosmetic industry along with cosmetic trends and actors involved in lignin based cosmetic development. The review covers the values that are apparent in the industry and how these are defined. Furthermore, the technical aspects of lignin are covered along with the production process of different types of technical lignins. The Literature Review finishes off with regulatory aspects related to the field and the ecological and technical opportunity of lignin based cosmetics. The Research Approach is presented in section *3. Research Approach* presenting the scientific viewpoint that the researchers have followed, included also an overall image of how the research was

conducted. In the methodology section, section *4. Research Methods,* the Ethnographic and qualitative methodology is motivated, describing how the research was carried out along with how the analytical framework was used to analyze the data. Ethical aspects are covered in section *5. Ethical Aspects*. The analysis, section *6. Analysis,* brings up the data generation from the interviews and ethnographic study and are studied through the lens of the analytical framework. A reflection of the choice of methodology, future outlook and academic and practical contributions are presented in section *7. Discussion*. The final message, *8. Conclusions,* relates to the research questions and the conduction of the research. *Appendix 1 - lignins potential as an SPF booster in cosmetic SPF mineral powder formulation* includes a Technical Project Plan for how SPF boosting properties in a SPF mineral powder containing lignin can be investigated. The Semi-structured interview guide can be found in *Appendix 2 - Interview guide for interviews with actors.* Furthermore, the concepts identified using Grounded Theory are found in *Appendix 3 - Concepts identified from qualitative interviews.* In *Appendix 4 - Author's contribution to the report*, the contributions to the report are specified.

2. Literature review

The literature review lays the foundation for the information retrieved on the topic, as well as to identify where the gap in the previous research exists.

2.1 The Cosmetic Industry

Approximately 450 million Europeans use cosmetic products such as shampoo, toothpaste, soap, hair conditioner, shaving cream, deodorant, perfume, skincare, or make-up every day (Rodrigues *et al.*, 2018). Indeed, this is a very large global market, with strong opinions and forces from consumers, as much revenue is generated from them.

Currently, customers are demanding natural cosmetic products more than ever because the cosmetic industry is faced with large sustainability challenges worldwide as threats toward the economy and environment are on the rise (Rodrigues *et al.*, 2018). This is largely due to the environmentally safe, non-toxic and sustainable profile natural cosmetic products have in comparison with conventional products which have been perceived to be harmful to the environment (Rodrigues *et al.*, 2018).

2.1.1 Current Status of the Cosmetic Market

Cosmetics started to get more widely used during the 19th century as a consequence of the formula being based on cheaper alternatives, chemicals, rather than natural sources (Kumar, 2005). It was not until later that consumers were starting to get more aware of health and environmental concerns related to the cosmetic industry (ibid). Health concerns referring to how they affect the health of the user and where environmental concerns refer to animal rights, clean air and water as well as waste management (ibid). In the 1990's, 20% of people in the US were Green Consumers, meaning that environmental considerations are reflected in their purchasing habits (ibid). As a consequence, green cosmetics were on the rise, and strategies included cruelty free, natural products with recycled packaging (ibid). In terms of health concerns, the natural ingredients, from plants, were

also an important player as such ingredients were received by customers as healthy (ibid).

Innovation is crucial to succeed in the cosmetic industry (Kumar, Massie and Dumonceaux, 2006). Other than that, the efficiency of the value chain (elements include suppliers, cosmetic companies, distributors and customers) that a company is included in determines how successfully that company will perform (Kumar, Massie and Dumonceaux, 2006) (Chandra and Kumar, 2000; Kumar and Chandra, 2001; Kumar et al., 2001; Kumar and Beattie, 2004; Mentzas, 2004). An explanatory figure of what such a value chain could look like can be found in Figure 1. Based on costs related to the value chain the final profit will change and thus companies can advantageously strive to become more efficient in their cooperation to reduce costs (Kumar, Massie and Dumonceaux, 2006). The obtained value of a cosmetic product is related to margins in terms of profits and is the difference between what consumers are paying and the sum of all costs attached to the production (ibid).

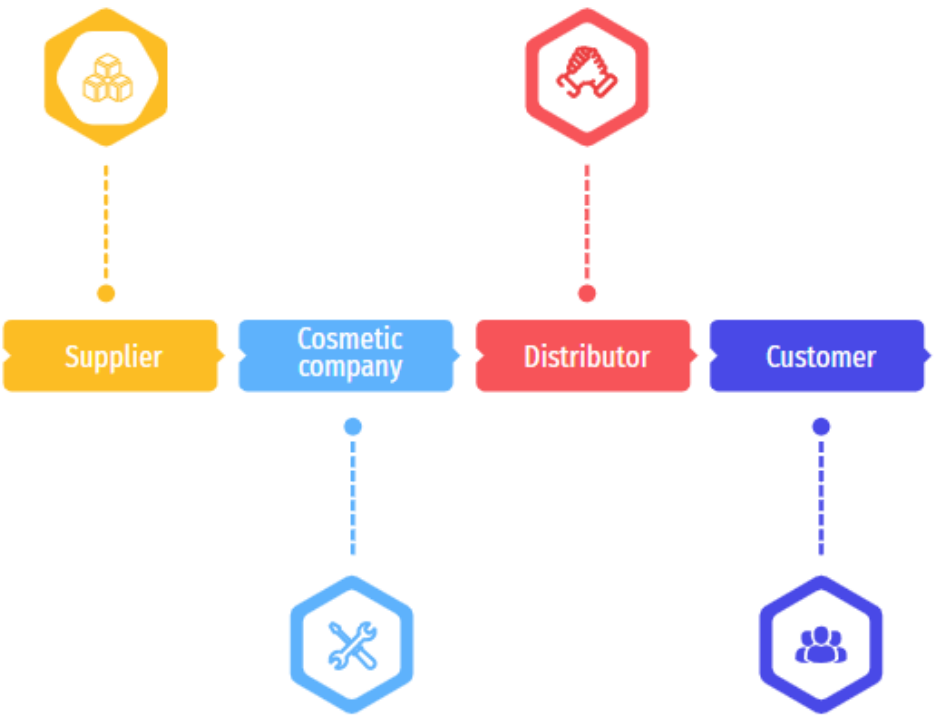

Fig. 1. An explanatory figure of how a cosmetic industry value chain could be composed from supplier to customer, based on findings in literature (Kumar, Massie and Dumonceaux, 2006a). Templates are accredited to SlidesGo and FreePik.

Competition in the cosmetic industry concerns quality, appearance and price (Kumar, Massie and Dumonceaux, 2006). In terms of who holds the power, consumers have great power as they have loads of brands to choose from causing cosmetic companies to compete on the attributes that were previously mentioned (ibid). Less power is in the hands of the actors where a lot of competition is present. For being competitive a company needs to consider price and uniqueness of product, according to Michael Porter's philosophy of competition (ibid). Possessing an advantage however does not always go hand in hand with ability to compete (ibid). To hold an advantage the company has to choose either a strategy offering a unique product at a high price or optionally offer a product that is neither costly nor unique (Kumar, Massie and Dumonceaux, 2006).

2.1.2 Competition between actors

Michael E. Porter suggests five forces of competition; "..threat of new entrants, bargaining power of buyers, rivalry between existing competitors, threat of substitute products and bargaining power of actors" - (Porter, 1980). The forces can be used to analyze the earning capacity that a company has (Porter, 1980). More specifically Porter describes how the forces are mild in the cosmetic industry as compared to other industries where competition can be more fierce.

Kumar *et al.* (2006) has analyzed the cosmetic industry using Porter's five forces finding that rivalry between existing actors is high, as is the threat of new entrants (Kumar, Massie and Dumonceaux, 2006). However they found that the threat of substitute products is low and how many cosmetic companies use this to increase their margin by offering application tools for applying the product. Furthermore the bargaining power of the buyers is high whereas the power of the supplier is lower (ibid).

2.1.3 Trends in Cosmetics

The bioeconomy consists of renewable biological resources and waste streams converted to sources of feed, food, energy, and other bio-based products utilized by society (Gaffey *et al.*, 2021). This contrasts

conventional alternatives stemming from the industrial revolution, anchored in large-scale, high profit, products and processes carrying the burden of high environmental impact (ibid). Recently, the global bioeconomy is increasingly becoming a contributor to the overall European economy as a whole (ibid). The Compound Annual Growth Rate (CAGR) for bio-based polymers is at 8%, significantly higher than the overall market growth rate of polymers (3-4%), and is expected to continue until 2025 (ibid).

According to the EU bioeconomy Strategy update, which supports the EU Commission's political priorities, a transition to a bio-based economy requires a profound transformation supported by the crucial role played by consumers and their behavior (Yildirim, 2020). One of the most vital turning points to reach sustainable development in a broader sense is reshaping consumption patterns, accompanied by a production which is sustainable (ibid).

The contribution of eco-friendly cosmetics to the global cosmetic industry market is 15 percent or lower than the total market value (Sadiq, Adil and Paul, 2021)(Bhawna, 2020). This shows that eco-friendly cosmetics is an incipient and emerging market. Consequently, it reveals subtle, but clear barriers among cosmetic consumers to adopt consumption patterns aligning with eco-friendly cosmetic products (Sadiq, Adil and Paul, 2021).

Several functional barriers to adopting unfamiliar and new products are identified in existing literature as being crucial to the perceived resistance. Such barriers are value, risk, and usage (Sadiq, Adil and Paul, 2021). Specifically, the barrier of usage has been identified as a significant friction-inducing force for the adoption of organic products (Tandon *et al.*, 2020). Furthermore, it is observed that consumers prize the discerned value of an organic product, as well as comparing its performance to the alternative (Sadiq, Adil and Paul, 2021). Additionally, the trust consumers express toward manufacturers' process for developing the organic products, as well as certifications used, is deemed to be quite low. This in turn heavily and negatively affects the risk perceived with bio-based products and

hampers the probability of a purchase. Therefore, the resistance against bio-based products increases and hinders the sustainable transition (ibid).

2.2 Values in the cosmetic industry

Expanding on value and its definition are the subcategories of value which in this case are: ecological value and aesthetic value. All values explicitly expressed by the interviewed candidates.

2.2.1 Value delivery through cosmetic products

In terms of value in the products that are delivered to customers, Kumar *et al.* (2006) have found that leading cosmetics companies are delivering value, that is heightened aesthetics, packaging and products of innovative kind, and technological efforts induced in the products (Kumar, Massie and Dumonceaux, 2006). Hence, the value lies in what is being delivered to the customer.

2.2.2 Ecological value

A contemporary view on the evaluation of an object's certain ecological value is directly related to a consumer's inclination toward making a purchase based on a particular product's ecological and environmental impacts (Jan, Ji and Yeo 2019) (Ayadi and Lapeyre, 2016; Jacobs *et al.*, 2018). It is preferable for a consumer to purchase products which align with the ecological benefits they care for (Hsu, Chang and Yansritakul, 2017). Such benefits are identified as: containing natural ingredients, using materials from sustainable sources, organic labeling, being environmentally safe/friendly, being biodegradable, having low carbon emissions, and refusing usage of animal testing (Hsu, Chang and Yansritakul, 2017). Collectively, the ecological value is created from the ecological benefits that the consumer, and the society as a whole gain from purchasing the particular product (Hsu, Chang and Yansritakul, 2017). Additionally, in the case of cosmetic companies purchasing biopolymers, the ecological value is expanded by the end customer, with regards to how end customers are the driving force of the demands on cosmetic companies to produce greener products (Bom *et al.*, 2019). Other driving forces of the transition is the availability of sustainable raw material and that laws and regulations are in

line with the motion (Bom *et al.*, 2019). Thus, we elaborate on what value is defined as for the cosmetic companies.

2.2.3 Aesthetic value

In the cosmetic industry the aesthetic value of an object lies in the eyes of the beholder (Plato and Meskin, 2014). Aesthetics addresses sensory inputs and therefore this analysis will examine sensory inputs which please rather than displease the observer (Plato and Meskin, 2014). In order to evaluate aesthetic value, we need to conform to a definition of aesthetic value. The definition of aesthetic value chosen is as follows:

"Aesthetic value is the value that an object, event, or state of affairs (most paradigmatically an artwork or the natural environment) possesses in virtue of its capacity to elicit pleasure (positive value) or displeasure (negative value) when appreciated or experienced aesthetically." - Plato and Meskin (2014)

2.2.4 Environmental aesthetic value of cosmetic product manufacturers

The ecological aspects of cosmetic products are becoming more important as customers and corporate parties are becoming more involved in ethical consumption (Todd, 2004). Within the field of cosmetics, ethics is a keyword, where the ethics of a customer is mirrored in her consumption behavior (ibid). Further, the environmental consciousness of customers are found in the ethics of a company which has a close relationship with customer values through their shared beliefs, products and advertising (Todd, 2004). Environmental values and aesthetic values meet in environmental aesthetics as environmentally conscious purchases accommodates not only for ecological sustainability but for a conscious lifestyle (Todd, 2004). At Toms of Maine, the personal is political, hinting on how their choices as customers fall under ethical concerns as well. When purchasing ingredients Toms of Maine considers environmental as well as aesthetic values so that not only the final product performance is a central outcome but also to, from a bigger perspective, contribute to a more ecological sustainable way of doing business (Todd, 2004)(Tom's of Maine, 2003). Cosmetic products producers, as the previously mentioned, link

between ethics and aesthetics in their way of advertising and as a consequence contributes to the customers awareness of the process of product manufacturing as well as background about included products (Todd, 2004). Thus, the companies are considerate in their choice of ingredients as they need them to live up to the ecological and aesthetic values that customers see and also to the companies standpoint.

2.2.5 Ethics in the field of cosmetics

Personal ethics, such as a consciousness towards overconsumption and environmental degradation, motivates customers to purchase green products rather than conventional ones (Todd, 2004). When the consciousness for sustainability is not as obvious for the customer, he or she can still be enticed to make the same conscious choice as a consequence of companies implementing aesthetic attributes related to sustainability in the product (Todd, 2004).

Ethical questions arise when one discusses the value that is embedded in nature. Carlson and Berleant (2004) discuss how objects in nature such as the forest itself can be assigned rights due to one's own view upon the matter. Thus, what is rightful or wrong actions against matter in nature sometimes has no clear answer and has more to do with the perception of ethical aspects of what nature beholds (Carlson and Berleant, 2004). When one sees values in the environment, it is suggested that ethics is incorporated in the way that ethics drives action with the goal that those values that are there are to remain (Todd, 2004)(Berleant, 1993). Therefore, the aspect of ethics is constant throughout the entire process of creating a cosmetic product sourced from nature.

2.3 Technical lignin

Discovered in 1838, lignin is one of the most abundant renewable resources after cellulose and is found in the cell walls of plants where it is involved as a water transporter component (Wool, 2005). The biopolymers are stable and divided into guaiacyl and guaiacyl-syringyl lignins where the latter is distinguished by including syringyl-propane subunits (ibid).

2.3.1 Characteristics

Lignin possesses antioxidant, antimicrobial and stabilizing properties and is a good candidate to replace other synthetic materials as lignin is biodegradable, carbon dioxide neutral and upcycled (Thakur *et al.*, 2014) (Singha and Thakur, 2010; Pinkert *et al.*, 2011; Bertini *et al.*, 2012; *Thermal Mobility of β-O-4-Type Artificial lignin | Biomacromolecules*, n.d).

The two forms of lignin are also referred to as alkali lignin and sulfonated lignin, where the latter contains hydrophilic sulfonate groups that allow it to dissolve in water (Sadeghifar and Ragauskas, 2020). The cleavage of bonds in lignin structure during pulp and paper industry processes cause small molecules to be formed (Wool, 2005; Sadeghifar and Ragauskas, 2020). These groups have other functional groups than that of the original biopolymers and the dark color of lignin is a consequence of such functional groups (Sadeghifar and Ragauskas, 2020). The functional groups, chromophores, in the smaller molecules enable lignin to have UV blocking properties, where the functional groups have UV absorbing properties along the light spectra (ibid). The dark color of lignin composes an issue when introduced in sunscreens, however through fractionation and acetylation the structure can be modified so that the intensity of the color is reduced (Zhang *et al.*, 2019).

By adding lignin with a weight of 2 wt% to a sunscreen product with an SPF of 15, the SPF could be doubled to 30 (Sadeghifar and Ragauskas, 2020). By increasing the lignin content to 10 wt% further increased that number to a SPF of 50 (ibid). After UV radiation, improved sunscreen protection was reported. lignin's synergistic effects together with already present ingredients in sunscreen is attributed to this effect (ibid).

In a study conducted by Qui X. *et al* in 2018 lignosulfonate was added to a mineral sunscreen containing TiO_2 (titanium dioxide) (Yu *et al.*, 2018). They showed that an esterification between hydroxyl groups of the TiO_2 and the carboxyl groups of the lignin led to an increased dispensability of the TiO_2 as well as an improved UV-blocking capability. With only 10 wt% lignin, a TiO_2 based sunscreen was able to reach SPF of 26 (Yu *et al.*, 2018).

Resistance against degradation is a hallmark of lignin, according to Wool P Richard *et al.* (2005). This is due to exceptionally stable bonds formed through enzyme-initiated polymerization resulting in (1) aromatic carbons creating biphenyl carbon-carbon linkages, (2) hydrolysis-resistant linkage between ethers, as well as (3) aromatic carbons bonding with aliphatic carbons in carbon-carbon bonding (ibid). Being resistant against degradation is a beneficial property in order to prolong the shelf life of a particular cosmetic product (Auffan *et al.*, 2010). Additionally Auffan M. *et al*. (2010) state the importance of a product's structural stability in relation to potential exo-toxicological effects. Since lignin's appearance on the cosmetic market is closely linked to combating environmentally harmful ingredients, this importance can not be understated (Wool, 2005).

The natural phenolic polymer, that is lignin, has good potential as an antioxidant (Pan *et al.*, 2006). When lignin is depolymerized the amount of phenolic hydroxyl groups increases and consequently aliphatic hydroxyl groups decreases, generating better antioxidant properties of the molecules (ibid). Meaning that a low molecular weight lignin molecule has better antioxidative properties than that of high molecular weight. The antioxidant properties that lignin possesses are affected by how it is treated during processing and seems to increase with temperature, reaction time, catalysts and a lesser amount of ethanol (Pan *et al.*, 2006).

