ABSTRACT

D'ORIO, ANGELA. Patent Landscape in Nonwovens. (Under the direction of Dr. Behnam Pourdeyhimi.)

No one has ever mapped out the technology drivers in the nonwovens market, until now. Literature review shows the importance of patent landscapes that are widely used in any area where technologies are developed. However, it is almost impossible to find detailed instructions on how to proceed when approaching this kind of analysis.

The first purpose of this research was to develop a step-by-step guide to patent search for nonwovens products. This protocol was then used to perform patent landscape analysis for two products, facemasks and commodity wipes. The analysis focuses on identifying the major market players, most cited patents, and technology drivers.

The second purpose was to provide information on the concept of patent strategy, focusing on claim construction and interpretation, and providing an outlook to the patent activity of the companies identified in the analysis, the 3M Company, the Procter & Gamble Company, and Kimberly-Clark Corporation.

Patent Landscape in Nonwovens

by
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BIOGRAPHY

Angela D'Orio was born on January 23, 1990 in Bologna, Italy. She grew up in the town of Rimini with her parents, Lina and Domenico, and her twin sister, Claudia. Angela is now married to Salvatore Luiso. Growing up she had a passion for history and philosophy authors, particularly the Stoics, and this drove her to pursue a career in Law. Angela obtained a Law Degree at the University of Bologna in 2014 and she received a Master of Laws (LL.M.) thanks to a joined program between the University of Turin and the United Nations in 2017. After completion of her law studies, Angela realized that she wanted to have a career in technology management and commercialization, and this led her pursue a doctoral degree in Textiles Technology Management in 2018 under the direction of Dr. Behnam Pourdeyhimi at the Nonwovens Institute. In 2020 she received a Graduate Certificate in Nonwovens Science and Technology, and a Graduate Certificate in Technology Commercialization and Entrepreneurship.

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1. INTRODUCTION

1.1. Statement of the Problem

The nonwovens industry has grown since its establishment in the late 1920s, and the definition of nonwovens has changed over the years, starting from 1952, (Shearer, 1952). Today INDA, (Association of the Nonwoven Fabrics Industry), defines nonwovens as "*sheet or web structures bonded together by entangling fibers or filaments (and by perforating films) mechanically, thermally, or chemically. They are flat, porous sheets that are made directly from separate fibers or from molten plastic or plastic film. They are not made by weaving or knitting and do not require converting the fibers to yarn*."

Because of the wide range of applications for the nonwoven products, the main challenge of the patent searcher when approaching this field is creating the most accurate search queries to isolate the most relevant patents. Products made of nonwoven fabric are found in several different markets, for instance filtration, automotive, medical, and geotextiles. The nonwovens industry includes different aspects of the supply chain and production, such as raw material supplier, roll goods producers, converters and fabricators of the end use products, and machinery industry (Batra & Pourdeyhimi, 2012).

Nonwoven products can be made using a variety of different technologies. Any small change during the processing can lead to a more desirable product, hence the identification of the role that these technologies have in the growth of the nonwoven industry can be challenging. During the innovation process, technology drivers are key to understand the path to take. For the purpose of this project, we use a patent landscape analysis. As Chapter 3 will explain in detail, a patent landscape report is a tool to map out the technology drivers within a given market. The projection of a 3D map shows concentrations of patents as mountains, hills and valleys; in the

projection, the mountaintops represent areas with high concentration of patents, and lagoon-like zones are areas with only few patents. After the analysis of the landscape, we can identify the main market players and most important patents.

1.2. Purpose of the Study

Patent intelligence is beneficial to many professionals in the business sector, as well as in the university settings. The scope of this study is to develop a protocol to connect patents to technology drivers and to market trends in the nonwovens industry.

The goals of this research are:

- Understand the process behind patent searching and provide a step-by-step guide that shows how to do patent landscape analysis when addressing nonwoven products
- Understand how to identify technology drivers when addressing a specific product in the nonwovens market.
- Investigate the topic of patent strategy, specifically relating to the language of patents and claim drafting

Specific objectives and questions behind the research are:

Objective 1: Create a systematic guide into patent search for nonwoven products

- Research question 1: How can we select accurate keywords?
- Research question 2: What is the role of classification codes in the search and what are the criteria to choose a patent classification?

Objective 2: Explain the role and importance of technology (or technological) market drivers.

- Research question 3: Can we identify nonwoven technology drivers through patent analysis?
- Research question 4: Which are the technology drivers in the nonwovens industry?

Objective 3: Explore the concept of patent strategy.

- Research question 5: What is the importance of the use of plain language in patents?
- Research question 6: What are the patent strategies of major players for facemasks and wipes?

This research is meant to provide recommendations to professionals who oversee decision-making in R&D in the nonwovens industry. We also aim to help graduate students who embark in the practice of patent search.

1.3. Significance of the Study

There is no evidence in literature of interest in patent analysis and landscape of nonwoven products. A few academic articles (Muller & Välikangas, 2002; Russo & Rizzi, 2009; Yang et al., 2010) provide examples of patent analysis, and none connects this concept to the textile and nonwovens industry. In this work, we aim to fill this gap of knowledge, by providing insights on technological drivers of the nonwovens industry. In addition, we will provide a step-by-step guide into patent search techniques through a description of the process, insights on keywords search, and the use of the classification codes when searching for patents in the nonwovens industry.

1.4. Scope and Limitations of Study

The main scope of the study is to develop a protocol that will match technology drivers with market trends through the tools of patent analysis. The benefit of the study will be its replicability. We chose a few market segments for researching and demonstrating the protocol; however, we intend to provide a set of instructions that can be used to research products in different

nonwoven market segments. The study presents limitations as well. First, the literature review is limited to the material that can be accessed through the resources available on the NC State library website, the Wake County Library System, as well as contents available free on the internet. NC State library provides access to several databases, including Textile Technology Index, Derwent Innovation Index, Web of Science, Frost & Sullivan, *etc*. Second, the only software used to perform the patent research and analysis is PatSnap™, which is a proprietary software and we have access to it through the NC State Office of Research Commercialization. If we used different platforms, we may obtain different results. Third, patent research is a reiterative exercise and there is not an effective method to validate the results (Lahorte, 2018). Patents can be excluded from the results because the words present in the title, abstract and claims, together with the classification codes, do not match the term used in the search. In addition, only experts in the field can truly evaluate the compilation and effectiveness of a patent landscape, because there is not a specific method that can be used to verify the accuracy of the patent search (Oltra-garcia, 2012). The accuracy of the patent landscape depends on the legal and scientific expertise of the person performing the analysis (Grant et al., 2014). Another important limitation is related to the term "nonwoven", which can refer to several products and applications, making it difficult to address a specific nonwoven market segment. We chose a few products for the purpose of this study, and we will identify a few technology drivers that may not represent the whole nonwoven industry.

1.5. Dissertation Outline

The dissertation is articulated in six chapters. Chapter 1 covers the scope of the research, research questions and objectives, and the limitations of this study. The second chapter is dedicated to explain patents and their classifications. Patent searching tools and techniques are addressed in chapter three, together with the role that patent analysis has in decision-making in R&D.

Nonwovens products and markets are the focus of chapter four, where we analyze the two nonwoven markets, filtration (personal protection facemasks), and wipes (commodity wipes). In the fifth chapter, we discuss the topic of patent strategy, showing different approaches and claim construction examples. Then we look at the major market players for facemasks and wipes and we analyze their most recent patent applications.

2. PATENTS

In the USA, patents are "a right to exclude", meaning that, if the invention does not have any market value, the patent will not have any value either. In the US Patent Act, patents are explained as property rights. Patents can be sold and the rights on them can be divided, similarly to other commonly known property rights, such as private property. Patent law creates an incentive to invent, disclose, and commercialize (to get market value). In addition, patent law encourages to design-around, meaning that people will try to solve basic problems without committing infringement. This incentive, which is often underestimated, may result in valuable second and third generations of inventions (Wagner, 2015). Patents are an intervention in a free market, and, according to the Utilitarianism, they are means to an end to solve a problem (at least in the US perception of patent law). Utilitarianism is a philosophical theory that emerged in the 18th century, and it prescribed actions that maximize utility, intended as the property of objects to produce benefit and advantage for all individuals. In this view, patents are a tool to maximize the benefit that research and technological advancement can bring to the community.

2.1. What are patents?

Patents are defined as a grant to the patent holder of the exclusive right to exclude others from making, using, importing, and selling the patented innovation for a limited period of time (U.S. Patent Act. 35 U.S.C. §§ 1 *et seq*). Besides protecting the rights of the owner, patents may be used to inform and support decision-making regarding R&D investments. Patents are great candidates for analysis and landscaping purposes for a few reasons. The primary patent quality indicators are related to investment, maintenance, and litigation, which form a basis for assessing patent quality when the evaluation focuses on the patent's potential for sale (Trippe, 2015). These indicators are briefly described as follows.

i. *Indicators for investment.* There are five indicators used by CHI Research to analyze patent portfolios for investment (Trappey et al., 2012). The first indicator represents the number of patent applications from a company and its subsidiaries in the previous year. The second indicator describes the percentage of patent growth in the previous year, and the third indicator is the current impact index. The fourth indicator, science linkage, is calculated using the average number of references that are cited from scientific papers. Finally, the technology cycle-time measures the median age of the cited patents.

ii. *Infringement and validity.* It is also crucial to know the history about the lawsuits involving the patents. In order to decide whether a patent has been infringed upon, a court must compare the claims of the patent to the defendant's device. Most often, this information is almost impossible to retrieve, because big corporations prefer to handle infringements via arbitration, and arbitral awards can be secret.

iii. *Citations and maintenance fee.* The number of references cited (backward citations) in a patent is evidence of a patent's validity. The number of citations received (forward citations), which represent references made by subsequent patents to the patent of interest, is also evidence of the importance other inventors attribute to the patent. Furthermore, citations are positively related to patentee decisions to pay maintenance fees (Trappey et al., 2017).