Moreover, the particular use case of lignin as feedstock for vanillin products is certainly a characteristic strength of the biopolymer(Fache, Boutevin and Caillol, 2016). Through lignin depolymerization lignin is converted to lignosulfonate, capable of being processed to vanilla extract, and has for half a decade been the most customary process for creating vanillin naturally (ibid). Interestingly, only 10% of the extracted lignins are used to prepare vanillin, since Kraft lignins (the majority of lignins produced) are typically combusted (ibid).

2.3.2 Categories of lignin

There are a number of different lignin types; Sulfur-containing lignins such as Kraft lignin and lignosulphonates, Sulfur-free lignin including Soda lignin, Organosolv and Steam explosion lignin, Greener lignins such as Ionic Liquid lignin and deep eutectic solvent lignin and lastly there is a category of other lignins including Milled wood lignin, Pyrolysis and Hydrolysis lignin (Luis Alberto Zevallos Torres *et al.*, 2020).

Organsolov is currently produced by a limited number of pilot actors around the globe, examples are CIMV, Fibria, Fortum and Fraunhofer (Mastrolitti *et al.*, 2021). The application area is mostly biochemical products such as elastomers, carbon fibers, polyesters, coatings and binders (ibid). None of these are currently producing Organosolv lignin towards the cosmetic industry. There are a number of methods for Organosolv extraction. What they have in common is the production of high quality sulfur-free lignin that is the outcome of hydrothermal treatment using water mixture, organic solvent such as methanol, ethanol or acetone, and acids or sometimes other additives (Mastrolitti *et al.*, 2021). Filtration is used to remove the cellulose, and water and acid enables for collection of lignin as it precipitates (ibid). Acidic catalysts included in the extraction serve to generate intramolecular condensation reactions and cleavage of etherbonds which provides a homogenous structure with a molecular weight of in between 1000-5000 g mol^-1, low dispersity and low ash content of <1% (Mastrolitti *et al.*, 2021). Compared to other lignin structures, Organosolv lignin has higher hydrophobicity and the temperature for glass transition is lower (ibid).

Considering lignin sulfonate, Kraft lignin, Alkali lignin, Enzymatic/Acid hydrolysis lignin, Organosolv and Steam Explosion lignin which are different sorts of technical lignins, Organosolv lignin and Kraft lignin has a high purity compared to other lignins, making them a good fit for products that are hypothesized to be more economically valuable (Mastrolitti *et al.*, 2021). Another aspect which correlates with this is that the yield of which it is produced is usually smaller, but relates to higher price ranges (Funkenbusch *et al.*, 2019a; Mastrolitti *et al.*, 2021).

2.3.3 Purification of common lignin categories

Chemical pulping processes are used for extraction of lignin from the natural source and is called delignification (Wool, 2005). The purpose of the process is the cleavage of ether bonds in the structure and as a consequence the polymer contains more hydroxyl groups instead (Wool, 2005). In pulp and paper industries delignification is carried out as a consequence of other ambitions (ibid).

Kraft lignin can be recovered, through acid precipitation (Luis Alberto Zevallos Torres *et al.*, 2020)(Mahmood et al., 2016). The final sulfur content is estimated to be 1.5-3% w/w (Luis Alberto Zevallos Torres *et al.*, 2020).

From interaction of wood and calcium the sulfite pulping process generates lignosulfonates which is one of the sulfur-containing lignin types (Luis Alberto Zevallos Torres *et al.*, 2020)(Saake and Lehnen, 2007), and which is water soluble with a sulfur content of approximately 5% w/w (Luis Alberto Zevallos Torres *et al.*, 2020)(Doherty et al., 2011). Lignosulfonates are currently used as binders, surfactants, adhesives and dispersing agents (Luis Alberto Zevallos Torres *et al.*, 2020)(Laurichesse and Avérous, 2014).

Soda lignins which are sulfur free lignins are purified under pressurized conditions with an alkali (Luis Alberto Zevallos Torres *et al.*, 2020)(Patt et al., 2000), resulting in a structure that is low in hemicellulose and contains no sulfur (Luis Alberto Zevallos Torres *et al.*, 2020)(Doherty et al., 2011).

For extraction of Organosolv lignin, both alkali and acidic solvents are used during the pulping process (Luis Alberto Zevallos Torres *et al.*, 2020)(Lange et al., 2013). One interesting aspect of the Organosolv lignin is its low molecular weight (Luis Alberto Zevallos Torres *et al.*, 2020).

2.4 Regulatory aspects

Regulatory aspects of cosmetics are different worldwide. In the EU a cosmetic product falls under a certain category based on where it is being applied physically if it meets the regulations, however in the USA certain cosmetics can be categorized into more than one category as long as the regulations are met (Ferreira *et al.*, 2022). In the same study, different regulatory frameworks and ways of classifying cosmetics are denoted to compose a challenge for global offering of a product. In a similar way, due to different categorization a consequence is that exchange of trade is limited or even prevented internationally, as one category may not be recognized in another regulatory framework (Ferreira *et al.*, 2022). The focus of this study will be on the regulations of the EU.

For a nanomaterial based cosmetic product to be approved, the safety of it must be confirmed by submission of information to the European Commission (Bowman, van Calster and Friedrichs, 2010). Furthermore, if there is doubt in the safety evaluation, the Scientific Committee for Consumer Safety (SCCS) provides their opinion on the topic (Bowman, van Calster and Friedrichs, 2010; Rauscher, Rasmussen and Sokull-Klüttgen, 2017). Once a nanomaterial has been approved it is presented in a catalog of overview (Bowman, van Calster and Friedrichs, 2010). More specifically nanomaterials are covered by the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (Rauscher, Rasmussen and Sokull-Klüttgen, 2017) which also covers the environmental safety aspects related (Bowman, van Calster and Friedrichs, 2010). European Chemicals Agency (ECHA) elaborates on the safety of the nanomaterial included in the framework of REACH (Rauscher, Rasmussen and Sokull-Klüttgen, 2017).

2.5 Ecological Opportunity

There is an interest in making use of waste or by-products for cosmetic applications which can be observed when looking into related fields. For instance, by-products from food-waste have been shown to be a valuable source which has relevance in cosmetics and where sustainability concerns of agricultural wastes demands for change (Schieber, Stintzing and Carle, 2001; Barbulova, Colucci and Apone, 2015). Schieber *et al.* (2001) and Barbulova *et al* (2015), mention environmental responsibility as a driving force of the transition.

2.5.1 Valorization of Biomass

The vast majority of chemical compounds manufactured today are derivatives of petroleum (Tuck *et al.*, 2012). Carbon-based manufacturing has been advantageous historically due to its vast quantity and energy efficient extraction (ibid). Recently however, both cost and supply have suffered in their advantageousness, threatening the manufacturing strategy from its former superiority and has opened the playing field to more sustainable alternatives (Tuck *et al.*, 2012). Indeed, the environmental impacts of petroleum based industries is also a large driving force toward the green transition, as utilizing fossil fuels is no longer a viable option (ibid).

Upcycling waste material is a hallmark of the green transition currently revolutionizing the chemical industry (Tuck *et al.*, 2012).

2.5.2 Environmental Urgency of UV Filters

The most commonly sold and used UV-filters are titanium dioxide and zinc oxide which are both examples of inorganic filters (Schneider and Lim, 2019). These inorganic filters provide high UV protection and since it is possible to shrink the particle size considerably, the visible layer of sunscreen on users skin is not as apparent because more transparency can be achieved (ibid). Although smaller nanoparticles can cause generation of oxygen species of reactive character, it is worth noting that the risk related

to human health is small, especially when the particles do not reach inner organs (Schneider and Lim, 2019). In this study about UV filters, Schneider *et al.* (2019) describes how organic sunscreen filter options to a greater extent than inorganic ones has unwanted environmental effects and how states/countries are responding to this through legislation. For instance the Hawaiian state has through the Hawaiian Reef Bill banned two types of organic filter types that are no longer legal to use (Schneider and Lim, 2019).

In order to mitigate potentially harmful effects there is an interest in gaining a deeper understanding of how biobased nanoparticles can offer an advantage compared to these inorganic sunscreens mentioned. Both with regards to environmental as well as health aspects. This demand for organic sunscreen filters both for sunscreens and other cosmetics products has resulted in organic alternatives, however some have been identified to have a negative impact on marine life (Huang *et al.*, 2021). Thus, there is a potential gap which lignin based sunscreen options may fill. Moreover, to fully understand the potential of lignin based products compared to inorganic zinc oxide and titanium dioxide one needs to compare how the different options interact with UV radiation.

2.6 Technical Opportunity

2.6.1 Nanotechnology

During the past decades, nanotechnology has experienced a large surge of interest within several industries. Currently, there are over 69,000 articles referring to the term “nanoparticle” published in scientific journals, which stands in stark contrast to just a few articles published during the period of 1950-1970, according to the search engine Scopus (Mihranyan, Ferraz and Strømme, 2012). Indeed, The Woodrow Wilson Project on Emerging Nanotechnologies (PEN) concluded that there has been an immense increase of registered products within nanotechnology of almost 1900% from the year 2005 to 2009 (ibid).

Most notably, nanoparticles have been on the agenda to broaden the horizon of synthetic cosmetic ingredients, but as of recent organic/natural nanoparticles has been in the limelight of cosmetic trends (Salvioni *et al.*, 2021). One particular use case is UV-filters in sunscreen products, as natural polymeric compounds have been shown to protect against UV-radiation (Yu *et al.*, 2018).

2.6.2 UV light and UV protection

Ultraviolet (UV) light is a specific portion of the sun's electromagnetic radiation reaching earth, defined as the spectrum of rays with a wavelength within an interval of 200-400 nm (Tran, Phan and Lee, 2021). UV light is further divided into rays of UVA (320-400 nm), UVB (290-320 nm), and UVC (200-290 nm) (ibid). The latter is the only type of UV light which does not reach the surface of the earth as the ozone layer absorbs it (ibid). Furthermore, no more than 0,1% of UVB light makes it to the surface of the earth (ibid). Therefore, only UVA and a miniscule fraction of UVB radiation constitutes the UV light which humans ultimately are exposed to and need to protect themselves against. (Tran, Phan and Lee, 2021).

Protection against UV-radiation is of great concern for all people, but especially those with fair skin (Kumar, Abbas and Aster, 2018). This is because the prevalence of malignant melanoma, squamous cell carcinoma,

and basal cell carcinoma stands in strong correlation with exposure to UV-radiation (ibid). The occurrence of malignant epidermal tumors is even more likely if risk factors like light skin, sun exposure, inflammation of the skin, and infection are combined (ibid). DNA damage induced by UV-radiation is a known driving force of mutations in well documented oncogenic transcription factors like CDKN2A, BRAF or RAS responsible for its pathogenesis (ibid). It is therefore of utmost importance for humans to protect themselves against UV-radiation.

2.6.3 Mineral Filters and their safety

Both TiO_2 and ZiO have been shown to be excellent UV radiation blockers in their nanoform and are therefore the two main UV-filters used commercially (Racovita, 2022). According to the Scientific Committee on Consumer Safety (SCCS) nano-TiO_2, a form of TiO_2, is considered to not pose any health risk to the user when used at a concentration of 25% and applied directly to the skin (Dréno *et al.*, 2019). Notably, the SCCS dissuades users from products containing nano-TiO_2 in a sprayable form as it presents potential inhalation and thereby exposure to the lungs which has been implicated to induce lung inflammation (ibid).

Recently, research has raised concerns with the safety of topical nano-TiO_2 (Racovita, 2022). Toward the end of the 20th century a surge of publications on the toxicity of TiO_2 uncovered that the inhalation of fine TiO_2 particles was in direct correlation with the prevalence of pleural conditions, especially daily workers at certain manufacturing plants were of particular exposure (ibid). Today, TiO_2 is classified as a carcinogen of type 2B by the International Agency for Research on Cancer (IARC) meaning it is "possibly carcinogenic to humans" (ibid). The classification also states that it is required to conduct further tests and studies to completely discern the potentially genotoxic and cytotoxic nature of the compound (ibid).

Also Zinc Oxide Nanoparticles (ZnONPs) have been in the limelight of toxicology controversy and their safety discussed. Numerous studies show that ZnONPs do not penetrate the epidermis, and therefore pose no adverse

effects. ZnONPs have however been shown to penetrate the skin of a few skin models where the skin has been either damaged by UVB-radiation or when applied to an allergic skin model (Holmes *et al.*, 2016). In those cases, ZnONPs have been shown to be able to interact with keratinocytes, as well as through hydrolysis lead to accumulation of zinc in the stratum corneum which can be transported to the systemic circulation and pose health concerns. Indeed, Chen Y. *et al.* (2022) showed that introduction of ZnONPs in combination with UVB radiation induced mitochondrial damage, in the form of swelling of the external membrane, as well as degeneration of the mitochondrial cristae in immortalized human keratinocyte (HaCaT) cells (Y.-Y. Chen *et al.*, 2022). It seems like an even safer UV-filter alternative could be considered within the cosmetic industry, and lignin is posing as a possible candidate.

Lignin has recently been tested for cytotoxicity and mutagenicity, safety assessments to ensure its safety for human application. In a safety assessment of sugarcane lignin, conducted using immortalized human keratinocyte (HaCat) cells, the lignin has been observed to adopt a dose-dependent behavior on cell viability with concentrations tested ranging from 375 to 1500 µg/mL (Antunes *et al.*, 2023). The cell viability however never reached lower than 75% and is therefore within an acceptable viability range according to ISO 10993-5, a standard Cytotoxicity Test (ibid). The results of this study are in alignment with previous results which also claim lignin only to be cytotoxic at much higher concentrations (Ugartondo, Mitjans and Vinardell, 2008; Arruda *et al.*, 2021). Lignin was also tested for mutagenicity in *S. typhimurium*, where no significant reversion was observed in comparison to the solvent Dimethyl Sulfoxide (DMSO) in concentrations up to 250 µg/mL (ibid). The authors of this study claim that these results are in accordance with previously conducted tests on lignins mutagenicity concluding it to be non toxic to the bacteria in the tested concentrations (Antunes *et al.*, 2023). The initial outlook for lignin as a UV-filter for cosmetic applications certainly appears promising from a toxicity standpoint as it seems to inherit adequate safety, but further studies

need to be conducted to thoroughly and comprehensively conclude the safety or potential toxicity of lignin to humans.

3. Research Approach

The research approach adhered to a philosophy where we arrived at a certain theory based on observations made and data collected. Empirical data was generated from the methods presented in Table 2 below.

Methods
Ethnographic method - Full observer
Ethnographic method - Observer as participant
Qualitative Interviews

Table 2. Methods that were applied.

Practically, we attended a global cosmetic fair, In-cosmetics 2023 Barcelona, which gathered influential cosmetic players around the globe at one place. At the fair seminars were hosted and a number of seminars was selected as foundation for the market trends in cosmetics to be used as a way of generating knowledge about how the value that is apparent in lignin based solutions is applicable or aligns with what is presented. The seminars focused on ecological value in the field of cosmetics. During the fair, field notes were made using a method of voice recording and photographing. The field notes include observations and conversations. The fair presented a zone of innovations around the globe and we investigated to what extent innovations in cosmetics integrate with ecological sustainability concerns.

We collected informative data from actors producing or developing lignin products directed towards the cosmetic industry. The data reflected the value that was recognized by each actor and the potential value that could be further generated for an even more efficient relationship. The findings provided data for understanding what value is being offered. Furthermore, similarities and differences between different actors were brought to the surface and analyzed. This analysis was performed to contribute to the understanding of what is needed for lignin as an ingredient in cosmetics to deliver sufficient value to customers. In total 11 interviews were made with lignin biopolymer actors that are active within the field.

3.1 Inductive Approach

For this research an inductive approach was chosen. Conducting research with an inductive approach involves generating a theory from observations and data, rather than the contrary where a theory is first created, whereafter observations and data either prove or disprove said theory, a deductive approach (Bryman and Bell, 2013). The authors hold the notion that generating a theory through analysis of data is best suited to answer the research question at hand, as conducting deductive research for this type of research question runs the risk of excluding important information by postulating a theory too narrowly. Instead, an inductive approach allowed this research to investigate each case individually as they included unique points of interest, critical for that specific case (Bryman and Bell, 2013). The data generated was interpreted and analyzed to result in a theory solely based on the data. This aligns with The Grounded Theory, which was the overarching research methodology dictating the methodological choices made, see section *4.2 Interviews with actors.* In our view, a quantitative approach would not be suitable for this research as we aimed to reach a deeper understanding of what value is delivered, rather than to what degree that value is delivered in specific Business to Business (B2B) cases. If one instead were to investigate to what degree different values influence consumers decisions, a quantitative approach could fit that research better (Slevitch, 2011).

3.2 Scientific Philosophy

The authors' ontological viewpoint is reflected in *3.2.1 Ontological viewpoint*, describing our constructivist standpoint on how the world is viewed. In the following section, our epistemological viewpoint of interpretivism is described, and addresses our view on how knowledge was created through the interpretations made by particular actors. It was critical that the way of viewing knowledge creation was in alignment with the ontological viewpoint. If not, the fundamental axioms in the process of creating knowledge would be false, and therefore undermine its validity (Thompson, 2011). Thereby, said premise allowed the choice of ontology

and epistemology, as constructivism and interpretivism are in parallel with each other (Bryman and Bell, 2013). Furthermore, the ontological and epistemological viewpoint of the authors was also taken into consideration and aligned with the viewpoint of authors of the literature chosen to lay the foundation of our research.

3.2.1 Ontological Viewpoint

Conventionally, ontological viewpoints address the nature of whether the existing reality is created by its inherent, unchangeable, observable properties traditionally classified as *objectivism,* or if it is created by an applied social construction of the world by the observer who dictates its perception of reality, *constructivism* (Bryman and Bell, 2013). The former worldview is traditionally in parallel with a positivist orientation regarding reality as an objective entity exposed to empirical observations and studies conducted by an external observer (Slevitch, 2011). This way of viewing the world aligns with an objective viewpoint of the world and is therefore often associated with quantitative research (ibid). The latter viewpoint, constructivism, stems from a subjective standpoint, regarding reality as a construction made by the observer rather than simply an empirical observation (Bryman and Bell, 2013). This subjective orientation is in parallel with the cornerstones of a qualitative research approach, and is therefore often seen in conjunction with it.

Since we chose a qualitative approach for conducting our research, we found the objectivist orientation to not be well aligned with our research orientation as it is too much of a rigid and empirical standpoint to how we interpreted the interviewed candidates' experiences. Instead, we deemed the constructivist approach to better reflect the subjective interpretation from each interviewed candidate, as it allowed for the knowledge creation to stem from the candidate's experienced interpretation of reality.

3.2.2 Epistemological Viewpoint

As previously mentioned, the epistemological viewpoint must align with the ontological viewpoint in order to establish a creation of knowledge which is

linear, and true (Slevitch, 2011). In line with the constructivist viewpoint we adhere to an interpretive viewpoint epistemologically, placing the focus of knowledge creation in the subjective, situational interpretations made for every distinct case. An interpretative approach demands a situational analysis of each individual case as this approach recognizes that the uniqueness of such studies would never be able to be contained within the frame of a positivist outlook (Al-Ababneh, 2020).

4. Research Methods

4.1 Ethnographic Methods

Ethnographic methods were used to investigate how ecological value is reflected between actors and manufacturers in the cosmetic industry to answer what the importance of ecological values are in the cosmetic industry. The portrayal of ecological attributes was investigated. Both with regards to how actors presented what ecological properties are of importance orally but also with regards to staging of the environment. Ethnographic methods were too used to investigate the status of the lignin-cosmetic industry.

4.1.1 Access to field of interest

A critical point for this study, as for any ethnographic study, was to ensure that we could take part at the fair In-Cosmetics® Barcelona (Bryman and Bell, 2013). The fair gathered the most innovative cosmetic ingredient developers at one place, making it a proper representative fair for investigating the take of an innovation such as lignin based cosmetics. Physical access was crucial to generate the data needed. In no way would it be possible to make the study intended to the same extent using online available material. We were welcome to participate through registration to the event in advance. The workshop BioCare® hosted by InnorenewCoE was available on Youtube, thus it was convenient for access.

4.1.2 Observer-as-participant

The authors used an ethnographical role of *observer-as-participant* at the fair. Per definition the role means that the focus lies on observing rather than active participation (Bryman and Bell, 2013). We participated in conversations at the fair where we presented ourselves as Master thesis students gathering data for our research, as well as our name tags indicated the same. The focus was not to share our beliefs but to hear what the respondents had to say, thus *observer-as-participant*. The conversations were initiated from curiosity to know what role lignin had in their business

or of their knowledge about the subject of lignin alternatively ecological or aesthetical value present, and where a full interview was not relevant. After such a conversation the authors summarized what had been discussed as soon as possible using voice recording on a phone device.

4.1.3 Full observers

The authors also adapted a role as *full observers,* which is an ethnographic role where the scientists do not interact with people in the environment, rather focusing on making observations and where people are not affected by their presence (Bryman and Bell, 2013).

This ethnographic role was adapted to generate an understanding for what is being presented at the fair with regards to the environment and the staging. Such observations were collected using a method of voice recording as described above as well as photographing.

An innovative material staging area was analyzed. The authors investigated the frequency of ecological values appearing in the booths presented. Ecological values were depicted in terms of concepts related to ecological sustainability and/or where the construction in an aesthetical manner alluded to ecological sustainability.

In-cosmetics® presented a great quantity of seminars and activities. Through careful analysis of what topics each seminar included, we choose two seminars to attend. The choice was based on consideration towards what data could be generated, where we wanted to attend those targeting ecological values in the field of cosmetics. We had a schedule with us containing the most relevant seminars, however due to overlapping interviews and seminars, not all of these could be attended. The description of each seminar was found at In-cosmetics event page and a panel discussion Sustainability trends as well as a seminar concerning Eco-design was chosen. At the seminars we participated as full-observers and took notes.

The observer role was also adapted during the Bio4Care workshop as we observed a recorded version online. We took notes, however as the material

was available online we could go back to re-observe when necessary during the analysis.

4.2 Interviews with actors

The Grounded theory (Glaser and Strauss, 2017), was used as a cornerstone for the research method for this study. The theory is commonly used when dealing with qualitative data and claims that the theories created emerge from choices based on data gathered and that data generation is performed in parallel with data analysis (Bryman and Bell, 2013).

The process consisted of four parts; theoretical sampling, coding, theoretical saturation and continuous comparison which are further described below.

4.2.1 Theoretical sampling

Strauss and Glaser (2017) explains how theoretical sampling is performed to arrive at a theory and is done by identifying categories followed by linking how properties of these categories are related (Glaser and Strauss, 2017). We have turned to eleven lignin biopolymer actors to collect data. From these interviews we have formulated categories which is the heart of the data analysis. Once the categories or a certain category has been claimed, in other words when the data generation offers redundancy to the category/ies the category/ies reaches theoretical saturation which is further used to formulate hypotheses (Bryman and Bell, 2013). Once hypotheses have been made these are used for understanding what other theoretical sampling is needed on the basis that there are other actors or objects that can be used to engage in new or existing categories or presents a variation in the concepts (leading to the categorification) (Bryman and Bell, 2013). The general framing of the question led us to reach out to actors in the lignin-cosmetic industry. To answer our research question we first needed to answer; How do actors of lignin biopolymers deliver ecological and aesthetic value in lignin as an ingredient for the usage of cosmetic product manufacturing? It was a natural step to turn to existing actors to answer this question. To choose an initial number of actors to interview we adhered to the following criteria when choosing participants; The participants are active at a

company which develops and/or produces lignin ingredients/products toward the cosmetic industry. What can be further stated about the sampling method is how the data generated is not only the basis of the hypothesis and final theories but also a criteria used to understand where to turn for further data generation. Hence, the theory was created alongside as we determined what sources of information to turn to next with regards to the data generation, coding and data analysis, as the Grounded theory suggests (Glaser and Strauss, 2017). For the gathering we turned to eleven lignin biopolymer actors for initial interviews.

4.2.2 Coding

Coding refers to a stage where the generation of categories is the main focus and a tool for theory generation. Practically, we examined our interviews and noted concepts and categories that we believed to play an important role for the interviewee. As opposed to a quantitative analysis of data, the qualitative approach and analysis through grounded theory accepts that the indications of concepts are changing by nature (Bryman and Bell, 2013; Glaser and Strauss, 2017). Thus, such concepts are constantly being compared with other concepts open for the possibility of them referring to the same event. Further, the data was analyzed using three types of coding methods: “Open coding”, “Axial coding” and “Selective coding”, described originally by Corbin and Strauss in 1990 (Bryman and Bell, 2013).

- *Open coding* results in concepts which can further be grouped into categories. The concepts are generated through “decomposition, study, comparison, conceptualisation and categorization of data” - (Bryman and Bell, 2013).
- *Axial coding* refers to the procedure after open coding where the concepts are being compared with each other having new contexts, consequences and underlying aspects in mind while creating new connections between categories identified (ibid).
- *Selective coding,* once categories have been identified a “kernel category”, which is a category coupled to the research question, is chosen and combined with other categories which relates to the

kernel one (ibid). By combining the categories one identifies what needs to be further elaborated on in a specific category or if other categories are needed to fulfill the relations to hold the information that generates the theory (ibid).

4.2.3 Theoretical saturation

What is referred to as theoretical saturation concerns both the coding part and the generation of data in the Grounded theory (Bryman and Bell, 2013). The former refers to when the coding process has reached a point where the audit of data no longer results in new findings about categories and concepts. The latter explains how once the data generated and analyzed no longer inform of outliers when it comes to the specific categories and concepts found in prior analysis.

4.2.4 Continuous comparison

Continuous comparison serves as a process for maintaining a close relation between conceptualisation and data collection (Bryman and Bell, 2013). The purpose of this is to generate categories from the concepts and the reasoning behind the concepts involved. It has been proposed that *memon* are to be used when generating categories and concepts (Bryman and Bell, 2013) (Glaser and Strauss, 2017). Thus, we used memon, that is we took notes when identifying categories and concepts (Bryman and Bell, 2013), which has helped us to pin down what reflections were made along with the categories or concepts identified.

4.2.5 Interviews with qualitative methodology

The choice of a qualitative methodology of generating data was based on the fact that we were interested in in-depth interviews with a representative from each organization. This approach aimed to help us understand the interviewee's point of view of their specific case and generate data specific for that setting rather than a generalized view. Through collecting case-specific data we investigated what individual actors value in their

offering, which differed from case to case, allowing us to identify what different actors value.

We used an overt role during the interviews where the participants in the study were well aware that they were being studied. Moreover, we wanted to develop a deep understanding of each participant's opinion, as for why we conducted qualitative interviews.

We used a semi-constructed form of interviewing referring to that we were interested in the value delivered from supplier to customer. Hence, the data we generated dealt with what value is currently being delivered and what could be changed to the better. A semi-constructed approach allowed us to have better comparability between the interview that we took upon ourselves individually as well as for comparing the interviewed responses with each other. As a consequence of our choice of methodology, flexibility became a key word for the interviews (Bryman and Bell, 2013). What is meant by flexibility refers to both how the questions were addressed and stated as well as practical aspects such as if recording was an option for a specific case (ibid).

Interviews were recorded and transcribed so that we could return to what had been stated afterwards and analyze the data systematically. Moreover, this allows for less bias related to researchers (Bryman and Bell, 2013).

Bryman and Bell (2013) discuss how some researchers are critical to the use of qualitative research methods and that the focus of the critique is that conclusions drawn from qualitative research are not generalizable (Bryman and Bell, 2013). What can be done to minimize this issue is to include a sufficient number of participants. However, as Bell et al (2013) mentions it is not the focus of a qualitative analysis to generalize but rather the construction of a theory of good quality (Bryman and Bell, 2013).

Flyvbjerg (2006) puts forward a notion where he argues that there never will exist context independent theory, or as he calls it ‘predictive theory’, within the realms of social science. In the view of Flyvbjerg (2006) social science research is always grounded in knowledge dependent on its context.

Furthermore, he argues there is no study more fitting to generate such knowledge than a case study. In fact, Flyvbjerg states how the choice of methodology is indeed dependent on what one aims to study. He describes whether a case can be generalizable or not depends on the case. The number of interviewees and seminars may be limited in the sense that they are few. However, what Flyvbjerg (2006) refers to as expertise knowledge, allows us to understand each case at a deep level thus describing the industry from context dependent knowledge which produces learnings (Flyvbjerg, 2006).

5. Ethical aspects

This section describes the ethics related to the project. For this project we considered both ethical aspects that related to the conduction of the micro ethnographic study and the interviews.

5.1 Ethical Considerations

We adhered to “informed consent”, thus informing the participants of the qualitative interview about the project and our interest in their answer, see *Appendix 2 - Interview guide for interviews with actors.* Informed consent is considered violated through hidden observation, in other words when the agenda is not notified to the interviewed (Bryman and Bell, 2013).

The personal integrity of the participants in the study was considered by keeping them anonymous in the report. This precaution was taken to prevent the individuals from being negatively affected for expression of personal opinions when motivating their answers. The participants were informed about them being anonymous. We do not specify in the report who said what but rather refer to them as an anonymous person at a specific company.

Since there are not currently many lignin actors directly towards the cosmetic industry, it may not be very difficult for people to find out what companies have been included. Hence, even though kept anonymity were applied, the participants were informed about the risks regarding confidentiality. Starting off the interviews we therefore informed the participants about how the data were to be handled and about data accessibility, who we are and what the research was targeting, the purpose of the study, why we reached out to this specific person, informed about confidentiality of information and asked about demand on anonymity.

The data management was carried out as follows. Interviews in person was recorded using sound recording on iphone, these files were downloaded in MP3 format and stored as personal cloud storage on google drive, a vendor which commits to the GDPR regulation of the European Parliament (*Regulation (EU) 2016/679 of the European Parliament and of the Council*

of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (Text with EEA relevance), 2016; *GDPR and Google Cloud*, no date). The transfer of data between devices was through the drive cloud and once the transfer had been made the sound file was removed from the hard drive of the other device. For interviews carried out over zoom the data was downloaded using zoom cloud recordings directly to the personal cloud storage of Google Drive.

We accessed the files using The Grounded Theory, where concepts and categories were denotified. The data was managed with respect to what had been stated by the participant providing it, this regarded specific statements about data storage, confidentiality or anonymity. The processing of the data was only done with respect to the research questions and the aim of the thesis. Once the sound files had been processed and memos had been composed these files containing memos were also stored in personal Google Drive accessible by the authors and supervisors only.

For the seminars the participants were however not informed as circumstances did not enable such presentations.

6. Analysis

The analysis is divided into three parts corresponding to an analysis of each research question.

- Lignin value chain status in the cosmetic industry
- Ecological value importance in the cosmetic industry
- Value offered from lignin biopolymer actors

6.1 The current status of the lignin-cosmetic industry

Through observing a seminar, actors present within the industry of lignin directed towards the cosmetic market were revealed. Furthermore, by engaging in interviews a pattern of how actors within the field are connected started to appear. In section *6.1.1 Actors within the field of lignin based cosmetics* below we elaborate on what actors are present and on the formation of the value chain of lignin actors directed towards cosmetics.

6.1.1 Actors within the field of lignin based cosmetics

In a seminar hosted by InnoRenew Coe called Bio4Care, European actors in the field of lignin based cosmetics were invited (*BIO4CARE Workshop*, 2022). The companies attending were as follows; Lignovations, Lignoflow, Lignopure, Motintura, Cosmelink and Bellejo, as can be seen in Table 3.

Participant	Location	Offering
Lignovations	Austria	LignoGuard® - Cosmetic ingredient
Lignoflow	Sweden	Lignin Gel
Lignopure	Netherlands	LignoBase™ - multifunctional ingredient
Montinutra	Finland	SpruceLigno™ - Wood phenols, Raw material
Cosmelink	France	Strategy and business development within Cosmetic industry
Bellejo	Belgium	Bellejo Sunscreen

Table 3. Presenting the participating actors at the seminar, the geographical location of the business and the offering that they make. All data is from the seminar (*BIO4CARE Workshop*, 2022)

Lignovations is an Austrian company which has patented a technology on developing lignin particles in colloidal form (*BIO4CARE Workshop*, 2022). The company has experienced a concern from the customer side with regards to the color of the product as they state that the customers are expecting a white product rather than one with a brownish base (ibid). Their current approach on how to solve this problem is to sit tight till the acceptance of another color on the final products is more established (ibid). One product, LignoGuard®, which is further processing of another product called LIGNOVA that is produced by another company called Fibenol (Lignovations, 2023). Lignovations LignoGuard® fields of application includes lesser need of using other UV filters as well as it serves as an emulsion stabilizer and as antioxidant (*BIO4CARE Workshop*, 2022). Furthermore, the product has a COSMOS certification and the speaker specified how they carried out the tests for 3-4 months and that the costs associated landed on approximately 20,000 € (ibid).

Lignoflow is a Stockholm based company which produces a black gel of lignin particles, with particle size ⩽100 nm which is soluble in water and that deforms when frozen (*BIO4CARE Workshop*, 2022). As for the market status they are currently looking into business opportunities related to their gel (*BIO4CARE Workshop*, 2022).

Lignopure has developed a particle technology which is patented and that is used for modification of crude lignin to spherical particles presented in powder format (‘Our Technology - Lignopure - Naturally Functional’, 2022). The powder can then be used as an ingredient in cosmetic products with features such as antioxidant and anti aging properties as well as an UV and Ozone protectant (‘Lignin-based Solutions - Lignopure - Naturally Functional’, 2022). Lignopure described their value chain from biosource to customer (*BIO4CARE Workshop*, 2022). What they identified is how knowledge about lignin as a bioresource serves as an important part for understanding structure-function relationship and thus the functionalities of a potential final product (ibid). Lignopure considers regulatory aspects and market interest when choosing a bioresource (ibid). Suppliers of lignin raw material are the next part of the value chain where Lignopure has multiple

suppliers of various types of lignin (ibid). During the process step the raw material is pretreated and particles are formed (ibid). Lignopure meet customer demand in the way that they provide optimized process conditions to be able to deliver a certain particle size and shape for the customer asking (ibid). Yet another step in the value chain is “R&D and technical support for clients" where Lignopure confirms the effectiveness of their ingredients to their clients, makes sure it is compatible with current regulatory requirements and market trends as well as using co-creation through customer insight to feedback into their development of better products (ibid). LignoBase™ is a multifunctional natural ingredient which they provide (ibid). Lignopure has three categories of clients, that is cosmetic manufacturers, formulation developers and ingredient distributors (ibid).

Montinutra is a raw material supplier of biomaterials that originates from saw dust, thus saw mills serve as a secure supplier (*BIO4CARE Workshop*, 2022). The company is a start up and was founded in 2018 in Finland (ibid). One of the raw materials that Montinutra is a supplier of is based on lignin (ibid). The product SpruceLigno™ is wood phenols and possesses antioxidative properties (ibid).

The founder of Bellejo, a company with a sunscreen containing lignin as an active ingredient, described how lignin serves as an SPF booster rather than as an UV blocker in their products (*BIO4CARE Workshop*, 2022). Bellejo expressed that regulatory aspects make it difficult to classify lignin ingredients as a UV filter, and as of today Bellejo utilizes lignin in their products as an SPF-booster (ibid). The lignin is sourced from beer waste, and one of Bellejo’s suppliers is Lignopure (ibid).

There was a limited number of actors present at the event. The status of the actors is different, as some are looking for application areas which is the case for Lignoflow, whereas others such as Lignopure have established customer relationships (*BIO4CARE Workshop*, 2022). Further, we observed that the actors are at different stages in the value chain, for instance Lignopure is turning towards formulators and Bellejo is a retailer thus supplying a final product for customers (ibid), as of why we have

investigated this further in section *6.2.2 Mapping lignin production chain.* The European actors are mainly focusing on the sun protecting and antioxidative properties of lignin. However, usage as colorant and emulsion stabilizer is also mentioned as application areas (*BIO4CARE Workshop*, 2022).

6.1.2 Mapping lignin production chain

A mapping of the production chain of lignin from raw material to end product was constructed in order to pinpoint how lignin is transported and modified into the final product. This mapping of the production chain, which can be seen in Figure 2. includes individual actors which have been categorized, and synthesized to a cohesive value chain. This value chain is plotted along an axis and their specific role in the chain is described.

In Table 5 the actors are presented together with in and out supply stream, where the lignin is supplied from and where it is delivered. The information was generated through the interviews and the workshop. What can be understood is that the value chain of lignin differs from case to case and that there is no strict scheduling of it. Table 5 presents the data used to produce a suggestive mapping of the lignin value chain. The raw materials of lignin differ depending on what feedstock supplier one turns to, according to Lignovations.