2.2. What is a Patent Landscape?

Patent Landscape analysis is a technique that allows to study a specific area of technology through patent data. Patent landscapes support informed decision-making and are designed to efficiently address the concerns associated with making high-stakes decisions in various areas of

technology, increasing the related degree of confidence for investing in new opportunities (Trippe, 2015). For many years, decision-makers in all fields operated based on personal knowledge, networks, and intuition. With the institution of patent analytics in the 1980s, it is possible to make these critical decisions with the help of data-driven approaches that mitigate the risks associated with the decision.

Government agencies, universities, as well as private companies can gain valuable perspective on a developing, or well-established field by generating a patent landscape. The insight gained from the preparation of a patent landscape report is useful to any organization engaged in the evaluation of technology, for instance researchers learn about the state of the art of a given technology, or business teams identify major assignees and potential competitors. When approaching patent landscape analysis, a few fundamental questions may help guide the research. These questions are:

- Who are the major players?
- When have they been patenting and how active they currently are?
- Which companies and inventors are collaborating with whom?
- What product-making technology are they working on?

The patent landscape tool helps creating a timeline to show the evolution a technology over a period, as it is shown in chapter three and in chapter five.

2.3. History

The idea of patents dates to the Greeks era. It was based on an incentive, and the government, similarly to the current patent law, granted it. The practice of patenting was eventually abandoned and there are no records of patents after the second century BC. During the Italian Renaissance, in 1474, the city of Venice released the Venetian Patent Statute, which contained

elements similar to the modern patent law; these elements are for instance the examination system, a temporal limitation, and the requirement for the invention to be useful. The Patent Statute was very successful in fostering technological innovation in Venice at the time (Wagner, 2015).

The USA inherited its patent law from England, which had a royal system where the King would grant "royal monopolies" and "letters of patents". These monopolies were based on a patronage deal instead of being focused on the invention. The Statute of Monopolies in 1624 outlawed most of the monopolies, besides inventions with novelty. The specifications part of the patent document was developed in 1778 in the case *Liardet v. Johnson*, where the detailed written description of the invention became one of the most important elements of patents.

In the USA, patent law was established in Article 1 section 8 of the Constitution. Then, with the Patent Act of 1790, the first federal laws established the system where patents were reviewed for validity by a commission. Three government officials, the Secretary of State (Jefferson), the Secretary of War (Knox), and the Attorney General (Randolph) constituted the Patent Board. The administrative structure was established in 1836, after the patent activity increased during the industrial revolution (Wogan, 2008).

In the Mid-20th Century, the US Supreme Court became skeptical and there was a reaction against monopoly. Many patents were struck down following the anti-monopoly movement. In 1952 the Patent Act was published, and the US Federal Circuit (Court of Appeal) was introduced in 1982. In the last 20 years, the general trend has been to follow international harmonization. A notorious example is the Leahy-Smith America Invents Act (2012), which switched from the first-to-invent to first-to-file system. Interestingly the United States were the last country in the world to do so. Nowadays, the World Intellectual Property Organization (WIPO) has established worldwide a common examination system that allows the applicant to apply for a patent in diverse

countries at the same time. For this purpose, the Patent Cooperation Treaty (PCT, 1978) assists applicants in seeking patent protection internationally for their inventions. By filing a single international patent application under the PCT, applicants can simultaneously seek protection for an invention in many countries, (the number is 153 as of December 8, 2020).

2.4. How organized – Classification

The classifications and indexing systems make the collection of patents easily accessible. There are a number of classification schemes in place, the International Patent Classification System (IPC), administered by the WIPO, the File Index (FI) and the File Forming Terms (F-term scheme) at the Japan Patent Office, and the Cooperative Patent Classification (CPC) scheme implemented by the European Patent Office and the United States Patent and Trademark Office (Meguro & Osabe, 2019). A patent classification is a system for organizing all patent documents and other technical documents into specific technology groupings based on common subject matter.

The use of classification codes in patent search queries has several advantages. First, classifications provide access to concepts rather than words. "*They enable a single inventive concept to be represented concisely and unambiguously, and they enable complex multi-faceted concepts to be searched in circumstances where single words or phrases do not lend themselves*" (Adams, 2001, p.16).

Second, classifications are language independent; therefore, the searcher has some control over the synonyms that are included. Because the IPC is published in different languages, non-English native searchers can easily retrieve patent publications written in English too.

The best known and most widely spread classification - both in application and usage - is IPC (Wolter, 2012). The IPC is a hierarchical system that is updated every year to include new

fields of inventions. The system has four levels of hierarchy: section, classes, subclasses, and groups (Risch & Krestel, 2019). To provide an example, the patent US8303693, *Nanofiber filter facemasks and cabin filters*, has as first IPC code B03C3/00, were the whole code shows that the patent is in the group B03C3/00; which is in the subclass B03C3, in the class B03, and in the section B. Section B contains patents under the description of "performing operations; transporting", where more specifically the subclasses B01 to B09 are described as "separating; mixing". Therefore, in the example, the patent is in the class of "separation of solid materials using liquids or using pneumatic tables or jigs; magnetic or electrostatic separation of solid materials from solid materials or fluids; separation by high-voltage electric fields"; in the subclass of "magnetic or electrostatic separation of solid materials from solid materials or fluids; separation by high-voltage electric fields", and in the group of "Separating dispersed particles from gases or vapor, e.g. air, by electrostatic effect".

For the purpose of the present research, the IPC is the classification scheme preferred. The IPC was created in 1968, and it is currently used by all intellectual property offices worldwide (Meguro & Osabe, 2019).

The classification-based search uses the classification units found for the search concepts of the invention. The first step to identify the classification unit is to start with an informal search, using the keywords that seem most appropriate to the searcher to describe the basics of the invention. The searcher can use the filter "Title-Abstract-Claims" to ensure that the first patents retrieved are relevant, as shown in Figure 1. To find a pattern relating the searched patents, we may search the classification codes within the retrieved patents and collect them on a spreadsheet. Usually more than one classification unit are relevant for the claimed subject matter, and we can add multiple units to the search query with AND (Foglia, 2007).

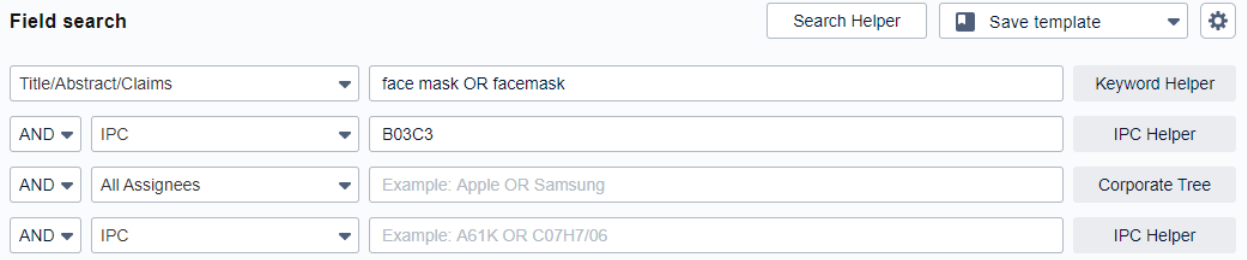

Figure 1. Basic search with IPC with PatSnap™.

2.5. Difference between the USA and the rest of the world

The US Patent Law differentiates itself from the rest of the world in a few elements. This study compares mainly the US system with the European patent law. The first difference regards the grace period. The USA has a one-year grace period (35 US Code section 102), *i.e.* the inventor can freely publish an invention without losing patent rights. If an inventor publishes an invention in other countries, he automatically loses all potential patent rights. According to the Leahy-Smith America Invents Act, this grace period effectively is limited to publications by the inventor himself or someone who directly obtained the information from the inventor. A third-party publication would potentially destroy the novelty of the invention, even though this last part is debated.

It is relevant to mention that when inventors work for an organization like a university, or a company, they sign a contract that mandate the assignment of all intellectual property created while working for this entity. This agreement is often called “assignment of inventions”, or ownership of discoveries. At NC State, it is called “patent agreement”. For example, at NC State University all faculty and graduate students sign the patent agreement when their status as employees begin. Interestingly, in the US, undergraduate students are not required to firm the patent agreement even when they work in laboratory. For this reason, it is recommended to use caution when involving undergraduate students in projects that are confidential and may lead to a patent application.

A second difference concerns the rest mode requirement. US patent law requires the inventor to include the best way to practice the invention in a patent application (35 US Code section 112). In this way, it is not possible to obtain a patent and keep some essential or advantageous aspects hidden from the public. In contrast, European patent law has no such requirement. As far as the publication of patent applications is concerned, US patents were only published after grant until 2001. This means that pending patent applications were not published by the USPTO and where not available for everyone to review. Nowadays, both American and European patent applications are published 18 months after their filing date, unless they have been withdrawn or they are filed with a non-publication request. It is important to note that the publication of a patent application is not an indication of the patentability of the invention in any way. It only means that the application is 18 months old. In both the American and European systems, the patent searcher can tell the difference between an application and a granted patent from the number in the top-right corner. If the patent number ends in an "A" the publication is an application, if it is a "B" the publication is a patent. Another difference between the American and the European systems is related to the opposition after grant. According to the European Patent Law, anyone can file an opposition with the European Patent Office (EPO) in the first nine months, and both the patent holder and the opponent then debate. Whereas in the USA, anyone can present reasons and evidence to the USPTO to challenge the validity of a granted patent during the reexamination procedure. However, the debate is limited to the patent holder and the USPTO examiner.

Last, European patents and applications typically contain “two-part claims”, *i.e.* a claim lists some features, followed by the phrase "characterized in that" or "with an improvement comprising", and then one or more further features. Those latter features are what constitutes the

invention (and so are often called the characterizing features). The former features are found in the prior art. In contrast, US patent applications (and patents) have one-part claims. When there are two-part claims in US patents, these are often patented by a European firm. In the USA, if an inventor uses two-part claims (also called "Jepson claims", after the first patent attorney who used them), anything before the characterizing portion is classified as prior art by definition. If the applicant by accident puts a novel feature in the pre-characterizing portion, the novelty will be regarded as prior art and may damage the patentability (Engelfriet, 2005). In Europe, if the applicant puts a feature, namely not occurring in the closest prior art, in the pre-characterizing portion of a claim, he is simply asked to move that feature to the characterizing portion. This happens frequently because the applicant often begins drafting the patent application based on a document that he considers closest prior art. However, if during the examination another document is regarded as closer prior art, the claim would need to be adjusted. These adjustments do not affect the patentability directly (Engelfriet, 2005).

3. SEARCHING PATENTS

3.1. Patent Search

Before all patent literature was available online, the only method of patent research consisted in an in-person visit to the patent office. Patents were organized by classification codes only, and if some of them were mislabeled, those would have ended up being lost (Hunt et al, 2004). With the advent of internet and online tools for patent research, the approach to patent research has changed, and it is now possible to perform the task from any terminal. The most impactful improvement has been the use of keywords, *i.e.* text words to start research queries and retrieve patents that contain them. The possibility of online searching with keywords and across all the classification codes at the same time drastically changed the patent research. While online searching is a great advantage, it also has drawbacks, because mislabeled patents may now appear in the search and mislead the researchers.

It is generally accepted that due to the nature of novelty, associated with patents, and the general practice of most organizations not to publish their findings in scientific literature, patent information is a source of unique content, complementary to non-patent literature (Trippe, 2015).

In addition, there is a need to formulate an aggressive strategy to protect one's IP. In fact, various companies, universities, institutions, and researchers are into the process to protect their core inventions (Mago et al., 2017). Patents give insights on technological advancements and market trends. In patents, there are technical information that cannot be found anywhere else.

3.2. Types of Patent Searches

Different kinds of patent searching techniques are available, depending on the reason behind the search. Before starting with the actual search, it is crucial to have one or more well defined questions to guide the investigation. For instance, a few common questions can be:

- Who (which companies) are in the competitive landscape?
- Which are the strengths and weaknesses of competitors?
- Who are the partners to work with?

The formulation of the questions serves to define the scope of the research and therefore the type of research. A few frequent types of search are listed below:

- Due diligence. This kind of approach attempts to survey a whole technology field. The purpose is to find information about competitors and collect intelligence about events that change the dynamics within a market, like mergers or acquisitions. Due diligence searches are commonly used to plan strategic decision. The main risk associated with this approach is an overall complexity in interpreting search results because of the broadness of the field.
- State-of-the-art. This is probably the simplest type of search, and it is essentially a survey of all relevant documents published in a given technical field or fields or patents filed by particular applicants or inventions presented by given inventors. In all types of searches it is also necessary to include searches in the conventional literature, such as scientific articles, theses and dissertations, the press, and "grey literature" such as instruction manuals and promotional literature (Clarke, 2018).
- Patentability. The most common reason behind a patent search is assessing whether an invention is patentable, meaning that the idea is novel and original. This assessment is also called prior art or novelty search, and it includes different sources and non-patent literature, like media, journals, and websites. Patentability search is performed first by the inventor and then by the examiners at the patent office.

- Freedom to Operate (FTO). Freedom to operate analysis is performed taking into consideration only the patent literature for issued and pending patents. The scope is limited compared to the previous type of searches mentioned; therefore, the search itself requires only a few keywords. The purpose of FTO is risk evaluation, *i.e.* to understand if others are working on a technology similar to the assessed one, and if there is a chance of infringement. One objective of a freedom to operate (FTO) search is to discover where, geographically, no patent protection exists, and to identify from which date patent protection will cease (if it exists today), because patents will no longer be in force.
- Infringement. The only purpose of this type of search is to demonstrate that an infringement is occurring. Infringement is any action that has been taken against a patented invention without the permission of the owner. Usually, this permission is given in the form of a licensing contract.
- Validity. Similarly to the patentability search, it consists of an exhaustive prior art search. It takes place after the patent has been granted, and it covers both patents and non-patent literature.
- Product specifications. This search is used to gather in depth info about a specific technology.
- Mining search. The purpose of mining search is to analyze all patents that assignees own in a definite technology area. It is often used when studying mergers and acquisitions.
- Opposition search. This search is carried out by the "opponents" that believe that the patent application should not be granted.

3.3. Searching Patents in PatSnap™

Several platforms are available to perform patent search, some are free like the USPTO website and The Lens, while others can be accessed through a subscription, like PatSnap™ and Derwent Innovation Index. As we mentioned in the limitations of the study, using different platforms may lead to different patent results retrieved. The USPTO website is very accurate when looking for US patents and it gives access to the patent prosecution information and documents. However, it is usually fairly slow compared to others and the outlook is outdated. The Lens is a platform offered by Cambia, an Australian-based non-profit social enterprise, and it has access to all the patents in the world. Differently from other free searching tools, The Lens creates graphs to help show the results. The main reason behind its exclusion with this project is that it does not work with classification codes. The NC State Office of Research Commercialization uses PatSnap™ and NC State affiliates have access to the Derwent Innovation Index. We chose to use PatSnap™ because it provides several tools to search, collect and analyze patent documents, and it additionally provides accurate automatic translations in English of foreign patents. More details on the analysis tools will be shown in chapter four.

PatSnap™ is a patent search platform that gives access to more than 120 million patents from 128 jurisdictions around the world. It requires a year subscription. Patent search is not an exact science (Lahorte, 2018); therefore, the adoption of platforms like PatSnap™ helps the searcher both to narrow down the results when identifying the most relevant patents, and to analyze the data.

There are also elements that help build a solid patent search query:

- INIDs (Internationally Agreed Numbers for the Identification of Bibliographic Data). Nowadays, patents around the world have a standard appearance. All patents

use INIDs codes and refer to the WIPO Standard ST.9 of the Handbook of Industrial Property Information and Documentation (WIPO Standard ST.9, 2013). The bibliographic data covered in the Standard range from data for the document identification, filing data, priority data, publication data, and data concerning technical information to data related to International Patent Conventions. In this way, when the searchers approach patents written in a different language, they will be able to identify information on the first page and understand whether the patent is of interest in the research.

- Boolean Operators. Operators are short statements used to connect the key words or criteria used to either broaden or narrow the scope of the search (Figure 2):
    - AND: both the keywords of interest.
    - OR: alternative or optional in our search (broad searches).
    - NOT: what needs to be excluded from the search. Caution is necessary to avoid the exclusion of patents of interest.

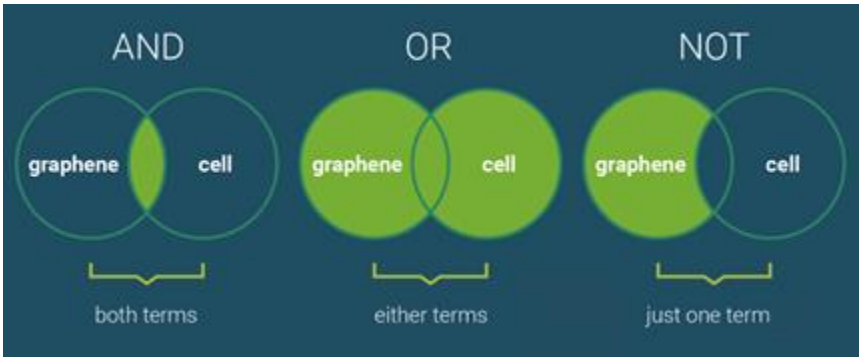

Figure 2. Boolean search terms, from patsnap.com.

- Use of parentheses. The use of parentheses gives the order of operations, which is the order used by the system to look at the query, like in linear algebra. The software evaluates within all the parentheses and retrieve the documents based on the priority

given by the order that the parentheses give to the terms and classification codes. In the advanced search function in PatSnap™, the system automatically writes the search queries in parentheses, as discussed later.

- Stemming and wildcards. Asterisks or question marks represent wildcards in PatSnap™. The asterisk replaces a string of characters at the end or in the middle of a word. For example, with the word *electr**, the results will include words like electrical, electronic, electric, *etc*. The question mark can replace an individual character in the middle or at the end of a word. It is very useful when the search includes words that can have a different spelling, like “color” and “colour”.

3.4. Search queries

Patent search is a reiterative process. There is no single correct way to conduct a patent search, (Hunt, 2007; Hitchcock, 2009; Adams, 2015; Gex-Collet, 2018). In literature, the most common searching technique requires the combination of keywords and classification codes. Identifying keywords is a task that every researcher addresses in their own way. For the purposes of this research, we used a table as a tool to brainstorm keywords. The table of concepts groups words based on the description of the object of the research. Each column represents features, characteristics, shape or function. The concept table is a tool that helps with collecting different words that we will enter in the searching software. The concept table is meant to change during the first rounds of search attempts. As the researcher learns more about the product or process, more words can be added. Each column may represent a group of similar words or words that belong to the same concept. However, the researcher has the freedom to manage the table as preferred.

Table 1 shows an example of concept table filled in for sweat absorbent liners. As mentioned earlier, the choice of words depends on the question asked, and therefore the kind of patent search that will be performed. The table of concepts is particularly beneficial when approaching patent landscapes because the results found by the search engine will be broad. Even though the researcher needs to attentively analyze several patents, this technique allows to understand whether the results match the object of the search. Specifically, if most of the patents retrieved relate to the product (sweat absorbent pad in the example), then the search query can be saved, and the results can be used for the analysis.

Table 1. Table of concepts, example of sweat absorbent pad.

Appearance	**Function**	**Features**	**Materials**	**Process**
Disposable	Absorbent	Wearable	Nonwoven Sheet, Nonwoven Web	Meltblow*
Thin	Transpirant	Light Weight	Wood Pulp	Spunlace*
Rectangular Shape	Device	Layers	Polyethylene	SMS
Liner	Locks Moisture In	Media	Polypropylene	Airlaid
Pad	Protects Clothing Items	Absorbent Core	SAP, Superabsorbent Polymer	
	Dry Feeling On Skin		Cotton	

During the first attempts, different results will show that other products in various categories are manufactured with the same process. In the example, a sweat absorbent pad is a liner of nonwoven layers, specifically a top sheet, an absorbent core and a back sheet. Several hygiene products are prepared with similar processes and materials, for instance baby diapers, feminine hygiene absorbent pads and nursing pads. It is important to keep the research question in

mind when proceeding with the search queries, because the results will be added or discarded from the list based of their importance.