Value Chain Actor	**Description**
Biorefinery	Supplier of raw lignin as a consequence of other interests (e.g. pulp industry)
Manufacturer	Process lignin and supplies modifiers
Modifier	Tune functionalities, deliver ingredient
Formulator	Integrate ingredient into formula

Table 4. The actors of the value chain with corresponding descriptions.

actors	**In**	**Out**	**Value Chain Actor**
Lignovations	Multiple raw material actors	Pilot customers, formulators	*Modifier*
Bellejo	Ingredient actors have removed odor,	Final customers of cosmetic products	*Formulator and retailer*

	powder format certain particle size		
CH-Bioforce Oy	-	Cosmetic companies (Loreal and Channel), and manufacturers (Lignopure)	*Manufacturer*
Chemyunion	Several actors, paper industries	An ingredient, for formulators	*Modifier*
Fibenol	x	Formulator (Lignovations)	*Biorefinery and manufacturer*
Godavari Biorefineries	x	-	*Biorefinery*
Innomost	-	-	-
AB Karl Hedin Bioinnovation	AB Karl Hedin	-	*Manufacturer*
Lignopure	Several actors (CH-Bioforce)	Distributor	*Modifier, formulator*
Montinutra	Biorefinery	Formulator	*Manufacturer*

Table 5. The table presents the flow of lignin for every case. x represents cases where the material is supplied by the mentioned supplier themself, - represents cases where an actor is not yet established or has not been communicated to us.

The value chain of lignin is visualized in Figure 2. It corresponds to the findings related to how actors in the qualitative interviews are integrated in each case value chain. The biorefinery delivers lignin to a manufacturer that extracts the lignin and modifier then generates an ingredient of it, which is then incorporated in a formulation by formulators and that is eventually sold by retailers as the final product. Furthermore, a distributor could be present as an actor between formulators and retailers, that is the case of Lignopure's value chain. Observe that an actor can occupy several steps in the value chain, thus the value chain is merely a simplification of the actions included in the overall chain of events.

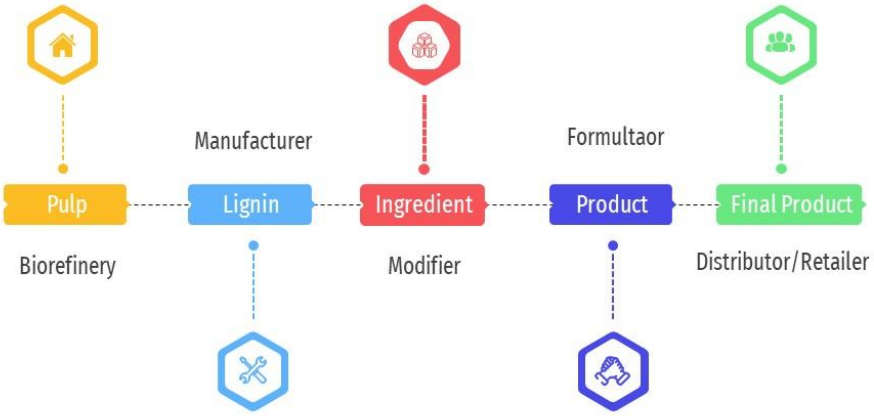

Figure 2: Timeline infographic depicting the production chain observed from beginning to end. Categories are defined as: (1) Biorefinery (2) Manufacturer (3) Modifier (4) Formulator (5) Distributor or Retailer. Templates are accredited to SlidesGo and FreePik.

The activities that the actors are involved in have been assembled into roles defining them. *Biorefineries* initiates the value chain, as a supplier of raw lignin, actors active as such are Fibenol and Godavari Biorefineries ltd. The raw lignin is further processed by Montinutra, CH-Bioforce Oy, and Fibenol, these are assigned the profile of *Manufacturers*. What the *Manufacturers* deliver is a refined lignin product, either ready as an ingredient, or needs to be developed further. The *Modifiers*, Lignovations, Lignopure and Chemyunion further develop the ingredient, offering a ready to use in cosmetics ingredient. The ingredient can then be integrated in a formula by *Formulators*, Lignopure and Bellejo. Moreover, L'Oréal and Channel are formulators as they supply lignin from CH-Bioforce. The final actor is the *Retailer* that would sell the product to the final customer, in this case represented by Bellejo as well as Channel and L'Oréal that were mentioned by CH-Bioforce OY.

6.2 Ecological values in the cosmetic industry

This section provides an analysis of data from ethnographic methodologies that generates an understanding of what factors are recognized as having ecological value by leaders in the cosmetic industry and thus in what way ecological values are important for the cosmetic industry.

6.2.1 Pilot interview

Early during the study we conducted a pilot interview with a person at Borregaard, a lignin supplier. For this interview we had prepared a semi structured interview guide with questions that did not yet have a focus on ecological and aesthetic value delivery. The pilot helped us to understand what aspects were of importance in the field that we were interested in, and the interview thus worked as a way for us to lead our research into a more niched topic of ecological and aesthetic value.

Our findings included regulatory aspects favorable for a lignin polymer ingredient to enter the cosmetic industry having to do with the naturality to the polymer and REACH became known to us at this point of time. Other findings were related to odor and color and functionalities of the polymer.

Our findings from this meeting led us to reformulate our semi-structured interview for our future meetings with lignin actors directed towards cosmetics. The questions thus targeted aspects that had been brought up at the interview with Borregaard and that we perceived as important.

6.2.2 Interviews

From a limited number of interviews we came to an understanding that the value chain of the field of lignin directed towards cosmetics had to be depicted to facilitate the understanding of value delivery. The mapping of the value chain is elaborated on and presented in section *6.1.2 Mapping lignin production chain*.

6.2.3 In-cosmetics

The cosmetic fair, In-cosmetics 2023 Barcelona, provided a website where we could plan our visit. We observed that the site included a few major topics; technical seminars, marketing trends, sustainability, innovation and formulation lab. Furthermore, we observed the actors of lignin that were to be present at the fair through the In-cosmetics digital portfolio, and we reached out to them in advance. From the platform we pinpointed events related to ecological sustainability, and participated at one seminar, one panel discussion and analyzed an innovation zone for the topic of ecological

sustainability values. Below is the analysis related to the seminars, innovation zone and the environment of the fair.

6.2.3.1 Eco-design and sustainability trends

We participated as full-observers in a seminar about eco design and in a panel discussion about marketing trends at In-cosmetics 2023. The seminar concerned the role of eco design for sustainable beauty and was presented by Dr. Laura Busata, Cosmetics R&D Manager, UNIFARCO S.p.A. In the panel-discussion Jo Chidley founder of Beauty Kitchen, Mike Sohn CEO and Representative consultant of Reach24H consulting Group, Dominika Minarovic and Elsie Rutterford Co-founders of BYBI and Phil Verey Managing Director of Proverance discussed the trends in the cosmetic industry, under the lead of Lisa Payne, Head of Beauty at Stylus.

One can not discuss cosmetic trends without mentioning sustainability. Payne initiated the discussion by asking the participants about what sustainability is to them. To the panel sustainability is about taking advantage of waste from nature, finding circularity, it is about being fully aware of what impacts the product that is being produced has on climate, waste, nature, workers and community. Such factors are related to the ecological value presented in the literature review, for instance ecological benefits are for a product to be sustainably sourced, safe for the environment, have low carbon emission and contain natural ingredients. Hence, what the panel expressed is how producers can offer ecological values in their products providing ecological benefits.

Rutterford mentioned how terms are confusing for customers referring to how what is sustainable and what is not can be misleading. A transparent approach will help customers and actors with this communication, however comes the problem of greenwashing. Busata agreed that greenwashing is an issue and the wrong way of communicating what sustainability strategies are carried out by a company.

Furthermore, the panel mentioned that sustainability is about avoiding greenwashing and as an ingredient supplier helping brands to avoid

greenwashing by communication of substantial claims. Payne and Verey touched upon the importance of communicating honesty to the customers and how it develops trust. The importance of ecological values are reflected in the way that the importance of rightful communication was brought up. Thus, the interest to provide the customer with a rightful picture of the product, allowing for conscious customers to make their choices based on honest attributes about ecological benefits.

Payne mentioned how the customer is today aware about clean beauty, which means sustainable beauty. This adds to the results depicting how consumers determine the value that is being delivered by the actors. Thus, the interest in production of sustainable products is intertwined both for customers and actors, wanting a more sustainable future now.

Chidley made an observation on what has happened concerning the area dedicated towards sustainability at in-cosmetics over the last 10 years, from what was 10 years ago one table is now being represented over the entire fair area. Hence, one can for sure conclude that sustainability has a well established place in the cosmetic industry. Busata touched upon how customers are getting more eager to make more environmentally conscious choices and how products nowadays need to deliver not only to the customer but the climate. This confirms with what is stated about ecological value, that customers are the driving force making producers develop greener products, as the customers interest seems to be mirrored in what is being shown by ingredient developers at the fair.

Payne pinpointed that future ingredients focus on sustainability, for instance upcycling is trending and Minarovic in the panel adds to this discussing how benefits of an ingredient will more and more come from nature rather than as a synthetic mimic of something which could be a natural ingredient. Furthermore, upcycled material should preferably be from that of a waste stream, avoiding ingredients that are more or less abundant over different seasons. Hence, the importance of offering ecological value is increasing in the cosmetic industry as the future of cosmetics focuses on aspects that are related to the ecological benefits that a product has.

Busata described that companies, in terms of eco-design, need to deliver a product where a sustainability strategy is incorporated in what is being delivered. In other words, customers are demanding action favoring society, environment or/and economy. In terms of ecological value delivery, this would indicate that companies should make actions in favor of the environment, which is communicated through formula ingredients and eco friendliness of the finished products according to Busata. The panel mentioned how small changes acting in favor of the environment stands for sustainability.

"..the consumer wont buy on sustainability alone." - Rutterford

Sustainability alone is not enough, as mentioned in previous results discussion, there needs to be a proven effect to. The panel asserted this too, as a product needs to possess characteristics of interest, "making the ordinary extraordinary" as Chidley stated. What she meant is that the customers are interested in not only the sustainability aspect but its efficiency. The characteristics need to be there for someone to be satisfied with the product and actually pursue it. If there is no effect there is no business opportunity. Thus, the extent of the importance of ecological value in the cosmetic industry does not go further than the aesthetic attributes of the product that is being offered.

6.2.3.2 Cosmetic ingredient innovations

According to In-cosmetics™, three quarters of their visitors initiate their visit at the fair at the 'Innovation Zone'. In the interpretation of the fair organizers, this is because the zone presents an array of the industry's most novel products, and this is a perfect way to quickly get a feel for the industry's cutting edge technology (*Innovation Zone*, 2023-04-17). This is largely because the ingredients presented at the Innovation Zone all have had their launch date eight months prior to the event at most and display novelty in the industry. A number of the products are even introduced to the industry at the fair itself. Thus, we believe the Innovation Zone to be an adequate source of information to research where the cutting edge of technology within the cosmetic industry lies, and what its priorities are.

The Innovation Zone was divided into two categories: (1) active ingredients, and (2) functional ingredients. These categories were distinguished by their use case, where active ingredients produce effects from the product applied, whereas functional ingredients provide function for the product, not necessarily a direct effect for the end-user. A photography of the innovation zone poster can be seen in figure 3.

Figure 3. Photography of the flagship poster for the 'Innovation Zone' at the in-cosmetics fair in Barcelona.

Sustainability was a hallmark of this year's Innovation Zone. The overarching naturalistic theme of the poster, along with the recurring slogan "responsibly solving for a better world" portrayed the image that nothing is more important than sustainability in the cosmetic industry. This was also reflected in the images chosen, as the organizers of in-cosmetics have chosen to include exclusively images with a natural motive.

The organizers of in-cosmetics chose to present six key themes in the flagship poster which represented what innovation is currently. Those were:

- Environment
- Social
- Governance

- Sourcing
- Operations
- Solutions

The overarching message of these themes is that innovation needs to be sustainable in a coherent way. It needs to be sustainable in more ways than just environmental. Innovation needs to take accountability for all the consequences of its existence.

6.2.3.3 Innovations in cosmetics are targeting sustainability

The fair In-cosmetics presented the leading cosmetic ingredients at a global scope. The event arranged for cosmetic ingredients actors to exhibit and connect with potential customers and/or collaborators. The event had an area with innovation booths, showcasing the latest innovations in active and functional ingredients. We investigated the recurrence of ecological benefits in the booths to understand how many actors are willing to put effort into developing such ingredients. The ecological benefits can be found in section 2.6.1 Ecological value, and include attributes such as organic labeling, being biodegradable and sustainable sources that are offered to the consumers. Our findings indicate that 76% of the innovations showcased relate to ecological benefits. More specifically 87 active ingredient innovations of 120, and 55 functional ingredient innovations of 68 were of such character. What we can conclude is that ecological value delivery is present in the innovation of the cosmetic industry as of today.

6.2.3.4 Ecological values in the environment

The field notes also revealed that ecological sustainability was incorporated in the staging of the fair. A nature inspired setting at the fair was dedicated towards meetings between exhibitors and manufacturers, see Figure 3. There were trees and bird songs surrounding the area and campervans serving food. Aesthetically, the setting inferred a sensory experience of being close to nature. A setting which may act as a way of encouraging one to include sustainability and ecological aspects in the discussion or having such in mind. In this way ecological values was communicated through the

setting of the fair. In other words, the setting delivered in terms of recognition of an awareness of naturality, that is ecological benefits.

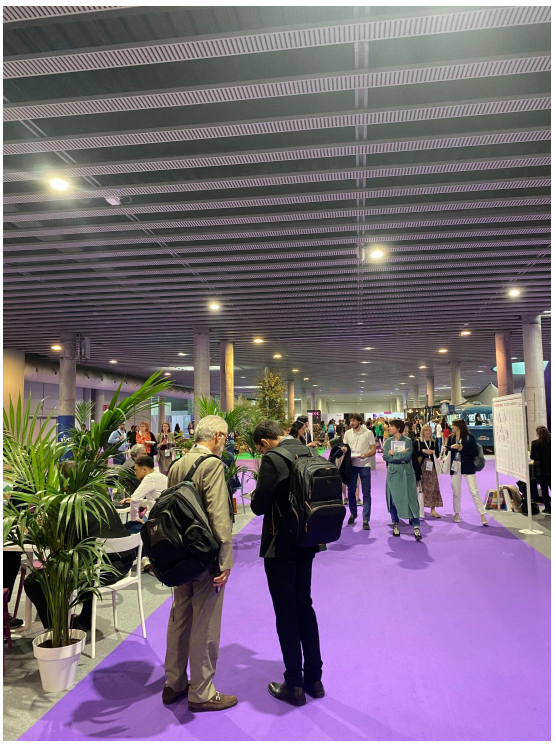

Figure 4. In-cosmetics meeting hall

In the meeting area there was a blackboard, shown in Figure 4, stating "What does innovation mean to you?". The blackboard served as a way of involving participants in sharing their view on innovation. The choice of question reflects that innovation is indeed important for the cosmetic industry. "LignoBase - natural functional, upcycled" is written on the board, which is the ingredient developed by LignoPure. "Inside Out Beauty", "Good chemicals" and "Alternative Plants" are too written on the board. The messages reflects how innovation in the cosmetic industry is about something other than merely the effect it has on the skin.

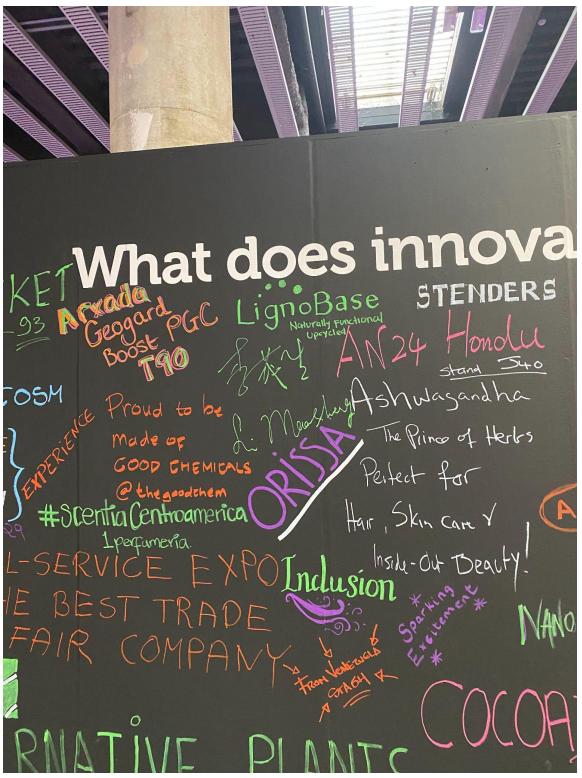

Figure 5. Blackboard representing what innovation is to participants at In-Cosmetics

6.3 Value offered from lignin biopolymer actors

During in-cosmetics in Barcelona the interviews conducted followed the interview guide less strictly than the interviews conducted in Sweden. We realized that the discussion came more naturally when the interview was more open and that the interviewee shared interesting information as he or she would orient the direction of the interview. The interviews were still carried out in a semi-structured manner, however they were more open. The intentions of the interviews remained clear, however the questions that were asked were not prepared in advance to the extent that we had planned. Once we had retrieved new information that allowed us to come up with other questions of interest which we wanted to ask other interviewees. The environment of the fair allowed us to adapt this more open way of carrying out the interviews. We were able to record a large proportion of the interviews and on other occasions we recorded a summarized version on our own once the interview was done.

We noticed a set of concepts which were recurring during the interviews. Concepts such as multifunctionality, color and naturality. The concepts that were identified were further investigated in relation to each other such as the grounded theory suggests to arrive at categories. Certain concepts remained unrevealed for us until a proper analysis had been made, however the concepts that we could point out on site allowed us to form an understanding of what source to turn to next or what other questions to ask with regards to uncertainties in how well adapted a certain statement was. We turned to other actors to understand their specific case which further helped us identify if the case aligned with statements from other actors.

We turned to the following actors of lignin based ingredients for our analysis. No lignin based product is currently available on the market. The participants are in different stages of their development of lignin based solution.

Companies
Lignovations
Montinutra
Chemyunion
CH-Bioforce
Innomost
Lignopure
Godavari Biorefineries ltd.
Fibenol
Bellejo
AB Karl Hedin Bio Innovation

Table 6. actors interviewed.

6.3.1 Open Coding Concepts

After the initial interviews had been conducted and all data had been collected, several rounds of open coding were carried out in order to generate relevant concepts from the interview transcripts. Importance of a

concept was evaluated based on descriptive language from the interviewed candidate, directly or indirectly mentioning the importance of the aforementioned concept. This evaluation was accompanied by the authors *a priori* knowledge of the subject to interpret the relevancy to the research question. Generated concepts were thereafter grouped into categories with an overarching theme. An example of the open coding procedure can be seen in figure 6.

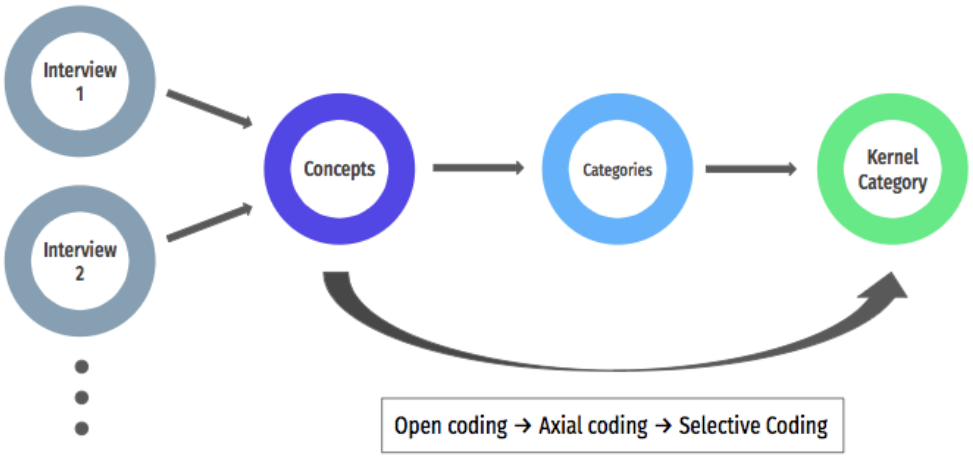

Figure 6. Figure visualizing the procedure for generation of concepts and categories from interview transcripts. Templates are accredited to SlidesGo and FreePik.

Through the process of open coding generated initial concepts were identified to be: Multifunctionality, Naturally Sourced, REACH Exempt, Transparent Value Chain, Chemically Unmodified, Particle Size, Application Area Variety, Clean Process, Renewability, Eco-Certification, Sulfur Free, Sustainability, High Value Application.

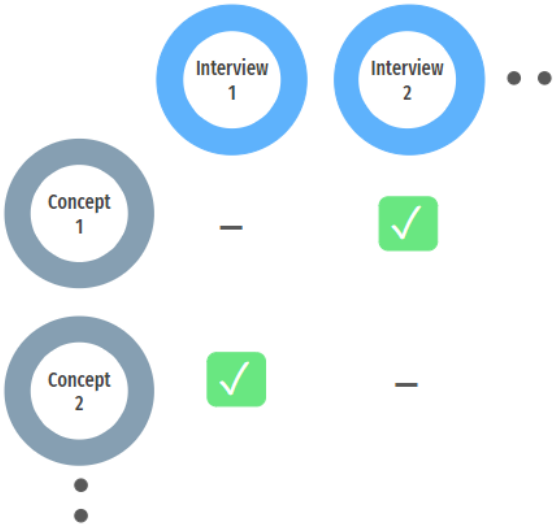

Figure 7. Model representing how the frequency of concepts mentioned was interpreted and analyzed. Templates are accredited to SlidesGo and FreePik.

6.3.2 Ranking Coded Concepts

Following open coding where generation and categorization of concepts was conducted, axial coding of the concepts and categories identified was carried out in order to compare and evaluate categories with new context and interpretations. Therefore, concepts were ranked based on frequency of mention, as well as inherent prominence. For this, the objectivity of a concepts' occurrence was supported by the subjective interpretation of a concept's importance to create a cohesive relevance score for each category. The ranking of the concepts can be seen in Figure 8.

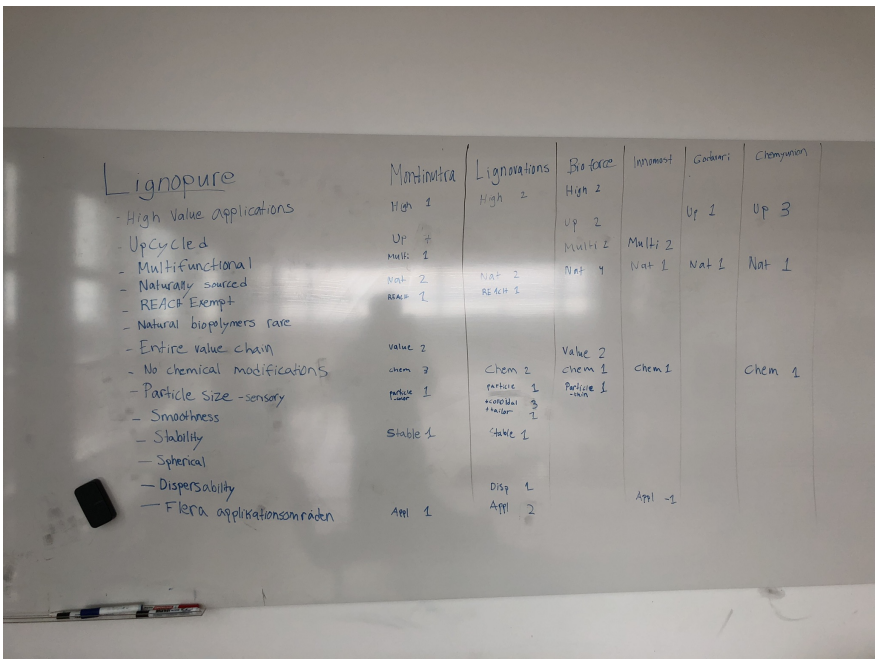

Figure 8. Visual representation of the ranking conducted on the concepts identified from the open coding rounds.

Attributing individual scores for each identified concept generated normalized values for each concept, which allowed for comparison in between concepts and ranking of their relevance. The highest scoring concept was ‘Naturally Sourced’ , mentioned 11 times, whereas the lowest was ‘Dispersibility’, only mentioned once.

6.3.3 Kernel Category

Following concept generation, categorization, and ranking, a selection of categories was made which through deduction have proven to have the most impact on the value of lignin in cosmetics, these categories are presented in Figure 9 with corresponding description. This allowed for us to make interconnections between the categories, refine, saturate, and create new final main themes, to close the gap to identifying our kernel category. The main themes identified are presented in Figure 9 and Table 8 presents the descriptions.

Category	**Description**
Green Profile	*The image that the ingredient can obtain through incorporation in a cosmetic product*

Sustainability	*Actions that deliver to the green profile through ecological benefits*
Certifications & Labels	*Communication of incorporated functions*
Aesthetics	*See section 2.6.2 Aesthetic value*
Customer Influence	*Offerings to the manufacturer*
Functionalities & Applications	*Ingredients usage in final products*
Physical or Chemical Attributes	*Characteristics of the ingredient on a structural level*
Impactful Circumstances	*Circumstances which indirectly affect the offering*

Table 8. Categories identified from recurring concepts, with appurtenant description.

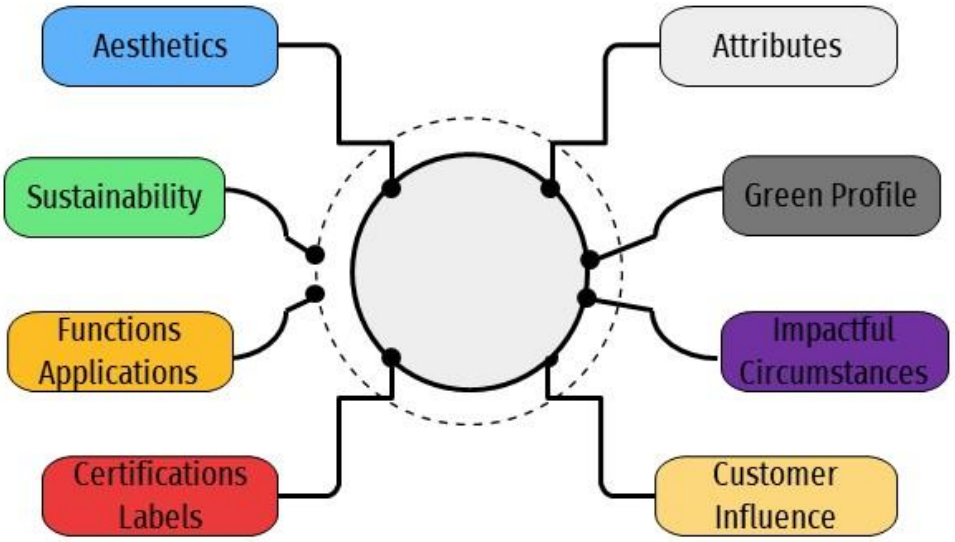

Figure 9. Visualization of main themes generated from rounds of open coding, category generation, and scoring. Templates used are accredited to SlidesGo and FreePik.

Through comparison and categorization conducted, the categories eligible to be the kernel category were: Sustainability, Green Profile, Impactful Circumstances, Physical/Chemical Attributes, Functionalities and Applications, Customer Influence, Certifications and Labels, and Aesthetics.

In relation to the research question; How can actors of lignin biopolymers offer ecological and aesthetic value in lignin for the usage of cosmetic product formulation? Green Profile was selected as the Kernel Category as the concepts included are central for not only the ecological value offered but the aesthetic offering too. As the section about ecological value describes, the ecological value is what consumers are requiring and thus the image that can be delivered to the customer is what is communicated as ecological value. In terms of aesthetics the Green Profile relates to the field as it is coupled to sensory experiences triggered by the profile. For instance, the naturality delivers a harmless feeling upon usage/purchase as a natural product is experienced as good for your skin, as suggested by Bellejo among others.

The interconnection of the category network also revealed the rightful positioning of the Green Profile category as the Kernel Category as the other categories' judgment support the Green Profile. By pursuing attributes of a Green Profile one is inclined to adhere to concepts of Sustainability. Through certifications and labels the Green Profile is communicated. Customer influence affects what Green Profile the actors aim to deliver. The Customer Influence is also coupled to Sustainability as ecological benefits include that the customer wants sustainability actions. The Aesthetics are delivered to the Green Profile as natural characteristics can be perceived as aesthetical by the end customer. The Functionalities and Applications interact with Green Profile in terms Physical and Chemical Attributes need to be present to deliver functionality, however without compromising for the Green Profile. One concept of Green Profile is that the chemical structure is there from the start and for Physical and Chemical Attributes there are concepts describing what the natural biopolymer offers as is, without these attributes it would not be possible to offer the Green Profile as is. Functionalities and Applications describes where the Green Profile can be offered as of today. Impactful Circumstances help explain how Green Profile can be offered, in terms of regulatory aspects and judging from the fact that the Green Profile elaborates from what has occurred in earlier stages of lignin processing. Thus, Impactful Circumstances include concepts

that elaborates that there is more responsibility of handling the biopolymer, than only the processing that one actor does. In other words, one has to be aware of and take responsibility for the whole value chain.

6.3.4 Green Profile

That lignin applications are biobased is frequently brought up by actors as attractive to the cosmetic industry, in the context of how this delivers to cosmetic industry in terms of sustainability. Furthermore, the aspect of lignin being a natural biopolymer also adds to the green profile. Lignopure mention that it is rare to find biobased polymers which are also sourced from nature, thus lignin is interesting having this in mind. Lignovations describe how this aspect is favorable as compared to synthetic ingredients where natural polymers hold the advantage of not causing degradation of the environment. Bellejo touched upon the same topic here, describing how lignin was an important cornerstone for finding an ingredient which would work for developing a sustainable sunscreen. The natural part is described as important in terms of how it delivers to the final customer. Lignopure and Lignovations point out that natural claims are of interest to them and their customers. Moreover, Bellejo describes how a natural product feels safe to put on your skin and in this context the idea originates from that lignin is something that is being consumed through food too. Thus, being safe for consumption adds on to the feeling of naturality in a final product. Not only Bellejo touched upon the subject of food. Fibenol describes how lignin is found in food too and that the lignin that they provide is in fact fit for a food context as well. In our interview with Bellejo the concept of natural came up reflecting customer interest too, a natural product delivered to the customer that wants a safe for your body, good for the environment kind of option. Meaning, that for a supplier it says something about the manufacturing process and the actions taken whereas for a customer it is an indication of a product being a good choice; environmentally wise and for skin health. Montinutra experiences that customers, based on their sustainability agendas, are interested in the naturality of the incoming ingredients. CH-Bioforce collaborates with two well known cosmetic companies; Channel and L’Oréal, which are driven by the natural and biopolymer

concepts. A lignin supplier could thus advantageously focus on these parameters as they mirror what their customers are interested in receiving. The concept of natural ingredients does not seem to be restricted to a limited production folder in cosmetics, as the actors have found customers to have different usage areas all interested in a natural option. Chemyunion, offers a lignin ingredient for hair straightening and mentions how the natural aspects of the ingredient is a highlight of the opportunity with lignin in hair care. As mentioned, Bellejo targets the sun lotion product range whereas Lignopure are launching a product that is an ingredient for different formulations.

The naturality to it holds and advantage in terms of regulatory aspects too as the regulatory side for a natural polymer is not as complex as if it was not, which is elaborated on in the section of important circumstances. Lignovations, together with CH-Bioforce, CHemyunion, Innomost, Lignopure and Montinutra, brings up how it is favorable to restrict from chemical modification of the lignin, keeping the naturality of the polymer persistent. CH-Bioforce states how they want to keep the lignin as natural as possible. Not modifying the structure chemically, seems to deliver to actors in several ways. One being on the regulatory front and the other one in terms of efforts. For instance, keeping the biopolymer natural could also mean that the lignin is applicable in a food context (Bellejo, Fibenol). Furthermore, the value of the Green Profile is coherent for actors' customers as regulations concerning whether the ingredient is natural or not can be neglected, says Fibenol. The Green Profile is of interest in the cosmetic industry as the reputation of offering products with a Green Profile is advantageous. Fibenol wants to be recognized for biobased initiatives, as does Chemyunion who states that they want to offer a 100% natural product which for them goes hand in hand with offering something sustainable to the market. Furthermore, Chemyunion and Lignopure agree that natural products are trending and that customers want more such offerings. To restrict from modifying the native structure of lignin seems to be a common strategy. Fibenol describes how their biggest benefit is that they keep the lignin native by not changing its structure and it is a benefit since they offer something natural to their customers.

The Green Profile, which offers a good reputation can be a limiting factor to some actors. Regulatory factors affect whether an ingredient can be classified as natural, biobased etcetera. Both CH-Bioforce and AB Karl Hedin Bioinnovation experience that even though restricting to a limited number of modifications during the treatment process these actions restricts their products from earning up to concepts related to the Green Profile. They share that when organic solvents are used, the product may be classified differently, for instance as microplastics. Highlighting that they too recognize no chemical modifications as favorable in the context of regulatory aspects.

Both Lignopure and Innomost agree upon the strength of a chemical structure being available from sourcing rather than the need to chemically modify it. Innomost means that one should consider the properties of lignin and what it can offer to a customer in its natural form to understand if there is a business opportunity, rather than trying to modify the structure. That the structure possesses characteristics naturally which enables multifunctionality of the product is important to CH-bioforce as well, and they believe in making as few chemical modifications as possible for maintaining a natural form. Nor has Fibenol any intention to modify their lignin chemically and the focus of the offering lies in the natural aspects that can be offered.

Replacing synthetic material is an important concept that explains partly what lignin ingredients can achieve. Bellejo described how lignin can be an important actor for replacing microplastics which are recurring in cosmetic products. Godavari biorefineries ltd. held that biobased options, such as lignin bipolymers, should replace synthetic phenols. The interviewee at Fibenol stated; “..the world will be biobased”. Pointing out that one needs to consider biobased options in all fields. Fibenol further described how lignin is such a biobased material, thus judging from the context the time for introducing a material as lignin is right now that the transition towards biobased materials is on its way. Biobased is a statement from a sustainability point of view, for Fibenol a biobased industry is the better way of targeting sustainability issues. On topic, Lignovations viewed the concept

of biobased as enabling sustainable actions. Montinutra believed that lignin as a renewable ingredient found in nature is an untapped resource for replacing fossil based options and experience from their customers that so are they.

6.3.5 Sustainability

The topic of sustainability was a recurring theme throughout all interviews conducted. Montinutra as well as Bellejo concluded that the value proposal from their side is fundamentally structured around sustainability, renewability, upcycling, and transparency of such concepts toward their customers. Without these crucial characteristics of the product, the value offered simply does not exist. Indeed, sustainability is the largest driving force for the entire cosmetics industry today, which is something Chemyunion as well as CH Bioforce Oy agreed on. Therefore, it was well motivated that the value proposition from biobased cosmetic companies revolve around sustainability. It has been made clear from all interviews conducted that a cosmetic company which does not keep sustainability in their greatest interest, is a company who will not succeed in the long term.

There also appeared to be clear consensus around the fact that the biggest strength for lignin in the cosmetic market is its sourcing. The fact that it is a by-product from the pulping industry is remarked by Montinutra to be the number one most attractive property of lignin right now. Montinutra mentioned that they are proud that they can provide lignin from wood pulp which is certified to be from a sustainable forest industry. At the same time they noted that there are even customers who have turned them down due to not fulfilling the certification of ‘organic’ forestry, which is an even tighter regulated certification. They argued that if a company can present a product as being ‘upcycled’, ‘agri-waste’, or just communicate clearly that the product is sustainable, customers are more inclined to purchase it. Indeed, CH-Bioforce Oy argued that: the fact that lignin has historically been a waste product is part of why its journey as a cosmetic ingredient is seeing the success it is seeing currently. Furthermore, CH-Bioforce emphasized that lignin is a high-value product due to the high amount of value it can put

out of such little volume. It is therefore not surprising that the valorization of biomass is something which is valued highly by the industry, as carbon-based chemical compounds are no longer a viable industrial option.

Adding to this notion was Innomost, who put forward the argument that lignin should be completely untampered with and utilized for the use cases where it sees fit, instead of trying to fit it into an application where it doesn't naturally belong. This further extended the view that resources should be utilized to what they most optimally can be utilized for, which adds another layer to the sustainability issue: It's not just a matter of optimizing the products and production chains which are already in place, but also contemplating which production chains are worth initiating, investing in and putting into practice: Are they really that good of a fit to what the demand is? If not, it might not be sustainable to invest in such an industrial process. In the view of Innomost, it is not sustainable to modify lignin just to fit a certain commercial agenda. Instead it is preferable to analyze where lignin can be applied in the best possible way in its natural form, and from there address whether or not it is justified to start producing it commercially on an industrial scale. This perfectly exemplifies how actors within the industry have both private and corporate motives when it comes to sustainability, and that this really is a driving force for many decisions currently made.