This first step of the patent search is the most time consuming, as already mentioned. The present research focuses on the creation of patent landscapes; therefore, the keywords will be selected with the purpose of collecting broad results. Only after several attempts and after reading the title, abstract, and claims of several patents, it will become clear which words work better.

3.4.1. Personal Protection Facemasks

The first patent landscape targets the filtration market, specifically the personal protection facemasks. To start, it is good practice to find a definition of the object to drive the research in the right direction. This first step may seem elementary, but it is important to identify exactly the product and start to identify the first keywords. For finding the official definition of facemasks, we consulted the Occupational Safety and Health Administrations (OSHA) website. The OSHA provides the following definition for personal protection facemask:

"A facemask is a loose-fitting, disposable device that creates a physical barrier between the mouth and nose of the wearer and potential contaminants in the immediate environment. Facemasks are not to be shared and may be labeled as surgical, isolation, dental or medical procedure masks. They may come with or without a face shield.

Facemasks are made in different thicknesses and with different ability to protect you from contact with liquids. These properties may also affect how easily you can breathe through the facemask and how well the facemask protects you.

If worn properly, a facemask is meant to help block large-particle droplets, splashes, sprays or splatter that may contain germs (viruses and bacteria), keeping it from reaching your

mouth and nose. Facemasks may also help reduce exposure of your saliva and respiratory secretions to others."

Through the words contained in this definition, we may start filling in the concept table, as shown in Table 2.

Table 2. Table of concepts, facemasks.

Appearance	Function	Features	Types	Material	Process
Disposable	Filters Particles In Air	Wearable	Barrier	Filtering Web	Meltblown
Thin	Transpire	Light Weight	Pathogens	Nonwoven, Non-Woven	Electrospun
	Device		Contaminant	Nonwoven Sheet	SMS
	Limit Exhaled Particles		Medical	Polypropylene	Wetlaid
	Respirator		Surgical	Laminated	Media

The first sets of queries will include a combination of the words taken from Table 2. After reading the main relevant patents retrieved by the system, we can select the most relevant classification codes. As mentioned earlier, for the purpose of this research, the only classification that is used is the International Patent Classification (IPC) managed by the Word Intellectual Property Organization.

The most relevant classification codes relating to face masks are shown in Table 3.

Table 3. Relevant IPC relating to facemaks.

A Human Necessities		
A41D13/00	A41 - Wearing Apparel	Professional, industrial or sporting protective garments, e.g. surgeons' gowns or garments protecting against blows or punches
A41D13/05		• Protecting only a particular body part
A41D13/11		• • Protective face masks, e.g. for surgical use, or for use in foul atmospheres
A41D31/02		• Layered materials
A61M16/06		Respiratory and anesthetic masks
A62B	A62 - Life saving - Fire fighting	A62B - DEVICES, APPARATUS OR METHODS FOR LIFE-SAVING (composition of chemical substances used in respirators, gas-masks, breathing apparatus or the like A62D;
A62B18/00		Breathing masks or helmets, e.g. affording protection against chemical agents or for use at high altitudes (A62B 17/00 takes precedence)
A62B18/02		• Masks
A62B18/10		• • Valves
A62B23/00		Filters for breathing-protection purposes
A62B23/02		• for respirators
A62B7/10		Respiratory apparatus - • with filter elements
A62B9/00		Component parts for respiratory or breathing apparatus
A62B9/02		• • Valves
B Performing Operations; Transforming		
B01D	B01 - PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL	B01D - SEPARATION (separating solids from solids by wet methods B03B, B03D, by pneumatic jigs or tables B03B, by other dry methods B07; magnetic or electrostatic separation of solid materials from solid materials or fluids, separation by high-voltage electric fields B03C; centrifuges B04B; vortex apparatus B04C; presses per se for squeezing-out liquid from liquid-containing material B30B 9/02)
B01D24/00		Filters comprising loose filtering material, i.e. filtering material without any binder between the individual particles or fibres thereof (B01D 27/02 takes precedence)

Table 3. Continued.

B01D46/00		**Filters or filtering processes specially modified for separating dispersed particles from gases or vapours**
B01D46/52		• Particle separators, e.g. dust precipitators, using filters embodying folded material
B01D46/54		• Particle separators, e.g. dust precipitators, using ultra-fine filter sheets or diaphragms
B01D39/00		Filtering material for liquid or gaseous fluids
B01D39/08		• Filter cloth
B01D39/14		• Other self-supporting filtering material
B01D39/16		• • of organic material, e.g. synthetic fibres
B03C	B03 - SEPARATION OF SOLID MATERIALS USING LIQUIDS OR USING PNEUMATIC TABLES OR JIGS; MAGNETIC OR ELECTROSTATIC SEPARATION OF SOLID MATERIALS FROM SOLID MATERIALS OR FLUIDS; SEPARATION BY HIGH-VOLTAGE ELECTRIC FIELDS	B03C - MAGNETIC OR ELECTROSTATIC SEPARATION OF SOLID MATERIALS FROM SOLID MATERIALS OR FLUIDS; SEPARATION BY HIGH-VOLTAGE ELECTRIC FIELDS (filters making use of electricity or magnetism B01D 35/06; separating isotopes B01D 59/00; combinations of magnetic or electrostatic separation with separation of solids by other means B03B, B07B; separating sheets from piles B65H 3/00; magnets or magnet coils per se H01F)
B03C3/00		Separating dispersed particles from gases or vapour, e.g. air, by electrostatic effect (exhaust or silencing apparatus for machines or engines having means for removing solid constituents of exhaust, using electric or electrostatic separators F01N 3/01) [2006.01]
B03C3/30		in which electrostatic charge is generated by passage of the gases, i.e. tribo-electricity [2006.01]
B05D5/12		Processes for applying liquids or other fluent materials to surfaces to obtain a coating with specific electrical properties
B29B	B29 - WORKING OF PLASTICS; WORKING OF SUBSTANCES IN A PLASTIC STATE IN GENERAL	B29B - PREPARATION OR PRETREATMENT OF THE MATERIAL TO BE SHAPED; MAKING GRANULES OR PREFORMS; RECOVERY OF PLASTICS OR OTHER CONSTITUENTS OF WASTE MATERIAL CONTAINING PLASTICS [4]

Table 3. Continued.

B29B13/00		**Conditioning or physical treatment of the material to be shaped (chemical aspects C08J 3/00) [2006.01]**
B29C48/00		Extrusion moulding, i.e. expressing the moulding material through a die or nozzle which imparts the desired form; Apparatus therefor
B29C51/00		Shaping by thermoforming, e.g. shaping sheets in matched moulds or by deep-drawing; Apparatus therefor
B29L9/00	B29L - INDEXING SCHEME ASSOCIATED WITH SUBCLASS B29C, RELATING TO PARTICULAR ARTICLES	Layered products
B32B	B32 - LAYERED PRODUCTS	B32B - LAYERED PRODUCTS, i.e. PRODUCTS BUILT-UP OF STRATA OF FLAT OR NON-FLAT, e.g. CELLULAR OR HONEYCOMB, FORM
B32B5/00		Layered products characterised by the non-homogeneity or physical structure of a layer (B32B 9/00-B32B 29/00 take precedence) [2006.01]
B32B5/26		another layer also being fibrous or filamentary [2006.01]
D Textiles -Paper		
D01D	D01 - NATURAL OR MAN-MADE THREADS OR FIBRES; SPINNING	D01D - MECHANICAL METHODS OR APPARATUS IN THE MANUFACTURE OF MAN-MADE FILAMENTS, THREADS, FIBRES, BRISTLES OR RIBBONS (working or processing of metal wire B21F; fibres or filaments of softened glass, minerals or slag C03B 37/00)
D01D5/00		Formation of filaments, threads, or the like [2006.01]
D01D5/20		with varying denier along their length [2006.01]

Table 3. Continued.

D04H	**D04 - BRAIDING; LACE-MAKING; KNITTING; TRIMMINGS; NON-WOVEN FABRICS**	**D04H - MAKING TEXTILE FABRICS, e.g. FROM FIBRES OR FILAMENTARY MATERIAL (weaving D03; knitting D04B; braiding D04C; net-making D04G; sewing D05B; tufting D05C; finishing non-woven fabrics D06); FABRICS MADE BY SUCH PROCESSES OR APPARATUS, e.g. FELTS, NON-WOVEN FABRICS; COTTON-WOOL; WADDING (non-woven fabrics having an intermediate or external layer of a different kind, e.g. of woven fabric, B32B)**
D04H1/00		Non-woven fabrics formed wholly or mainly of staple fibres or like relatively short fibres
D01H1/728		• • • by electro-spinning
D06M	D06 - TREATMENT OF TEXTILES OR THE LIKE; LAUNDERING; FLEXIBLE MATERIALS NOT OTHERWISE PROVIDED FOR	D06M - TREATMENT, NOT PROVIDED FOR ELSEWHERE IN CLASS D06, OF FIBRES, THREADS, YARNS, FABRICS, FEATHERS OR FIBROUS GOODS MADE FROM SUCH MATERIALS (treatment of textiles by mechanical means D06B-D06J)
D06M11		Treating fibres, threads, yarns, fabrics or fibrous goods made from such materials, with inorganic substances or complexes thereof; Such treatment combined with mechanical treatment, e.g. mercerising(D06M 10/00 takes precedence; decorating textiles by local treatment D06Q 1/00) [2006.01]
D06M13		Treating fibres, threads, yarns, fabrics or fibrous goods made from such materials with non-macromolecular organic compounds (D06M 10/00, D06M 14/00 take precedence; treatment with complexes of organic amines with inorganic substances D06M 11/59); Such treatment combined with mechanical treatment [2006.01]
D06M15		Treating fibres, threads, yarns, fabrics or fibrous goods made from such materials with macromolecular compounds; Such treatment combined with mechanical treatment (D06M 10/00, D06M 14/00 take precedence) [2006.01]
D06M16		Biochemical treatment of fibres, threads, yarns, fabrics or fibrous goods made from such materials, e.g. enzymatic [2006.01]

The first search queries are a simple combination of a couple of keywords and one classification code. These serve the purpose of orienting us in understanding which ones work and which ones do not work. We will refine the search queries after analyzing the results retrieved by the software. For example, a few options of search queries are shown in Table 4.

Table 4. Search queries, facemasks.

#	Search Queries	Status	Simple	Total	Database
1	nonwoven OR web OR fiber web	All	20,129	61,443	all databases
2	IPC:(B03C3) AND (filtering mask) AND DESC:(nonwoven)	All	63	240	all databases
3	((filtering mask) AND DESC:(nonwoven) AND IPC:(B03C3)) AND (A62B7/10)	All	8	29	all databases
4	(A41D13/11) AND (filtering mask) AND DESC:(nonwoven)	All	190	603	all databases
5	(filtering mask) AND IPC:(A41D13/11)	All	376	479	US
6	TAC:(filtering face piece) AND IPC:(A62B23 OR A62B18)	All	207	734	all databases
7	(filtering mask) AND IPC:(A62B18/00)	All	266	324	US
8	TAC:((non-woven OR nonwoven) AND mask) AND IPC:(A62B23 OR A62B18 OR A62B7/10)	All	153	191	US
9	TAC:((non-woven OR nonwoven) AND mask) AND IPC:(A62B23 OR A62B18 OR A62B7/10 OR A41D13/11)	All	190	234	US

3.4.2. Commodity Wipes

The second landscape addresses wipes. The word wipe covers a variety of purposes, there are personal wipes, like the ones used on babies or the cosmetic ones to remove makeup, and there are general purpose wipes used mainly for cleaning. Industrial wipes also fall in this last category and are characterized by their strength and resistance. Their purpose is to reach the end of the cleaning task without deteriorating or tearing. When looking at dictionaries, for instance the Merriam Webster, we find the following definition of wipe: "*a disposable cloth treated with a*

cleansing agent, for wiping things clean". This definition helps us in initiating the brainstorming process for our table of concepts (Table 5).

In this dissertation, we aim to investigate the patents for the general purpose cleaning wipes, without considering the personal care and the personal hygiene one. To achieve this purpose one of the columns will be containing terms that we will use to refine our search using the function "NOT".

Table 5. Table of concepts, wipes.

Appearance	Function	Features	Not	Material	Process
Disposable	Cleaning	Absorbent	Personal	Fiber Web	Meltblowing
Thin	Hold dust	Liquid retention	Baby	Pulp	Hydroentangling
Light weight	Collect dust	Low cost per use	Makeup	Nonwoven Sheet	Spunbonding
	Wiping	Disposable	Abrasive	Polypropylene	Airlaid
	Absorb oil and water			Microfiber	Composite

The first few queries help us in finding more keywords for the table of concepts and identifying relevant IPC codes, as listed in Table 6.

Table 6. Relevant IPC relating to wipes.

IPC	Code explanation
A01N25/34	. Shaped forms, e.g. sheets, not provided for in any other group of this main group [2006.01]
A47L13/10	. Scrubbing; Scouring; Cleaning; Polishing [2006.01]
A47L13/12	.. Implements with several different treating devices [2006.01]
A47L13/16	.. Cloths; Pads; Sponges (metal scraping sponges A47L 13/07) [2006.01]
A47L13/17	... containing cleaning agents (A47L 13/19 takes precedence) [2006.01]
A47L13/256	..... for mops made of cloth [2006.01]
A47L17/08	.. Pads; Balls of steel wool, wire, or plastic meshes [2006.01]
A47L25/00	Domestic cleaning devices not provided for in other groups of this subclass (for cleaning spectacles G02C 13/00) [2006.01]

Table 6. Continued.

A61F13/15	. Absorbent pads, e.g. sanitary towels, swabs or tampons for external or internal application to the body (non-absorbent catamenial receptacles A61F 5/44); Supporting or fastening means therefor; Tampon applicators [2006.01]
A61K8/02	. characterised by special physical form [2006.01]
B08B1/00	Cleaning by methods involving the use of tools, brushes, or analogous members (B08B 3/12, B08B 6/00, B08B 9/00 take precedence) [2006.01]
B32B3/00	Layered products essentially comprising a layer with external or internal discontinuities or unevennesses, or a layer of non-planar form (fibrous or filamentary layers B32B 5/02; particulate layers B32B 5/16; foamed layers B32B 5/18); Layered products essentially having particular features of form (B32B 1/00 takes precedence) [2006.01]
B32B5/02	. characterised by structural features of a layer comprising fibres or filaments [2006.01]
B32B5/22	. characterised by the presence of two or more layers which comprise fibres, filaments, granules, or powder, or are foamed or specifically porous [2006.01]
B32B5/26	... another layer also being fibrous or filamentary [2006.01]
C11D17/00	Detergent materials or soaps characterised by their shape or physical properties (shaping soap C11D 13/14) [2006.01]
C11D17/04	. combined with or containing other objects [2006.01]
D04H1/00	Non-woven fabrics formed wholly or mainly of staple fibres or like relatively short fibres [2006.01]
D04H1/42	.. characterised by the use of certain kinds of fibres insofar as this use has no preponderant influence on the consolidation of the fleece [2012.01]
D04H1/46	... by needling or like operations to cause entanglement of fibres (D04H 1/45 takes precedence; needling machines D04H 18/00) [2012.01]
D04H1/54	.. by welding together the fibres, e.g. by partially melting or dissolving (in combination with needling D04H 1/485) [2012.01]
D04H1/56	... in association with fibre formation, e.g. immediately following extrusion of staple fibres [2006.01]
D04H13/00	Other non-woven fabrics [2006.01]
D04H3/00	Non woven fabrics formed wholly or mainly of yarns or like filamentary material of substantial length [2012.01]
D04H3/16	... with bonds between thermoplastic filaments produced in association with filament formation, e.g. immediately following extrusion [2006.01]

Then, pairing the most relevant IPC with our set of keywords, we start creating the search queries. The search queries are part the second stage of patent searching. We look into several

different combinations and select the ones that provide the most accurate results. A few examples of meaningful search queries employed in created the dataset on commodity wipes is listed in Table 7. During the second phase of patent search, we can use several tools to refine the results that PatSnap™ will retrieve. For example, we can limit our search in a specific time frame to look at patents that have been published within the last 20 years, or we limit the database to search in only patents from the United States Patent and Trademark Office database. We can also refine our search by only looking at patents that have been granted and are active at the time of the search.

Table 7. Search queries, wipes.

#	Search Queries	Status	Simple	Total	Database
1	TAC:(nonwoven OR non-woven) AND TA:(wipe*)	All	756	1139	US
2	TAC:((nonwoven OR non-woven) AND multistrata) AND TA:(wipe*)	All	3	19	US
3	TAC:((nonwoven OR non-woven) AND wipe*)	All	1364	2025	US
4	TAC:((nonwoven OR non-woven) AND wipe*) AND CLMS:(wood pulp)	All	88	109	US
5	TAC:((nonwoven OR non-woven) AND wipe*) AND CLMS:(polyester)	All	275	386	US
6	TAC:((nonwoven OR non-woven) AND wipe*) AND CLMS:(rayon)	All	135	180	US
7	TAC:((nonwoven OR non-woven) AND wipe*) AND CLMS:(meltblown OR melt-blown)	All	176	237	US
8	TAC:((nonwoven OR non-woven) AND wipe*) AND CLMS:(spunlaced AND polyester)	All	5	6	US
9	TAC:("industrial wipe")	All	16	26	US
10	TAC:(fibrous material AND particle load) AND TACD:(wipe)	All	7	7	US

3.5. Challenges

Nowadays everyone has access to tens of millions of patents, free of charge, through websites and search tools like USPTO, Espacenet, Google Patents, Lens.org, *etc*. With the help of these tools, patent research has become easier compared to twenty years ago. Nevertheless, the high amount of data makes patent search also more challenging, especially if the user lacks professional training. Many users of the aforementioned patent research tools are graduate students, as well as scientists and engineers. Investigate the patent literature requires considerable mental effort. The language of patents is not the same Standard English that is used, for instance, in research papers, as we will explain in chapter five. As Feldman (2009) states, the language of patents is far from what we can define as our standard way of communication. Elements like jargon and scientific vocabulary make patents hard to interpret. For example, the word "comprising" can be simplified by saying "includes but it is not limited to", *i.e.* the invention may actually contain elements that are not listed in the description given. Feldman suggests that judges appointed to cases where patent interpretation is a key factor are often not well equipped to succeed in their function. The language of patents is abstruse, and the formulation of the claims is not common either. In claims, difficult processes are articulated in one sentence structure.

The most widely used method for patent search is the keyword-based search. However, there are some disadvantages in using just keywords. First, keywords can be imprecise, and have context-sensitive meanings. Synonyms and different ways of spelling the same word may also influence the results. Moreover, patent drafters invent their own terms (Clarke, 2018). According to White (2010), almost four million U.S. patent documents, nearly half the total number issued, are invisible to keyword searches. Second, as mentioned before, language may be an obstacle to a successful search; sometimes patentees purposely use vague or inconsistent terminology for hiding

patent content or extending claims validity. Patentees often give words a different meaning from their ordinary dictionary definition; in some cases, they even create new terms to describe their inventions in order to emphasize their originality (Meguro & Osabe, 2019). Another disadvantage is that public patent databases generally contain full-text patent data from the 1970s forward. Titles and abstracts may not be available for earlier patents. For example, U.S. patents prior to 1976 can only be retrieved in the USPTO patent database by number, date and classification.

4. NONWOVEN MARKETS

4.1. Personal Protection Facemasks

Products like masks and respirators are classified as Respiratory Protective Equipment (RPE), which is a particular type of Personal Protective Equipment (PPE). RPE are used to protect the individual wearer from the inhalation of hazardous substances and comprises respirators and breathing apparatus (which include air supplied devices). Respirators can be powered or unpowered. The latter will be the focus of this chapter, with a special interest in disposable filtering half masks. We will use the definition of facemasks given in par. 3.4.1 throughout this chapter. The category division is shown in Figure 3.