6.3.6 Aesthetics

All interviewees recognized color as an aspect that differentiates lignin based ingredients from what the market is used to and which has been and for some still is a challenge for its reputation. The actors have gone ahead solving the many times referred to as challenging color aspects of lignin in different ways. Chemyunion mentioned that their product is used in combination with other hair care products thus the visual aspect is solved when it is diluted and the color is not apparent in a final product.

The attitude towards the pigment does however seem to change. Lignopure mentioned that they are experiencing that the color can be of interest for inclusive beauty, for products to be available in different tints. They mentioned that they see that the pigment of lignin could open up for a new

application, as colorants. Bellejo and Lignovations, on topic, recognized the pigment as a favorable attribute in the final products as enabling a more skin like tone.

“I think it is like some of the companies says, the brown is the new green”
- Fibenol

As Fibenol put it, being biobased and natural could, for example, be communicated through the brown or beige color of a product. Meaning that natural products are usually not transparent or white but rather have a more natural color, that is tinted. Montinutra suggested that the reason the pigment of cosmetic products should be transparent or white has to do with what consumers are used to. In terms of aesthetics a naturally colored pigment such as what can be achieved by incorporating lignin in a formula could perhaps add to the environmental aesthetic value of purchasing such a product by communicating a naturality in the formula.

In the product that the actors offer for the cosmetic industry it is crucial that the product does not have an unappealing smell. Fibenol and Lignovations recognized how the sulfur containing lignins such as Craft, has to be modified for an application such as in cosmetics. If lignin contains sulfur naturally is thus an indicator for if a supplier can deliver a non odorous polymer that neither has been chemically modified. For instance Montinutras lignin does not contain sulfur and can deliver a pleasant smell without any chemical modification. For Bellejo, the smell is closely tied to what supplier that can be relevant.

The particle size is an important characteristic to the end customer as it affects the properties of the ingredient. AB Karl Hedin Bioinnovation and Montinutra agreed that it affects the color. Lignopure offers a spherical and dry micro particle to deliver the smoothness, dispersibility and stability which customers are interested in. Bellejo agreed that the size of the particle enables the right consistency of the product. Lignovations considered tailoring particle size important for the end customer as the right shape and size allows them to deliver a high performance product with good

dispersibility . In other words the molecular characteristics are what delivers in terms of aesthetic attributes to the end customer.

actors offer a trending product which has attributes related to the category Green Profile. Chemyunion claimed that customers want more sustainable options. Lignopure agreed, and described how they consider certifications and natural testing through which they can communicate the sustainability aspects to the final customers. Montinutra and Lignovations agreed that customers are asking for products with concepts related to ecological values. Bellejo expressed how that a product is biobased and natural can add to the customers experience with the product as making a choice which is good for themself as well as the environment. The idea of a product being natural in other words adds to a feeling of safety, that the product will not harm your skin. Thus, lignin actors could suggestively offer this sensory experience by communicating the Green Profile to their customers.

The classification of the ingredient that is being supplied is suggested as important for its reputation. CH-Bioforce and AB Karl Hedin Bioinnovations were concerned regarding whether regulatory aspects will keep up in the field of this type of cosmetics. Currently, modifications cause the ingredients to be classified as microplastics which does not mediate the image that actors aspire to achieve.

6.3.7 Physical and Chemical Attributes

The most central effect lignin possesses, and therefore provides as an ingredient is its UV-blocking effect. Karl Hedin Bio Innovation AB explained in a separate interview that the functional groups *chromophores* which lignin naturally inherits provides its effect to block UV-rays from the sun and therefore gives cosmetic formulations increased SPF. The cosmetic market has awaited a natural UV-filter or SPF-booster which avoids harmfully impacting the environment, explains Bellejo. Therefore, the main effect of blocking UV radiation is extremely sought after in cosmetics and is lignins main selling point from an efficacy stand-point. Indeed, lignovations' view on the UV blocking ability aligned with previous notions

as they also identify UV protection to be the strongest area of lignins characteristics.

Even so, other actors within the industry posed the counter argument that lignin does not have the UV-blocking capability to be classified as a UV-filter alone. Lignopure is one of the actors who put forward this notion as they believe that the UV-blocking capability of lignin is too weak compared to conventional alternatives. This is not to say they don't believe the UV-blocking effect is not the main selling point of lignin, but simply that it could only suffice as an SPF-booster in combination with traditional mineral UV-filters, and not as a UV-filter on its own. Additionally, they added that the regulations for UV-filters are harder than those for SPF-boosters and therefore it would slow down a possible market entry for such a novel ingredient. Thus, it is more preferable to allow lignin to enter the cosmetic market in the most favorable way, that is as an SPF-booster, in order to have it optimally received by the industry, allowing it to face the least resistance.

Lignins second to most prominent characteristic after the UV-blocking capacity of lignin, is its antioxidative capability which has been described by Innomost amongst others as lignins main selling point. Collectively, five out of the ten interviewed companies mentioned antioxidative characteristics to be of great interest when it comes to lignin in cosmetic applications.

Lignopure started their journey with being interested in high value applications of lignin and instantly turned to the antioxidative properties as this was the most prominent effect of lignin. In accordance with this, Innomost mentioned antioxidative properties as the most interesting for lignin, even more interesting than the UV-blocking properties which was not a commonly observed opinion from this study.

On the contrary, the only company interviewed who actually sells a final cosmetic product with lignin in it, which is Bellejo, did not mention the

antioxidative properties once during the interview, insinuating that the UV-blocking properties must be of greater importance than the antioxidative at least in their product.

The antimicrobial properties which lignin possesses are mentioned to be of slight interest for one particular interviewed candidate. Both CH-Bioforce Oy and Fibenol mentioned the antimicrobial characteristics of lignin, however only CH-Bioforce Oy portrayed it as an interesting selling point when it comes to the cosmetic industry. Since this characteristic strengthens lignins multifunctionality it is understandable how this could be beneficial for lignin in cosmetic applications.

Lignovations mentioned the sulfur-content of lignin to be a problem for the application of the cosmetic industry as this entails a certain unpleasant smell for the end-user. Indeed, compounds of sulfur generally do not have a pleasant smell. According to lignovations it was crucial for cosmetic formulators to remove the sulfur contents before applying lignin to cosmetic products, or alternatively using an extraction method which does not introduce sulfur content from the start. CH-Bioforce Oy and Karl Hedin Bio Innovation AB agreed on this notion and also identified sulfur compounds as a challenge for the cosmetic application of lignin. Interestingly, Montinutra which are using a sulfur free lignin claimed that their lignin not only does not have an unpleasant smell but rather has quite a pleasant smell, reminiscent of forest or sawmill pulp.

The importance of multifunctionality for lignin can not be understated. Collectively, Interviewees expressed that lignin will not succeed without offering more than a single effect for the end customer. When asked what the main strength of lignin was, Montinutra answered that the main benefit of lignin currently is that it does not only provide spf boosting effects, or just an emulsifying effect, or simply an antioxidative effect, but that it provides all of these traits simultaneously. That was the main strength of lignin in their view. Lignopure agreed that being multifunctional makes lignin unique, and additionally makes it fit into what is trending in the

cosmetic industry. They identified simple formulations, reducing waste, and multifunctionality to be the trends in the cosmetic market as of recent. Therefore, lignin fits well into these trends in their opinion. This is perhaps a counter reaction to previous cosmetic trends in which ingredients were expected to have one clear, well-defined effect in which it excelled.

For many actors of lignin biopolymers, it was vital to address the particle size of their lignins. This is because the particle size ultimately dictates the stability and smoothness of the end product, which are arguably two of the most important physical properties of the product. Unique for Lignovations was their ability to tailor the particle size to the customers needs, which they claim is a unique selling point. Montinutra talks about different modifications in order to make the product more appealing. Here, the particle size was also brought up as a factor to be modified for a brighter end product. Along with the size of the particles, their shape was also brought up as an important factor for their success. Montinutra and Lignopure agreed on the fact that the shape of the particles should be spherical in order to create a more stable and smooth end product which is more appealing for the end customer.

6.3.8 Impactful Circumstances

There are numerous factors influencing the value proposition of lignin in cosmetics. The majority of them surround inherent characteristics of the lignin itself, mentioned earlier. However, a fair number of factors would rather be classified as impactful circumstances as they heavily influence lignin's value proposition, without being a characteristic of lignin itself. Instead, these circumstances affect lignin in an indirect way.

The major impactful circumstance which all interviewees mentioned in one way or another is the European parliament’s regulatory framework REACH which regulates the safety of all chemicals produced within the European Union. Early on during the interviews, Lignovations explained to us that they can benefit from lignin being an exemption from these regulations, due to the fact that it is a natural compound, and not strictly a chemical

compound. Because they keep their lignin unmodified, and as close to its native structure as possible, they stand outside the REACH regulations, or as they call it, they are REACH exempt. This not only means that the process of getting the lignin to the market is quicker, but it ensures for the customer that the product is natural and harmless. During our pilot interview, Borregaard explained that it is a unique selling point for them that their lignin is REACH exempt, because that automatically tells the customer it is a product with few or none harmful properties which is desired in the cosmetic industry.

The second main factor affecting lignin and its value offered are labels and certifications. Early on during the interviews we understood that all the sustainability efforts customers are demanding have to be ensured in some way and that is via labels and certifications. Lignopure told us that when they choose a supplier for their part, they consider what labels and certifications they carry so that Lignopure can be sure that they can provide what their customers are demanding in terms of sustainability, organic agriculture and sourcing. Not only sustainability is considered but labels like vegan, biobased, and making sure the end product can be claimed cosmos approved for organic claims. Furthermore, Montinutra and Fibenol supported this notion that certain certifications and labels ensuring a natural product with a clean process behind it is of utmost importance.

6.3.9 Functions and Applications

The multifunctionality that lignin possesses is a very important offering according to actors and something that is appreciated by the cosmetic industry. Innomost and Lignopure suggested how one function may not be enough to compete against other options. lignin comes with several benefits in one molecule, which can simplify the ingredient lists on the final product which is positive for the image a company delivers in terms of naturality in their product, according to Lignopure. In terms of ecological value, that the biopolymer can offer several functionalities all in one could mean that several ingredients in a formulation could be replaced with merely this one. Depending on the background of what other ingredients are included in a

formulation, their carbon footprint etcetera, this replacement could deliver in terms of several of the ecological benefits mentioned in 2.6.1. Aesthetically, a simplified ingredient list could also deliver to the customer in terms of how the product is received.

That the biopolymer offers several benefits in one molecule makes the application areas wide spread. Chemyunion mentioned that they use lignin as an active ingredient for straightening the hair. Lignopure suggested application areas where the goal is to have good antioxidant properties as well as spf boosting and color is possible functionalities, both BB-creams and hydration creams are mentioned as products that could be relevant. Lignovations mentioned how lignin can be used as a colorant. For Bellejo, the focus was on the development of sunscreen and where lignin acts both as an SPF booster when combined with mineral filters, as a colorant and also acts as a preservative. The different application areas that actors have brought up and the function that is being delivered reflects how a lignin biopolymer can deliver aesthetic value through the formulation that it is being incorporated in. Either by acting like an active ingredient protecting the skin from sun damage or with an appealing tint that falls more natural with the customer's skin, in a BB cream.

Several interviewees agreed that lignin as a biopolymer is heterogeneous. What the chemical structure of lignin is determines what functionalities it has and what functions are heightened or not, according to Lignovations. For instance, Lignopure described how the color can be modified but that it can affect other functionalities too as a consequence. Montinutra explained how they chose the strategy of not chemically modifying lignin but that as a consequence the color that the lignin that is being delivered becomes a challenge. Another example is how lignins containing sulfur need to be treated before application in cosmetics, as Bellejo motivated. What appears is that actors are challenged by the cosmetic industry to deliver ingredients with great benefits in form of functionalities which sometimes demand chemical modifications, however still have to maintain a Green Profile including no chemical modification to deliver fully to customers. This is a

balance between offering ecological value and aesthetic value. By maintaining the native structure of lignin actors can deliver on several ecological benefit points as stated earlier. However, by modifying the structure, the outlook of lignin in cosmetics can be positively affected. In other words, if color modifications can make the final product achieve a white color this is received as aesthetically pleasing to consumers. Judging from what actors have stated about challenges related to the natural color of lignin. However, such modification could jeopardize what ecological benefits that can be communicated.

6.3.10 Certifications and Labels

From the interviewees it has come to our knowledge that for actors of lignin offering products directed towards the cosmetic industry certain labels and certifications can be advantageous. Lignopure mentioned certifications such as vegan, biobased and for organic labeling, cosmos approved as important such for the final customers. Montinutra and Lignovations agreed upon the importance of labels and certifications from a customer standpoint. Montinutra have been asked by cosmetic actors about organic forest practices and vegan labeling and Lignovations offers eco-certification to their customers. What can be achieved in terms of labeling has do with the full process of how lignin has been handled throughout the value chain. Lignopure as well as Bellejo described how they have certain criteria on actors at earlier stages of this value chain. Factors such as sustainable sourcing from plants and certified forestry practice are brought up by Lignopure. Bellejo too described labeling as a way of communicating with customers the benefits of the products. Labeling thus can be seen as a way of communicating the ecological and eco aesthetic value of the ingredient or the product to the customer. What the actors are referring to when discussing labeling and certifications is what the end customers appreciate or makes them inclined to pursue the product. The labeling may say something about how ecological sustainability has been taken into account in the process of manufacturing the ingredient, for example Lignopure considered their supplier in terms of what it can do for labeling the lignin product as vegan or with regards to organic forest management. Surely, a

certification defends that such a measurement has been taken into account and thus customers interested in ecological benefits/value delivery have some sort of proof that certain benefits are found in the offering. The aesthetical part of it being that the certification and labeling consequently affect what statements can be made at the final product that are interfering with the sensory system of the final customer and thus serves as a way of communicating benefits to a certain type of customer.

6.3.11 Customer influence

The final factor affecting the value proposition of lignin in cosmetics is considered to be the influence the customers demand has on the product. For Lignovations, their ability to tailor their particle size to the customer's needs allows them to modify their value proposition based on what the customer is seeking. Lignovations described how some customers are well satisfied with a product which is exempt from the classification of being a nano-material because it demands less regulations. Simultaneously they described them having other customers which specifically want the product to be classified as a nano-matieral for various reasons. Therefore, the customers ultimately influence what the value proposition looks like per specific customer case.

Another take on this is simply what the market is demanding. That is, what is trending? One could argue that because sustainable, naturally sourced, harmless products are trending now, as shown earlier, selling lignin which carries properties aligning with those demands is part of what the value proposition includes. This is naturally due to how demand drives consumption. But one also has to address the use case of the final product. This will heavily dictate what the value proposition looks like for lignin in cosmetics. If the end product will be a sunscreen, it might be preferable to have high dispersibility so the end product feels smoother to the touch, but if one would develop a powder, other properties will be of much more importance. As Chemunyion are developing an ingredient for an anti-frizz spray they for example valued characteristics which minimize static electricity, which are vastly different properties than those developing ingredients for sun screens.

The importance of having transparency in how a product is sourced and manufactured is paramount for all companies within the cosmetic industry. Indeed, as previous findings have discerned, the topic of sustainability is central for value propositions. Both Montinutra and Lignopure mentioned how having a transparent value chain is a crucial factor for the value proposition of their products, as it facilitates an understanding of the company for other actors engaging with them and creates trust for the company.

7. Discussion

7.1 What does the industry of lignin-based cosmetics look like?

Findings from interviews conducted alongside the ethnographic study carried out shows that lignin actors are at different stages of how far they have come in their business, some are start ups and others are more established. The actors also differentiate in what is offered and to whom. In other words, the value chain differentiates from case to case and for some cases there is no established value chain present.

The lignin cosmetic value chain is composed of at least 5 actors; Biorefineries, Manufacturers, Modifiers, Formulators and Retailers, where the lignin is supplied in the order of the listed actors, see Figure 5. However, these actors can be integrated or overlapping. In other words, in some cases a company can serve as both a Modifier and a Formulater or a Biorefinery and a Manufacturer. From the Formulator, an additional actor may be present as the product can be supplied through the hands of a Distributor to Retailers.

We present a cohesive mapping of the actors identified and specify their correlation to one another, explaining how the value chain for lignin in the cosmetic industry currently exists, as well as how it evolves during its course. The mapping creates a synthesized version of actors within the industry where their roles represent where an actor would fit along the axis

if all of them were connected in the same production chain. Therefore, the mapping provides a report on how the production of lignin products in the cosmetic industry generally looks.

Our findings of the cosmetic industry in some ways align with the notion put forth earlier that the greatest dictating force of the value proposition is the customers who heavily influence what companies want to provide for the industry (Kumar, Massie and Dumonceaux, 2006a). What has been understood is that the value offered in each sequential step is constantly changing throughout the value chain, as actors value different factors individually. However, collectively the values converge to a common end goal, which is to satisfy the end customers needs. Therefore every value proposition along the way of the value chain intends to shape and manufacture an end product with a certain set of characteristics, aligned with the end customers interests.

7.2 How important are ecological values in the cosmetic industry?

Ecological values are considered to a greater extent as of today, than 10 years ago (Jo, Panel-discussion). More ingredients adhering to ecological benefits are to be seen from now on according to Payne in the Panel discussion. Revealing that ecological values are getting more important than ever. Moreover, the findings concerning the innovations justifies that innovations are indeed accounting for ecological value delivery both for functional ingredients as well as active ingredients. Another aspect revealing the importance of ecological values is a major focus on communication to customers. The staging of the fair too reveals that ecological values are pervading in the image that the cosmetic industry wants to deliver. Busata describes how transparent communication is beneficial, and Payne together with Verey elaborates on the subject as to how such communication delivers to both parties in terms of trust.

Todd (2004) describes how a company that is strongly driven by environmental and aesthetic values need to offer both aspects in their

products and how by doing so contributes to an environmentally conscious business form (Todd, 2004)(Tom's of Maine, 2003). Our findings however indicate that the ecological value does not trump the efficiency of the product itself, a product has to possess other characteristics otherwise it is not applicable as Elisie Rutterford in the Panel discussion puts it.

7.3 How can actors within the lignin polymer production offer ecological and aesthetic value in lignin for the usage of cosmetic product formulation?

Lignin polymer actors offer ecological and aesthetic value through implementing the eight parameters identified in the analysis section; Green Profile, Sustainability, Aesthetics, Physical and Chemical structure, Impactful Circumstances, Functions and Applications, Certifications and Labels and Customer influence. Green Profile plays a central role in what value is offered by the actors to their customers. Such a message was described by Belljeo stating that customers want a natural product because it delivers a sense of being safe for not only the environment but for their body as well. The Green Profile delivers a sensory experience that is eco-aesthetic as there are ecological benefits incorporated in the obtained product that from a Green customer point of view would deliver a feeling of safety.

Earlier, it has been stated that cosmetic companies need to communicate safety to their customers, more specifically with regards to animal testing (Kumar, Massie and Dumonceaux, 2006a). With regards to the safety image, we elaborate that the Green Profile holds what ecological and aesthetic values need to be communicated to deliver an image of safety in the industry of lignin-based cosmetics. Customers are motivated to purchase based on environmental aesthetic value delivery (Todd, 2004), we present what ecological and aesthetic values are offered by actors of lignin and thus what attributes can be presented so that customers can make such justified purchases.

It has been observed that lignin biopolymer actors have to put extra consideration into understanding and satisfying the needs of the customers. As noted previously, the ecological value a product offers is in direct correlation with a customer's will to purchase a product on an ecological or environmental basis (Hsu, Chang and Yansritakul, 2017). This has been observed in how actors of lignin offer ecological value as their value proposition is often heavily influenced and shaped by the customers demands, for example transparent value chains, ecological certifications, and organic forestry sourcing all base their value propositions on customers demands for a more sustainable industry. Therefore, the findings of this study stand in opposition to the view of Jan *et al.* (2019), that ecological benefits are not considered valuable by cosmetic customers. Instead, we elaborate on the findings of (Hsu, Chang and Yansritakul, 2017), stating that ecological benefits are the most significant factor for determining value delivery in lignin based cosmetic products.

7.4 Competitive advantage of Organosolv lignin manufacturer

Porter's 5 forces have been used to analyze the competitive advantage of an Organosolv Supplier directed towards cosmetics.

Rivalry between existing competitors is low as the actors within the field directing lignin ingredients towards cosmetics are limited. Additionally, suppliers are inclined to collaborate with one another, which might contribute to that situation. The lignin-cosmetic industry is not yet well established. This does however also mean that since there are so few actors within the market, everyone wants to be the first to catch a break. Therefore, even though the internal rivalry is numerically low as in few people are competing, the importance of being the first to succeed is quite large and therefore also an important factor to consider.

Smooth market entry is possible if one keeps the lignin as close to native as possible which causes the *threats of new entrants* to be high. However if we're talking about nanomaterials the entry is costly in terms of tests and time. For an Organosolv lignin supplier it will be regulatory difficult to enter the market if the ingredient is on nanomaterial level. Furthermore, if

chemical modifications are carried out, as for now this can not be accomplished with offering all concepts related to a Green Profile.

According to Lignopure, natural biopolymers are however rare, which gives an opportunity as customers want the naturality. With regards to this there would thus not be many product substitutes available. Multifunctionaliy serves as a way to compete with threats, for instance there are many antioxidants out there so to compete it is valuable that lignin ingredients possess several functions according to actors. Looking beyond identical substitutes, mineral filters certainly pose a substitute as a natural UV-filter albeit not as a natural biopolymer. These substitutes' price point could therefore raise the substitution risk higher. Thus, the threat related to *product substitutes* is medium.

Bargaining power of buyers is high as the lignin based ingredients are not yet well established. It could cost the company much in terms of finding new customers as the recognition of lignin is not very established. Not being able to offer a green profile could be a downside making customers choose other actors.

The bargaining power that actors hold is low as lignin is a waste product from pulp and paper industry and since new application areas are being explored. Hence, it should not be very problematic to purchase. In nordic countries, where the forest industry is large, there are many potential actors of raw material. As the volumes in the cosmetic industry are quite low as compared to other industries such as fuels, this also speaks for the fact that there will be material available.

7.5 Regulatory aspects are related the to preservation of the Green Profile

Several actors have commented on the regulatory aspects related to classification of materials in REACH. A few actors as of today, experience struggles related to the classification, as modifications during processing restricts a natural product offering. Raising the question of whether or not regulations will follow suit? Fibenol expresses that regulations are not

tailored for the biobased world and that this withholds a problem for the naturality of the material. Lignovations agrees, stating that sustainable materials are not being promoted as biomaterials seem to fall under the same regulatory parts as synthetic material. For CH-Bioforce regulatory aspects classifies the lignin ingredient as bioplastics, as a consequence of the lignin being separated from the biomass with anything other than water during processing. actors in the lignin-cosmetic industry seem to deal with these difficulties in one or two ways; 1) keep the polymer natural by avoidance of modification and thus be REACH exempt, or 2) wait for regulation to change. According to our findings, the naturality which is a part of the Green Profile is however important for the portrayal of the delivery, thus future turns in this topic is of crucial importance for the outlook of actors within the industry.

A few actors have expressed that to apply for UV filter certification is time consuming and difficult. Furthermore, incorporating lignin as an SPF-booster instead is more preferable in terms of how fast they can offer such a product to customers. The regulatory parts are very restricted for nanomaterials in cosmetics according to Bellejo. Who further touched upon how Nanomaterials of lignin is interesting for the future but that there is a lot of work to it.

7.6 Academic and Practical Contribution of Knowledge

The theoretical contribution of this analysis is the elaboration on the status of the lignin cosmetic industry. The study constructs a mapping of how the lignin cosmetic value chain is structured, thus generating new knowledge about how actors are connected in the specific field. From what has been specified in scientific literature about the actors involved in the field, we elaborate on what actors are involved as actors. Furthermore, the ecological and aesthetic value a lignin supplier offers is one part of the contribution, which is presented in the form of categories that holds what actors as of today deliver to their customers. This insight contributes to a yet quite unexplored field where lignin is a potential main character in tomorrow's cosmetic products. Theoretically, describing what attributes a lignin actors

products could offer brings literature one step closer to mapping the potential of lignin as well as understanding if lignin can offer the properties within eco-friendliness and aesthetics that is crucial for its success as an ingredient that cosmetic products developers are curious to engage with.

The practical contribution of this analysis provides new insight into the status of lignin actors targeting the cosmetic industry. The status of the actors is presented with regards to what actors are active and how such actors are connected in a value chain. For lignin developers these practical aspects could serve them when evaluating their business opportunity. In other words, a mapping of the value chain can be helpful for determining what actor they should enter as. Moreover, the overlook of what actors are already present in the field is also helpful to evaluate the business opportunity. The categories revealing what value actors offer as of today contributes in a practical way to new entrants or established actors. This in terms of how they can turn to these categories when evaluating their product. The contribution is thus also that these actors receive some elements for judging if this is a business opportunity which they wish to pursue, based on whether they can offer something that other lignin-actors can not as of today or vice versa.

The relationship between the kernel category and the other categories explains the factors affecting the finite value that is being offered by actors as of today. Hence, the academic contribution consists of value delivery literature and the practical part the equipment that these categories supply actors with.

The contribution also includes a technical project plan of how to evaluate on what is the optimal composition of a SPF mineral powder. This will thus be based on what ecological and aesthetic value the Organosolv lignin actors could offer in the product.

The contribution is also constituted by a brief biomedical overview of the clinical safety of mineral filters TiO2, and ZiO in comparison to Lignin as well as the cytotoxicity and mutagenicity of lignin, which addresses the clinical safety of it as an ingredient in cosmetics.

7.7 Methodology Reflective Section

The analytical framework made it possible for us to identify the categories that serve as pillars for what ecological and aesthetic value is offered by actors of lignin. Through coding of the data we could generate concepts and categories that contained the core message of the interviews in relation to the research question. The systematic approach of analyzing allowed for a comprehensive understanding and coupling of data.

Interpretation of data was context dependent. This was shown in the way concepts expressed in one context were by some actors communicated in different terms in another context. As the grounded theory allows for interpretation of how concepts are expressed by interviewees (Bryman and Bell, 2013; Glaser and Strauss, 2017), combining qualitative interviews with chosen framework was therefore adequate for this research.

One could argue that as the analysis of data was performed after all interviews had been carried out, it would affect the outcome of the results differently as if the analysis was made after each interview. If the analysis would have been performed after each interview, that could have affected the direction of the upcoming interview in terms of interesting concepts allowing us to ask more questions related to a certain finding, to a further extent. However, we see greater benefit from analyzing the results after all interviews had been conducted as every interview is unique because of the novel field of lignin and every interviewee has individual topics to address which should not be affected by previous interviewees inclinations. Analyzing the findings after each interview could possibly skew the other interviews to omit important information which is important to them but not to the prior interviewee. Therefore, we adhere to the methodology of analyzing the findings after all interviews have been conducted to allow individual importances to be expressed.

It should be noted that the motive for the candidates to participate in this study is certainly colored by their positive inclination toward lignin as a product due to them working with it commercially. Therefore, we

acknowledge that important industry secrets may be kept confidential in order to protect the business. Furthermore, the candidates' attitude toward lignin are of course also colored by their personal connection to it as a result of their businesses. This is, however, an unavoidable circumstance, and nothing heavily affecting the data retrieved from the interviews.

7.8 Authors contribution

The authors have carried out the practical work, the interviews and microethnography, together and both have participated at all such occasions. The fact that both researchers were present at every occasion was advantageous. Being two researchers working together allowed for cooperation which simply is not possible if the research is done individually. Assisting each other with practical matters showed to be a strength for the research. Additionally, cooperating during the analysis and discussion was also a benefit for the research as it allowed for different point of views to emerge and therefore a deeper more nuanced analysis. For the analysis of the transcripts the authors have divided the work equally, and specifications of the division can be found in Appendix 4 where the contribution to the report is further specified.

7.9 Outlook - Value Chain Plasticity

One circumstance made particularly clear from conducting interviews with actors from different sectors of the production chain was that the value considered in every sequential step of the production chain was under constant modification. Evaluating the value of lignin in cosmetics, one has to address particular concern to the fact that the value offered in the product will not be defined and interpreted equally throughout the entire production chain. Naturally, actors, manufacturers, and distributors value different characteristics, because they have different ambitions and agendas
Furthermore, the value of lignin at a particular point in the production chain has to take into consideration the value at another point of the chain.

8. Conclusion

Actors involved in the lignin cosmetic industry are limited and are in early stages where they are occupied trying to find their niche, as found studying the Bio4Care workshop. Furthermore, integrating with actors within the field of lignin in cosmetics the industry could be mapped. We present a mapping of the actors in the lignin cosmetic industry which elaborates on the value chain Kumar *et al.* (2006) suggests for the cosmetic industry in the way that the actors involved as suppliers have been further mapped. The mapping of the value chain that lignin is integrated in, includes the following actors; Biorefineries, Manufacturers, Modifiers, Formulators and Retailers. All actors contribute to the valorization of lignin individually with the contribution necessary at every sequential step. As a whole, the actors converge their efforts into a cohesive operation which transforms the byproduct which is lignin into an upcycled material which can be implemented into a cosmetic product. In this case, lignin is enabled through the steps of valorization in the value chain to serve as an ecologically and aesthetically valuable source of delivery.

The microethnographic study of the leading actors of the cosmetic industry, concluded our understanding of how important ecological value is in the cosmetic industry as of today. Conclusively, the findings indicate that the ecological value is of large importance, however never so important that it overshadows the importance of the functionality of the cosmetic product itself. Customers are demanding more from companies in terms of actions taken toward sustainability (Todd, 2004; Rodrigues *et al.*, 2018). Our findings indicate that customers are not ready to negotiate on performance for the sake of sustainability and/or ecological improvement. Aligning with how it is suggested that an environmentally conscious company needs to offer value both in terms of ecological and aesthetic value in the product (Todd, 2004). The micro-ethnographic study also shows that ecological values are taken into consideration by the actors and organizers of the in-cosmetics® fair judging from how ecological values are heavily portrayed as attractive in the setting of the fair and the aesthetics of the actors' booths.

The Grounded Theory was used to analyze the qualitative interviews, arriving at eight categories describing the most critical ecological and aesthetic value aspects. Upon identification of the most valuable asset for explaining what is offered, Green Profile was identified. This indicates that a green profile of a cosmetic product is crucial for value delivery. The Green Profile is considered to be the image of a product which is portrayed to the customer. It includes 8 concepts which were identified to be recurring over the interviews. The concepts were; Naturally sourced, Biobased, No chemical modification, Natural biopolymer, Chemical structure unmodified, and Replace phenols/fossil based materials. All aspects of Green Profile are of special importance in what the actors offer, and they all aim to portray the product in a way which communicates to the customer that the product is ecologically favorable. Thus, the Green profile describes what value is being offered by the actors in terms of ecological value and aesthetic value. Kumar *et al.* (2006) specify that caution taken towards animal testing delivers safety to the customer and to this we elaborate on what other attributes can be offered by an actor to deliver ecological and aesthetic value, more specifically for the lignin-cosmetic industry. Todd (2004) states how environmental aesthetic value delivery motivates purchase. Our findings present what specific attributes present ecological and aesthetic values directed to consumers in the lignin-cosmetic industry. Hsu *et al.* (2017) shares this notion that cosmetic customers base their willingness to purchase based on ecological values. To this we elaborate on what such ecological values actors within the lignin-cosmetic industry can offer, aimed to satisfy customer demands.

The Green Profile was identified as the Kernel Category, meaning it is the most important, and central category explaining the value proposition of lignin. All other categories identified are intertwined to the kernel category in a network which affects what is offered in terms of value. These categories can be used by future actors developing strategies or for current actors aiming to improve what is being delivered.

Appendix 1 - Technical Project Plan - Nellie Henriksson

Lignins potential as an SPF booster in cosmetic SPF mineral powder formulation

A Technical Project Plan

Nellie Henriksson

Aim

The aim of this project is to investigate if lignin can improve UV blocking properties of a cosmetic sunpowder formula. Further, the study aims to find the optimal composition of such a formula with regards to the quantity of lignin added.

Hypothesis

The hypothesis holds that lignin is an effectful spf-booster in a dry powder and not only in liquid sunscreens.

Theory

The two categories of sunscreens available today are chemical and physical ones, where the physical ones are those where zinc oxide and titanium dioxide is frequently being used (Qian, Qiu and Zhu, 2015a) (Lewicka *et al.*, 2011). As a consequence of wanting to limit the use of synthetic organic chemical UV absorbing options, searching for natural alternatives is on the rise (Qian, Qiu and Zhu, 2015a; Sadeghifar and Ragauskas, 2020). A natural polymer, lignin, has been proved to increase the spf effect of suncare applications (Qian, Qiu and Zhu, 2015a; Yu *et al.*, 2018). Lignovations, an Austria based company, has a lignin product that can double the spf of a formula once added and allow for a reduction of the usage of conventional UV filters by 50% (*BIO4CARE Workshop*, 2022). Bellejo, a Belgium based company that we met with, has developed an alternative sunscreen using lignin as a spf-booster for a formula containing mineral filters, available in different tints.

Sun Protection Factor

SPF is a measurement that explains how much UV radiation (UVR) reaches the skin with the sun protection as compared to how much that would reach the skin without the protection (Zhang and Naebe, 2021). Ultraviolet radiation is the radiation at a wavelength between 290 nm and 400 nm, it includes Ultraviolet B (UVB) is the UV radiation within the range 290-320 nm and ultraviolet A (UVA) is UV radiation within the range 320-400 nm (*ISO 24444:2019(en), Cosmetics — Sun protection test methods — In vivo determination of the sun protection factor (SPF)*, 2023). Sunscreen products protect skin against erythema, that is redness (*ISO 24444:2019(en), Cosmetics — Sun protection test methods — In vivo determination of the sun protection factor (SPF)*, 2023). SPF is a function of CIE erythemal spectral effectiveness (E_λ), solar spectral irradiance (S_λ) and spectral transmittance (T_λ), as shown below in equation 1 (Qian, Qiu and Zhu, 2015).

$$(1)\quad SPF = \sum_{290}^{400} E_\lambda S_\lambda \Big/ \sum_{290}^{400} E_\lambda S_\lambda T_\lambda$$

Lignin structure

Lignin can be found in the cell walls of plants where it is linked to cellulose and hemicellulose through covalent bonds (Lourenço *et al.*, 2017) (Gellerstedt, Ek and Henriksson, 2009). Lignin provides the plant cell walls with stability, is an actor in water transportation and serves as a protection against pathogens (Lourenço *et al.*, 2017) (Campbell and Sederoff, 1996; Boudet, 2000; Donaldson, 2001; Boerjan, Ralph and Baucher, 2003; Vanholme *et al.*, 2008). The abundancy and arrangement of lignin differs between softwood and hardwood (Lourenço *et al.*, 2017).

The lignin structure consists of monomers; coumaryl, coniferyl and sinapyl alcohols. These three structures have an aromatic ring that are further referred to as H, G or S units. H units are the aromatic rings where no methoxyl group is coupled and is referred to as *p*-hydroxyphenyl, if there is

one methoxy group present it is a guaiacyl aromatic rings, that is the G unit and if two methoxyl groups are coupled to 5' or 3' carbon that is the S unit syringyl (Lourenço *et al.*, 2017). The type of lignin encountered in hardwood and softwoods differentiate, both G and S units are present in hardwood whereas softwood is composed of G units (Lourenço *et al.*, 2017).

Spf-boosting properties of lignin

The natural polymer is an abundant renewable resource (Wool, 2005b), and serves as a protectant from UV rays in plants (Zhang and Naebe, 2021). lignin has UV absorbing properties, containing chromophores which can absorb UV light within a range of 250-400 nm (Sadeghifar and Ragauskas, 2020). By combining lignin with metal oxides such as titanium dioxide and zinc oxide in sun lotions, the quantity of inorganic filters can be reduced (Zhang and Naebe, 2021). Conjugated carbonyl groups, aromatic rings and carbon carbon double bonds are responsible for the absorption and are also responsible for the color that lignin possesses (Sadeghifar and Ragauskas, 2020) (Polcin and Rapson, 1971; Paulsson and Parkås, 2012).