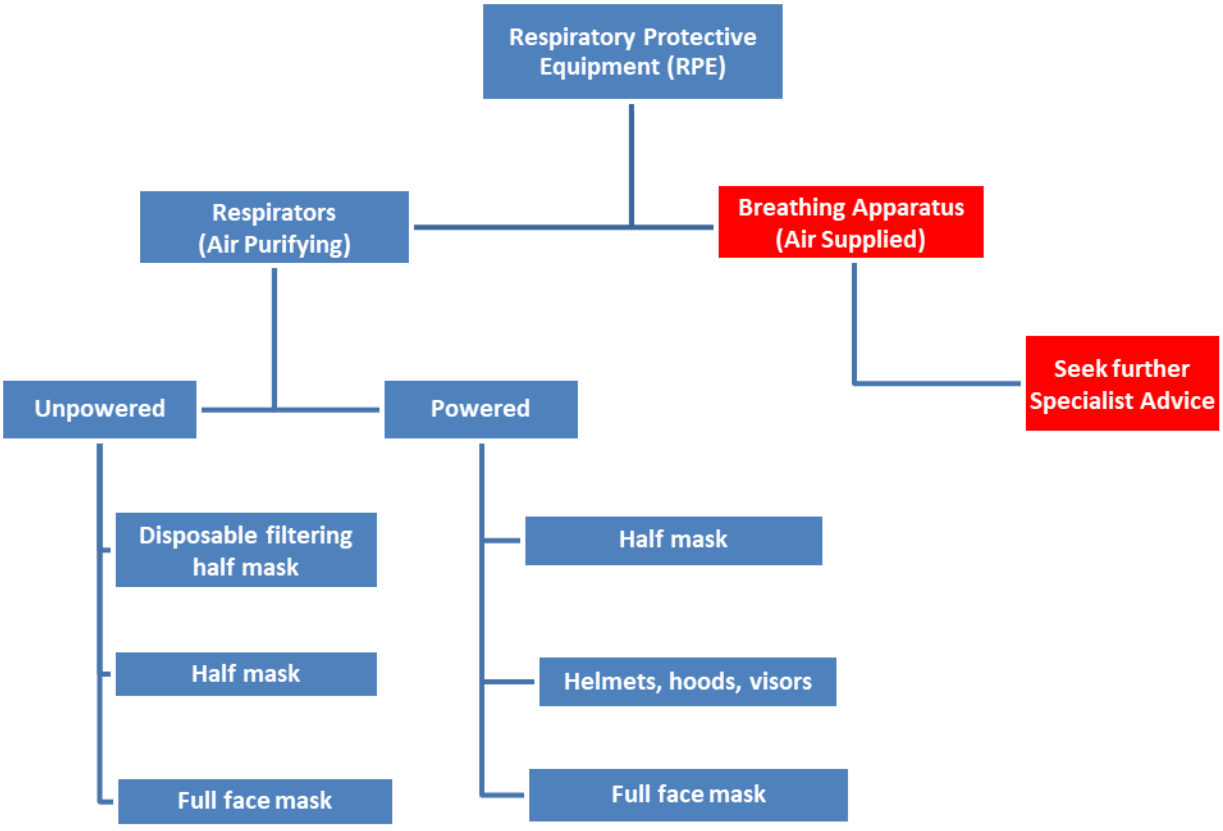

Figure 3. Respiratory Protective Equipment, source Health & Safety Authority.

Different databases refer to these filtering devices as facemasks, masks or respirators (Figure 4). These devices utilize a wide range of media, from inexpensive media used in facemasks to more expensive high-efficiency media used in respirators. Personal protection facemask categories include those sold at the consumer level and those used in industrial, commercial and healthcare environments, with the exception of medical face masks used during surgical procedures (included within the medical/surgical end-use category). Particulate respirators are able to capture dust and pollen, and become more effective as particles accumulate on filters, but require filter replacement when user breathability is compromised. Gas and vapor respirators can capture gases and vapors by use of chemical filters; these respirators do not protect against airborne particles, but the filter does not require replacement unless its capacity is depleted. Combination respirators can capture both particulate, and gas and vapors.

Facemasks are typically made of three layers, with a meltblown placed between two spunbond polyester or polypropylene layers. The meltblown material acts as filter by stopping microbes from entering or exiting the mask. Some facemasks additionally include a glass, a film layer, or multiple layers of meltblown. Most face masks feature pleats/folds to allow the user to expand the mask and cover the face from the nose to under the chin. Pleated facemasks, which account for nearly 90% of disposable facial masks, are rather loose and are not designed to protect the wearer from fine particulates or aerosolized contaminants. The advantages of pleated facemasks are low cost, comfort, and no vision restriction. Pleated facemasks do offer some protection to the wearer by reducing the possible transmission of blood, bodily fluids, and airborne bacteria that may be exhaled or spattered from the patient in the case of medical and surgical masks, but the primary purpose is to prevent particles being expelled by the wearer into the environment. They are usually made of polyester, wood pulp, viscose, fiber glass that have been

spunbonded, meltblown or hydroentangled. The threat of infections and pandemics is a driver that should influence future facemask demand at the consumer level. Facemask manufacturers are also trying to differentiate their products and grow demand by adding antimicrobial properties, odor absorbing properties, and color.

Respirator masks — molded in a cup shape to follow the contour of the face — provide higher protection to the wearer by filtering dust, vapors, and bacteria. Respirators range from full hood to full- and half-face pieces to disposable half masks covering just the mouth and noise. The different designs offer different levels of protection. Some respirator masks come in replaceable-cartridge, multiple-use models with up to nearly 30 components. Typically, one or two cartridges attach securely to a mask that has built into it a corresponding number of valves for inhalation and one for exhalation. Some of the disposable respirators have valves to provide the effective removal of heat and moisture.

The most common products of this category are N95 respirators and surgical masks. These are used to protect the wearer from airborne particles and from liquid contaminating the face. Surgical masks help protect the sterile field. They are designed to protect the patient from the exhaled microorganisms from the healthcare provider.

Masks are cleared by the Food and Drug Administration (FDA), whereas Respirators meet the Centers for Disease Control and Prevention (CDC) guidelines for mycobacterium tuberculosis exposure control, and they are certified by the National Institute for Occupational Safety and Health (NIOSH) as N95's and designed to provide a secure face-to-respirator seal. This seal helps reduce the wearer's exposure to airborne particles, making them appropriate for protection from laser and electrocautery plume. OSHA determines the appropriate respiratory protection for specific hazards and enforces its use, and only allows the use of NIOSH-certified respirators.

Figure 4. Masks on the left, and respirators on the right. Source https://fastlifehacks.com/n95-vs-ffp/.

4.1.1. Market

Frost&Sullivan in the North American Respiratory Protection Market of October 2018 shows the trends and drivers for this market. The demand for respiratory protection in North America was valued at $1,122.8 million in 2017 and is estimated to reach $1,238.2 million by 2022. The market is expected to grow at an estimated CAGR of 2.0% from 2017 to 2022. The main five market participants are 3M Scott Safety, Honeywell, Moldex, and Draeger (Figure 5). These companies account for 89.2% of the market share.

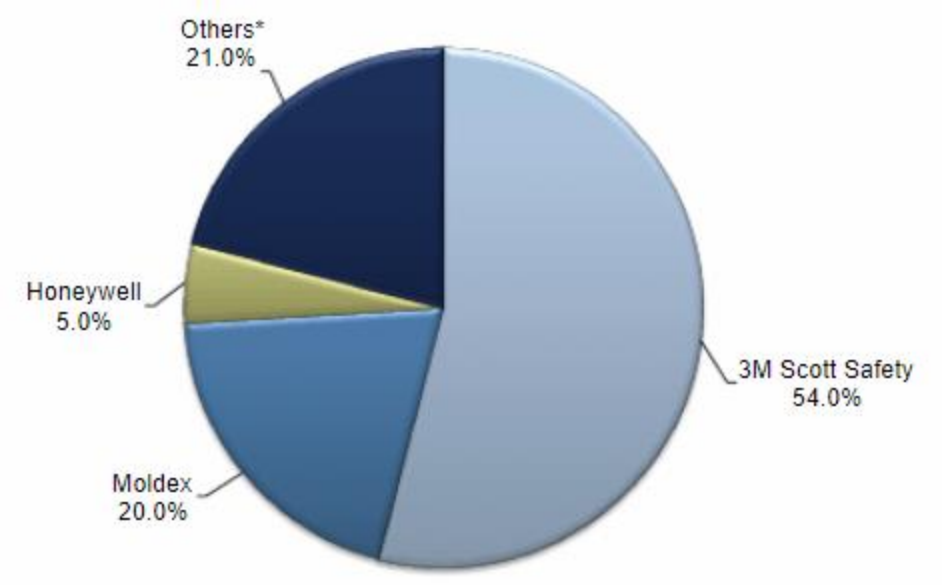

Figure 5. Disposable respirator segment: percent revenue by participant, North America, 2017. Source: Frost & Sullivan.

The Disposable Respirator Segment includes three types of filters designated with letters N, R, and P. N-Series filters are used in atmospheric conditions that are free from aerosolized oils. The particulate matter should be free from oil. R-Series filters may be used against oil-based liquid aerosols. P-Series filters are versatile and can filter out both solid and liquid aerosols, including oil-based liquid aerosols. Respirators fall into the following categories: N95, N99, N100, R95, R99, R100, P95, P99, P100. The numbers indicate the filtration efficiency percentage as described by NIOSH. The market players are developing disposable respirators with features such as cool flow exhalation valves, alterations in nose clip design for ease of adjustment with facial structure and developing patented filter media to enhance respirator life (Frost&Sullivan). The segment revenue is expected to reach $329.2 million by 2022.

The market share analysis shows that 3M accounts for the largest market share in the disposable respirator segment. Factors such as a proprietary Cool Flow™ valve technology, higher brand recall, and involvement in product development as well as qualitative fit testing procedures give 3M a competitive edge over other market participants. Moldex is another key participant in

the disposable respirator product space. The company has developed a proprietary Ventex® valve and Dura-Mesh® shell, thus reflecting upon the initiative of the company to remain competitive in the disposable product space. Product development with focus on ergonomics is expected to help Moldex remain a major participant in this segment. Honeywell offers respirators in a cup as well as in a flat fold style to facilitate better comfort. The need for ergonomic design of respirators will support the product demand for Honeywell.

Disposable respirators are preferred widely, as they require no maintenance and are low cost compared to other respiratory protective equipment. Industry participants, such as 3M and Honeywell, have introduced products that provide better seal with the face, reduce heat buildup, and have strong outer shell for better rigidity. A major focus is to improve the ergonomics, which results in better comfort. The product segment is price sensitive, and the availability of low-cost disposable respirators attracts more customers. Regulatory compliance is expected to support the demand for products approved by regulatory bodies (OSHA, NIOSH). These regulations are expected to counteract the competition of cheap substitutes.

In dollar and unit sales, facemasks account for the majority of the nonwoven consumption in the personal protection category (96.3% of the square meters and 92.0% of the weight), as respirators typically use less nonwoven per unit (Figure 6). In 2016, the personal-protection filtration category used 571 million square meters of nonwoven material, weighing 17 thousand tons. The outlook is positive for personal protection masks, as square-meter consumption is expected to increase to 620 million square meters, weighing 19 thousand tons (annual increases of 1.7%) (Curran, 2018).

North American Personal Protection Air Filtration Market Nonwoven Material Consumption by End Use										
	2011		2016		2021f		2011-2016		2016-2021f	
	SQM (MM)	Tonnes (MM)	SQM (MM)	Tonnes (MM)	SQM (MM)	Tonnes (MM)	SQM% (CAGR)	t% (CAGR)	SQM% (CAGR)	t% (CAGR)
Face Masks	513	15	550	16	597	17	1.4	1.4	1.7	1.7
Respirators	20	1.3	21	1.4	23	1.5	1.4	1.4	1.7	1.7
Total	**533**	**16**	**571**	**17**	**620**	**19**	**1.4**	**1.4**	**1.7**	**1.7**

Figure 6. North American Personal Protection Air Filtration Market, source INDA Estimates 2017

4.1.2. Data visualization and analysis

PatSnap™ provides a platform, the Workspace, which allows collecting the relevant patent retrieved through the different search tools. The Workspace allows for different means of analysis through instruments such as the functions Analyze, Insights, and Landscape.

For the purpose of this research, the patent collected have been retrieved using the search queries shown in Table 4. All the patent data was cleaned so that the following data is based on the 811 patents deemed relevant. To clean the data, we went through all the patents retrieved and made a judgement by reading title, abstract and independent claims to prove relevance to the topic of facemasks.

The analysis of patent data usually starts with the identification of the major players. The top assignees (Figure 7) are the companies with the largest patent portfolios in the technology field. While 3M is the most prolific company in terms of patents relative to facemasks, with 200 applications, the average number of patents issued to the other top assignees during the analyzed period of time is below 10.

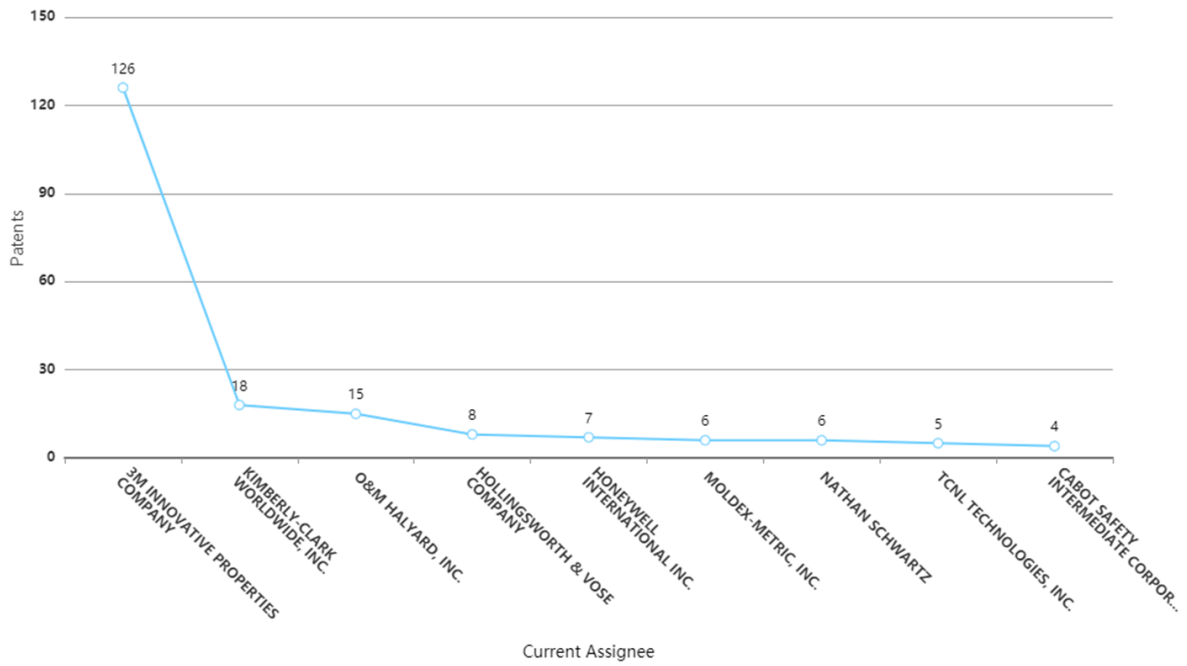

Figure 7. Top current assignees for facemasks patents.

Market reports as IbisWorld state that the Respiratory protection equipment manufacturing market in the United States is mature and the barriers to entry are high. The analysis of the major players in all the market reports shows that 3M holds the largest market share (40%), followed by Honeywell International Inc. (34.7%) and Mine Safety Appliances (17.4%). It is important to notice that Honeywell is not as prolific in patent applications. The reason might be that Honeywell buys base materials, like for instance sheets of meltblown PP, to use as filtering layer for the masks.

Next step of the analysis is to look at the most prominent inventors. In every company, some groups are more creative than others, leading to writing more patents. By sorting the data by top inventor names (Figure 8), we may be able to identify which groups and which divisions in every company are leading the number of inventions disclosed by the company. The next-generation products are most likely coming from these highly creative groups. In the present research, it is notable that all the top inventors belong to the 3M Company's Personal Safety

division and Occupational Health and Environmental Safety division; except for A. Houde who works for O&M Halyard in the Infection Prevention and Surgical Solution division, and K. Brunson who belongs to the Safety Product division of MSA.

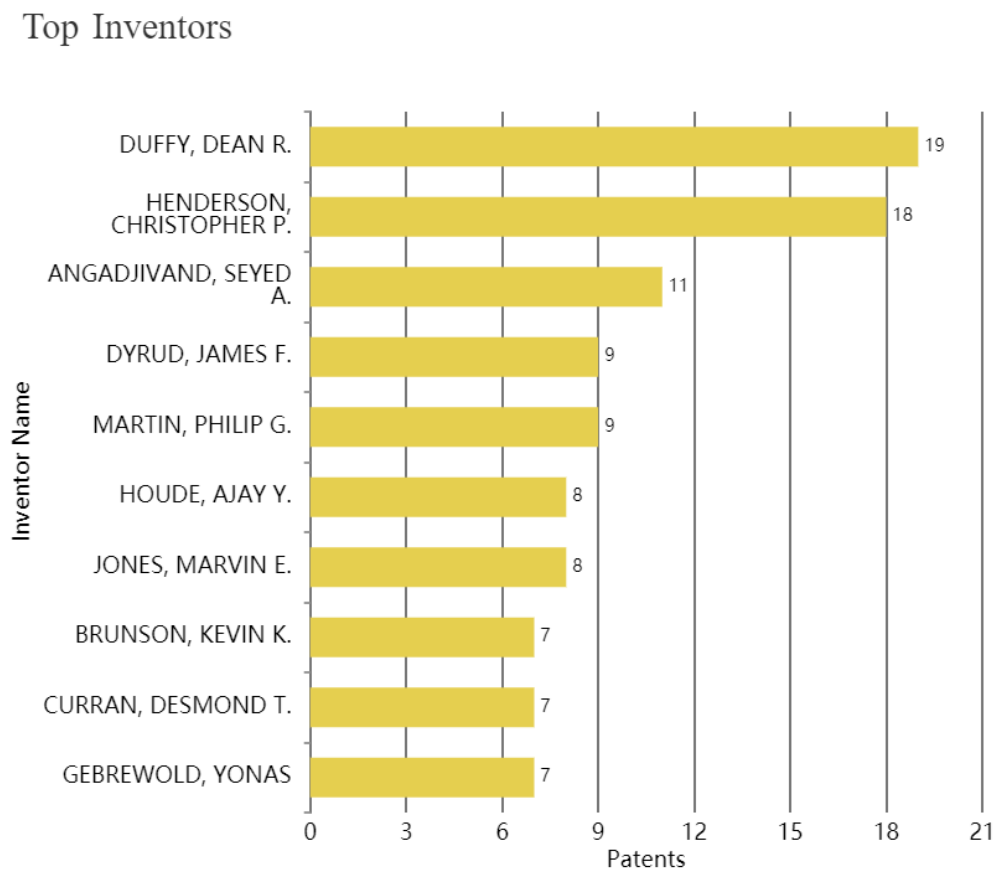

Figure 8. Top inventor names for facemasks.

Moving on with the analysis, one way to develop an understanding of the market drivers inside the facemask segment is through the visualization of patents according to their IPC sub-groups during the last 20 years (Figure 9). Data shows a peak in patent applications in years 2014-2015 for most sub-groups. In particular, protective facemasks and filters for respirators show the largest change. If the market data from the following years (2016-2019) shows a peak in sells of

those specific products, the application trend of IPC sub-group may be identified as an indicator of market trends.