Several experiments have been carried out where lignin has shown to have an effect on the SPF of sun lotions, increasing the sun protection properties of the formula (Sadeghifar and Ragauskas, 2020). In one study lignosulfonate was coated onto titanium dioxide particles and showed results of an SPF 50+ when 10 wt% of the titanium dioxide coated with sulfonate lignin particles was added to a pure cream (Yu *et al.*, 2018). In another study, 2 wt% of lignin was added to a sunscreen lotion with SPF 15, resulting in an SPF of 30 (Qian, Qiu and Zhu, 2015a). Similar to findings of combining lignin with titanium dioxide, zinc oxide combined with lignin also results in a major increase in UV absorbance (Sadeghifar and Ragauskas, 2020) (Gutiérrez-Hernández *et al.*, 2016). In commercial sunscreen lotion lignin nanoparticle addition of 5 wt% could increase the spf factor by 5, from SPF 5.4 to SPF 30.0 (Lee *et al.*, 2020; Sadeghifar and Ragauskas, 2020).

Furthermore, synergetic effects between lignin and other ingredients in sunscreen lotions have shown to enhance the UV absorbance when the formula has been exposed to UV radiation (Sadeghifar and Ragauskas, 2020). The antioxidative properties of lignin are also responsible for the positive effect described (Sadeghifar and Ragauskas, 2020).

UV mechanism of lignin structure

Lignin has UV absorption within the range 200-400 nm (Zhang and Naebe, 2021). UV light causes electron jumps to occur between a certain orbital to one empty antibonding orbital of the chemical structure, allowing for absorption within the range of UV light and visible light (200-800 nm) (Zhang and Naebe, 2021). More specifically, the electron jumps from 1) orbitals of pi bonding to pi antibonding orbitals, 2) from orbitals with no bonding to either pi antibonding or 3) sigma antibonding orbitals (Zhang and Naebe, 2021)(Förster, 2004). In lignin, the functional groups that enable such absorption are chromophores (Zhang and Naebe, 2021). The chromophores that are active in this way in lignin have been summarized (Zhang and Naebe, 2021), and are shown in Table 1 below.

Table 1.

Chromophore	**Wavelength (nm)**
Double bonds (CH=CH) conjugated with aromatic ring	200
Quinone methide and quinones	240 & 282
Chalcone structures	270-273
Free radicals	280-282
Metal complexes with catechol	320

Table 1. Chromophores responsible for absorption of light within wavelengths indicated are presented based on Zhang's et al. summarization (Zhang and Naebe, 2021).

Both the molecular weight of lignin and the phenolic groups in its structure are coupled to the UV blocking properties (Zhang and Naebe, 2021). The reason behind this being that the molecular weight influences dispersibility and as for the phenolic groups, UV protecting properties are influenced by photostability (Zhang and Naebe, 2021) (Paulsson and Parkås, 2012).

By making alterations in the structure, size or shape of lignin one can consequently affect the UV protecting properties (Zhang and Naebe, 2021). For instance, methoxyl groups linking to phenolic groups alter the UV protection in a positive matter, due to the oxygen's lone pair. When changing the structure of lignin one may increase the UV protecting abilities or its color, however to reach satisfaction on both points is challenging (Zhang and Naebe, 2021).

Spherical particles of lignin have proven to be preferred, having to do with the fact that more chromophores are present on the surface of lignin when the particles have low packing density (Zhang and Naebe, 2021) (Qian et al 2017; Hong et al, 2017). A smaller particle size provides better UV blocking properties (Zhang and Naebe, 2021)(Qian et al, 2017). When lignin is at nanoparticle scale it gains a higher surface area, thus contains more chromophores which grants the structure with better UV blocking properties (Zhang and Naebe, 2021). Since there are more chromophores per particle, less lignin in terms of weight will be needed for the same amount of chromophores, thus the color intensity is reduced (Zhang and Naebe, 2021).

Lignin integrated with mineral filters

When lignin is combined with zinc oxide the UV blocking spectrum increases as a consequence of lignin causing the mineral particles to have a higher quantity of electron hole pairs (Zhang and Naebe, 2021). Lignin has also been shown to affect the dispersity of the composition as it is combined with zinc oxide or titanium dioxide which also has the same turn-out of better UV absorption (Zhang and Naebe, 2021).

Color

The brown color that lignin possesses is a consequence of absorption of light at a wavelength in the range 400-800 nm (Zhang and Naebe, 2021). The dark color is a challenge for the aesthetics of the final products (Sadeghifar and Ragauskas, 2020). However, judging from the actors interviewed in this analysis the critical view upon the color is changing and for the right application the pigment can instead serve as a valuable asset.

Other aspects

A hydrophobic lignin is perhaps preferable in sun lotions, as it is suggested to provide better sun blocking properties to sun lotions than hydrophilic lignins as well as it does not disrupt the emulsification of the formula (Sadeghifar and Ragauskas, 2020).

Elemental analysis

With the elemental analysis the sulfur (S) content of a compound can be determined (Frąckowiak *et al.*, 2001). In practice elemental analysis (EA) is composed of a reactor where redox reactions occur, hence oxidation of the composites (ibid). These oxygen containing compounds are then separated and detected through gas chromatography and a thermal conductive detector (ibid). Through elemental analysis the molecular formula can be determined knowing the elements present and their mass percentage together with the molecular weight of the sample (Frąckowiak *et al.*, 2001).

Klason method

Klason method can be used to determine if the lignin sample is contaminated by carbohydrates as carbohydrates are solubilized by sulfuric acid whereas lignin is not (*Acid-insoluble lignin in wood and pulp, Test Method T 222 om-21*, 2006). Hence, after treatment with sulfuric acid lignin can be filtered out and weighed.

The lignin content is calculated as Equation 2 suggests, thus the sample is weighed prior to the addition of acid and finally once the lignin has been collected (*Acid-insoluble lignin in wood and pulp, Test Method T 222 om-21*, 2006). To summarize, Sulphuric acid is added to the lignin as well as water, which is boiled. Once the lignin has settled a filter is used to collect the lignin (*Acid-insoluble lignin in wood and pulp, Test Method T 222 om-21*, 2006).

$$(2)\ lignin,\ \%\ =\ (lignin\ weight,\ g\ *\ 100)/weight\ of\ sample,\ g$$

Materiel

Purified lignin delivered in a powder format is needed as well as a mineral powder with sun blocking properties. A suggested formula is Clinique's Sun SPF 30 Mineral Powder for face, 9.5g. The product contains both Titanium dioxide and Zinc oxide. More specifically, the following ingredients are included in the formula; Talc, Titanium Dioxide, Ethylhexyl Methoxycinnamate, Polymethylsilsesquioxane, Polymethyl Methacrylate, Silica, Acrylates/Ethylhexyl Acrylate Crosspolymer, Synthetic Fluorphlogopite, Boron Nitride, Magnesium Myristate, Dimethicone, Petrolatum, Magnesium Ascorbyl Phosphate, Diphenylsiloxy Phenyl Trimethicone, Phytosteryl/Octyldodecyl Lauroyl Glutamate, Magnesium Palmitoyl Glutamate, Stearyl Glycyrrhetinate, Sodium Palmitoyl Sarcosinate, Dimethicone/Vinyl Dimethicone Crosspolymer, Butylene Glycol, Palmitoyl Proline, Vinyl Dimethicone/Methicone Silsesquioxane Crosspolymer, Isocetyl Myristate, Hydrogen Dimethicone, Methicone, Lauroyl Lysine, Perfluorooctyl Triethoxysilane, Caprylyl Glycol, Microcrystalline Cellulose, Tocopheryl Acetate, Trimethylsiloxysilicate, Silica Dimethyl Silylate, Triethoxycaprylylsilane, Aluminum Distearate, Aluminum Hydroxide, Tin Oxide, Palmitic Acid, Hexylene Glycol, Hydroxyapatite, Aluminum Chloride, Phenoxyethanol, [+/- Mica, Zinc Oxide (Ci 77947), Titanium Dioxide (Ci 77891), Iron Oxides (Ci 77491), Iron Oxides (Ci 77492), Iron Oxides (Ci 77499)] <ILN42047> (*Clinique Sun SPF 30 Mineral Powder Makeup For Face*, no date). A mixing device, Turbula, and a high pressure device is needed for the preparation of the samples. Transpore tape, quartz microscope slides and a UV transmittance analyzer is needed for the SPF determination.

Method

Preparation of samples

The purity of the lignin samples are to be tested through elemental analysis and is to be sent away for analysis. The detection of sulfur (S), sulfur containing lignin, is not preferable.

Using the Klason method, presence of hemicellulose and cellulose can be confirmed or ruled out. Once the purity of the sample has been confirmed one can proceed with the experiment.

Eleven samples, one zero and ten samples including lignin, are to be prepared containing a quantity of lignin as indicated in table 2. One of the samples is to be a zero and serve as a reference for the analysis. The total mass of the samples are to be 2.00 g. The fraction of lignin and mineral powder to be added was calculated using the following equation. The samples are prepared using a mixing device, for instance Torbula, through dry mixing. Once mixed the samples are pressed using a device with high pressure.

$$w/w \ = \ 100 \ * \ (lignin\ mass/(total\ mass))$$

Sample	**lignin (wt%)**	**lignin (g)**	**Mineral powder (g)**
1	0	0.00	2.00
2	1	0.02	1.98
3	2	0.04	1.96
4	3	0.06	1.94
5	4	0.08	1.92
6	5	0.10	1.90
7	6	0.12	1.88
8	7	0.14	1.86
9	8	0.16	1.84
10	9	0.18	1.82
11	10	0.20	1.80

Table 2. Preparation details on how to prepare the eleven samples.

SPF determination

Pilot determination

This in vitro SPF determination is suggested through inspiration in related study, (Qian, Qiu and Zhu, 2015).

Quartz microscope slides of 2 mm thickness are covered with transpore tape. The same amount of tape is used for all slides. One zero, without any sample on the tape, is prepared to serve as a reference for the SPF measurements. Using a brush, the pressed powder samples are to be applied on the slides covered by tape. The powder should cover the tape with 2 mg of powder for every cubic centimeter, that is the standardized application thickness for what is classified as protected skin (Eurofins, no date). Thus the amount of powder for each quartz slide is determined based on the size of the slides. For each sample, five measurements on separate slides are to be made. UV transmittance is to be measured using a UV transmittance analyzer. The UV transmittance analyzer measures the UV transmittance (T_λ) and the SPF determination is then achieved using constants for CIE erythemal spectral effectiveness (E_λ) and solar spectral irradiance (S_λ).

ISO determination

For determination of sun protection factor of the samples the regulations specified at Läkemedelsverket apply. The sun protection factor is determined through UVB protection determination and is examined in vivo in accordance with ISO 24444:2019. (*Solskyddsprodukter | Läkemedelsverket*, 2021).

The SPF is determined on each individual examined in the study and then combined where the average of these data points is the SPF of the composition. The SPF of each individual is a product of the *minimal erythemal dose on product protected skin* derived by the *minimal erythemal dose on unprotected skin* (*ISO 24444:2019(en), Cosmetics — Sun protection test methods — In vivo determination of the sun protection factor (SPF)*, no date). The minimum erythemal dose answer to when radiant exposure is

starting to cause redness of the skin, this with respect to more specific criteria available in ISO 24444:2019.

Services for SPF determination are available, and Eurofins is one example that are adhering to the ISO described above (*Sun Protection Testing*, 2023-04-16).

For further analysis of lignin mineral powder potential

UVA protection needs to be determined for a market entry as the mineral powder needs to possess both UVA and UVB protection along with the UVA protection corresponding to at least a third of the SPF value. One can examine these points either in vivo or in vitro in accordance with ISO 24442:2011 or, alternatively ISO 24443:2012. The critical wavelength, that is the wavelength for which 90% of the UV radiation has been absorbed, needs to be determined. Furthermore, water resistance can be an interesting point to examine and can be so following either SS-EN ISO 16217:2021 and ISO 24444:2020 or SS-EN ISO 18861:2021 and ISO 16217:2021. (*Solskyddsprodukter | Läkemedelsverket*, 2021)

Customer analysis

Once the results are available for the samples the aesthetics of the samples can be assessed. With regards to compositions of lignin and mineral powder in the samples, the color will differentiate. The samples may also feel different on the skin, as a consequence of the different sample compositions. To analyze the optimal composition of lignin and mineral powder, such aesthetics can be assessed with the help of customer feedback.

Smoothness assessment

Include a group of volunteers to try out this new product. The evaluation of smoothness should be carried out without other aesthetic factors contributing. Thus, the zero sample and the samples including lignin at an effectful level should be applied using the same tools (brush) and without any knowledge about color of the sample to avoid sources of error, should the aesthetics of smoothness and tint not conform.

Results and discussion

Once SPF boosting properties as well as smoothness of application has been generated. An optimal composition holds both aesthetically pleasing properties as well as wanted SPF.

From the results one can examine how much the SPF increased as compared to the original mineral powder product and how much the color differentiates as a consequence. For further optimization of such a product one may want to alter the color. The mineral powder itself has pigment in it which could be removed to facilitate a lighter shade. Moreover, there are methods for reducing the color of lignin, however this is not further covered in this report. Judging from what increase in SPF is found, one can further investigate the opportunity of reducing mineral filters in the formula by adapting the lignin content so that it serves the SPF that one wants the product to achieve.

The smoothness results and SPF results of the samples should be evaluated together to arrive at a conclusion regarding what samples serve the customers in terms of SPF and smoothness in the final product best.

Appendix 2 - Interview guide for interviews with actors

We are two students at Uppsala University conducting our master's thesis within the field of nanotechnology in cosmetics. We are interested in learning more about lignin in cosmetics and how ecological and aesthetic value is delivered/offered in B2B cases, and we think you are an interesting company for this study. This research will further our own understanding on the topic, as well as contribute to new academic knowledge as a whole, which will feed back to the interviewed candidate. Since we are conducting our research at the research group for the Department of Material Sciences, Nanotechnology and Functional Materials at Uppsala University, this also aids their research on another type of lignin.

Before we start, we would like to inform you that it is included in our research guidelines that we tell you that even though you will be. Before the meeting, there are a few things we are obligated to bring up. We wish to record this meeting and store it on our personal drive cloud for the time of the research. Further we wish to transcribe the sound file into text format and this information will be a part of our thesis. We will make sure to keep your name anonymous, however we can not guarantee that other researchers will not be able to judge from context who the interviewee is, since the business of lignin in the cosmetic industry is currently a novel market with few actors involved. If after the interview if you feel that there are parts which you wish to remove, let us know as soon as possible and we will remove those parts.

Background info

Tell us briefly yourself, who are you? What’s your background? What's your position and how long have you worked at the company?

What product are you/the company currently developing or selling? If selling; may we ask who your customers are?
Explain aesthetic and ecological value and ask what they are delivering.
For open answers.
What attributes of your product are ecologically favorable?
What attributes of your product are aesthetically favorable?

If you have customers, do you know if the value that you deliver aligns with what they are asking for in your products?

What type of lignin are you currently working with? And why?
Why not other types of lignin?
What type of formulation is your product (Powder, gel, cream etc..)
What products is your ingredient designed for and why?

If customers;
How many?
What companies/type of companies?

If not;
What do you believe to be the reason that is?
What is the outlook?

Ecological value Q’s - Probing questions

Do you consider your product sustainable, and environmentally safe? Why? Why not?
Does your product carry any certifications or labelings in its favor? Can your customer label their products as organic or similar?
What kind of testing do you conduct/outsource for your product? Toxicological? Degradability? Animal testing?
Where do you source your lignin from, who are your actors?
What is the ecological footprint of your product?
How do laws and legislation govern what actions you can take as a business regarding ecological topics?

To what extent do you need to consider value exchange further down the line in the value chain?
How do you distinguish yourself from competitors and in what way are you unique?
Is your product 100% natural or do you use any additives?
Do you identify any gaps in current legislation, or opportunities for laws to provide new possibilities?

Aesthetic value questions

What aesthetic attributes would you use to describe your product?
In what way does the chemical composition affect the final product? (Functional groups, hydrophobicity, solubility etc…)
We've understood that the smell of lignin can be displeasing and needs to be addressed. Do you experience this and if so how do you deal with it? How important is the smell/aroma of your product?
Environmentally favorable products often grant the customer large ecological benefits. Do you experience that you have to put extra consideration into the aesthetics when developing a more eco-friendly option?
In what way is color important in the product?

To what extent do you need to consider value exchange further down the line in the value chain?
In what way are the tactile/physical properties important for your product?

More

Have you carried out any tests/certification? And from these, what claims can be made? (involvement in REACH?)
We have from previous interview candidates identified that your actors, or those who perform the lignin extraction, have tighter rules and regulations on them. We have identified that this can slow down the process of introducing biopolymers to the market. Is this something you have experienced or have any insight to? Do tighter rules and regulations on your actors directly affect you in any way?
How much lignin towards cosmetics do you produce?
Do you have a regulatory data sheet?
What is your main challenge right now and what is the most important step moving forward?

Thank you for taking your time to participate in this interview!
Do you have any questions for us?

Appendix 3 - Concepts identified from qualitative interviews

Green Profile	Sustainability	Certifications & Labels	Aesthetics
Naturally sourced	Upcycled	Ecological	Smoothness
Biobased	Renewable	Organic forest sourcing	Particle size
No chemical modifications	Valorize waste streams	Certified wood	Color
Natural biopolymer	Clean process	Vegan	Smell
Untapped resources	Biodegradable/Harmless	Organic	Dispersability
Testing with natural extracts	Reduce carbon footprint		Particle shape
Chemical structure is there from start			Explosive
Replace phenols/fossil based materials			Bioplastic

Customer influence	Functionalities & Applications	Physical/Chemical Attributes	Impactful Circumstances
Transparent value chain	Multifunctional	Spf-boost	REACH exempt
Customer demand in symbiosis with offering	Different applications	Antioxidant	Smooth market entry
Flexibility/Tailoring	Geographical area	Antimicrobial	Entire value chain
Trust	BB creams	Color	Transparent value chain
Homogeneity in delivered product	Hydration creams	Smell	Consistent quality of product
	Colorant	Sulfur-free	Homogenous product
	UV protecting formulas	Spherical	High profit low volume
	Anti frizz	Good stability	Regulatory difficult to be UV-filter
		Low molecular mass	
		Skin protectant	

Appendix 4 - Authors contribution to the report

KN - Klas Nordell

NH - Nellie Henriksson

Discerning the value of lignin biopolymers in the cosmetic industry and personal care

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Figures

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