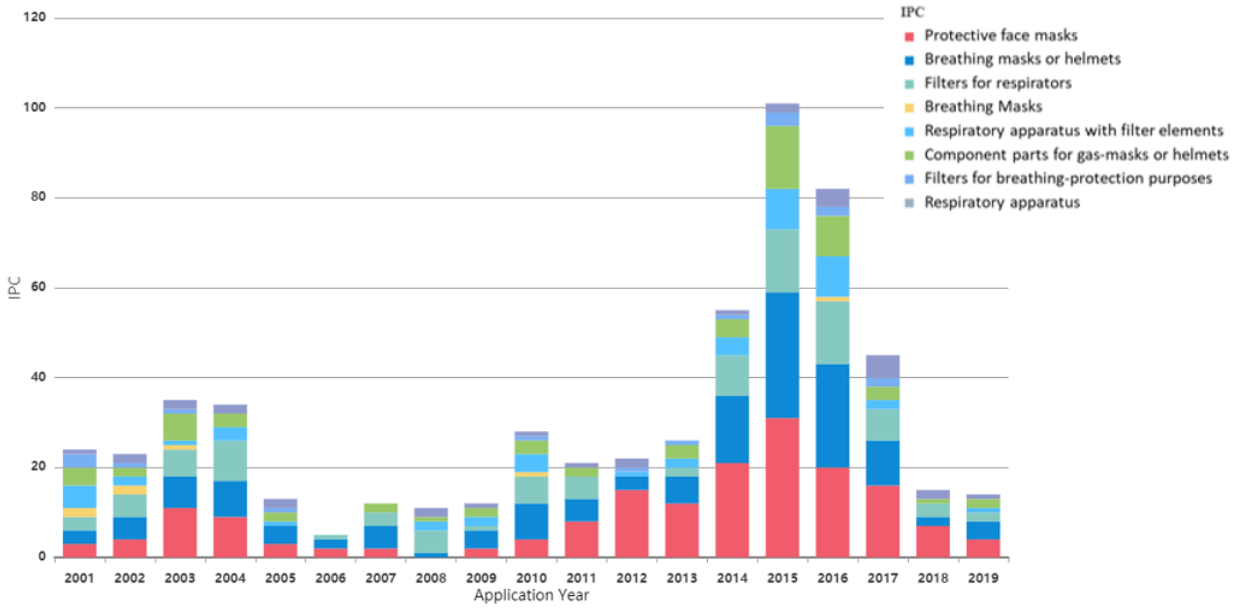

Figure 9. Application trend of IPC sub-groups.

One step to better understand which are the most relevant patents is to perform patent citation analysis. Figure 10 shows the ten most cited patents. Their visualization helps to understand which patents are more prolific and have their technology built upon others. These patents are important because they tend to contain important ideas upon which the most relevant patents nowadays have been built.

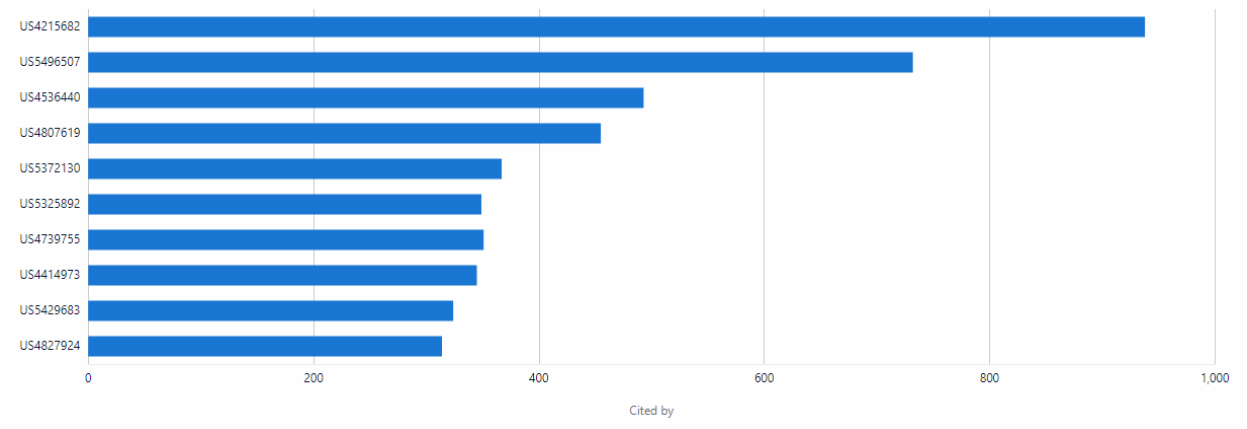

Figure 10. Most Cited Patents.

However, an in-depth description of the filtering layers in the body of the facemasks is only reported by the following four patents, which are the patents upon which the technology is built.

US4215682 Melt-blown fibrous electrets – 3M Innovative properties - 1980

A persistent electric charge is introduced into melt-blown fibers during the melt-blowing process. When these charged fibers are incorporated into fibrous webs, they provide unique properties, including improved filtering properties. The average fiber diameter of the fibers is less than 10 µm and the charged particles can hold a persistent electric charge of at least 10^{-8} C g^{-1} of microfibers, with a half-life of at least six months in a room-temperature, 100%RH environment.

US5496507 Method of charging electret filter media - 3M Innovative properties - 1991

A method of charging a nonwoven web of thermoplastic microfibers to provide electret filter media is provided. The method includes impinging on a nonwoven web of thermoplastic nonconductive microfibers with a resistivity greater than 10^{16} Ω-cm, and capable of having a high quantity of trapped charge jets of water or a stream of water

droplets at a pressure sufficient to provide the web with filtration enhancing electret charge and drying said web.

US4536440 Molded fibrous filtration product - Minnesota Mining & MFG Company - 1985

Molded filtration products, such as disposable face masks, with a pressure drop of less than 30 H_2O mm at a face velocity of 85 L min^{-1} are prepared by assembling at least one fibrous shaping layer and one fibrous filtration layer in face-to-face contact and subjecting the assembly to heat and molding pressure. Preferably the assembly comprises two shaping layers, one on each side of the filtration layer with a total loft of at least 5 mm. The shaping layers in total weigh between 40 and 150 pounds per ream and contribute less than 20% of the total pressure drop through the filtration product. At least one of the shaping layers comprises (bicomponent) fibers that can be bound together at points of fiber intersections by coalescence of binder material on the fibers. Any shaping layer upstream of the filtration layer has a basis weight of less than 50 pounds per ream. The filtration layer is attached and in close contact with the shaping layer(s) by at least fiber entanglement.

US4807619 Resilient shape-retaining fibrous filtration face - Minnesota Mining & MFG Company - 1989

New molded fibrous filtration face masks that are highly resilient and shape-retaining are provided using one or more molded fibrous shaping layers, with a fibrous filtration layer disposed on one side of or between the molded fibrous shaping layers; the molded fibrous shaping layers having a total basis weight of at least 150 g/m^2, and at least one of the fibrous shaping layers having an average density over the central area of the face mask of no greater than about 0.2 g/cc, such that at bends of the layer during deformation of the face mask the layer elastically deforms and tends to return to its original thickness and shape when the deforming pressure is removed.

(Please note that all the patents belong to the same company, today known as 3M Innovative Properties, that used to be called Minnesota Mining & MFG Company before the 90s).

The largest invention families are shown in Figure 11. A patent family is a set of patents taken in various countries to protect a single invention (when a first application in a country, called "priority", is extended to other offices). In other words, a patent family is the same invention disclosed by a common inventor and patented in more than one country. Patents with very large invention families often belong to the most successful inventions that have received a large number of resources for increased level of coverage (either by expanding the technological coverage or geographical reach). These patents belong to families that range in size between 34 and 43 documents. The first two, US3890966 and US3888246 relate to anti-fog surgical facemasks and the standardized current assignee is Johnson &Johnson. All the other patents belong to the 3M Company and related to Flat-folded personal protective devices and Melt-blown fibrous electrets.

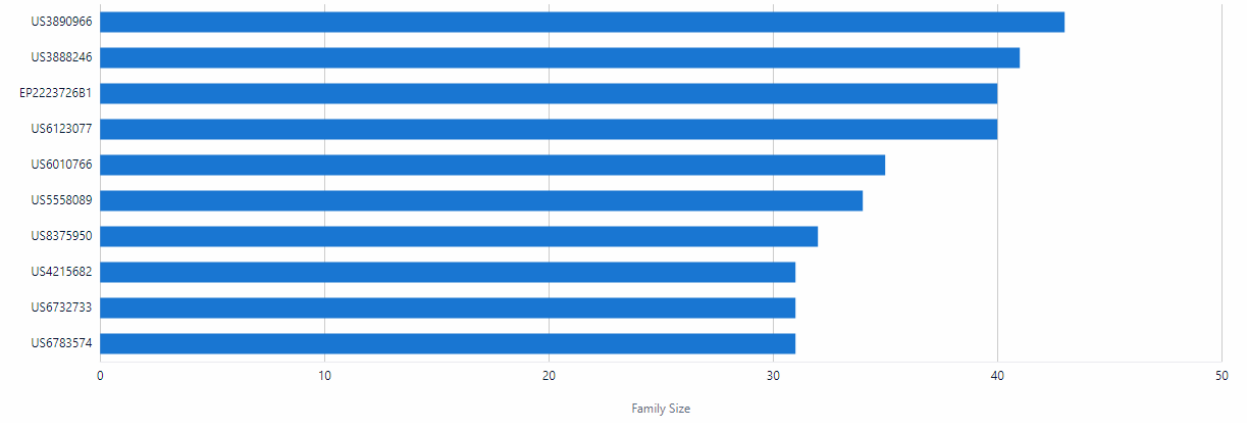

Figure 11. Largest Invention Families.

Last, the patent analysis also identifies the most litigated patents, which are the patents involved in the greatest number of litigation cases. This may indicate the litigation risk associated to patenting in a similar technology space. Figure 12 shows the ten most-litigated patents. In all

the lawsuits, the plaintiff was 3M Company against smaller companies. The average time for the litigations was below six months, and the longest case was resolved in 1.5 years. The litigation overview includes six cases in total, where five cases involving 4 patents relate to the mask body, one case (five patents) the central portion, one case (two patents) the central panel, and two cases (two patents) the microfibers. The outcomes of four of the six cases are undisclosed, while two reached settlement.

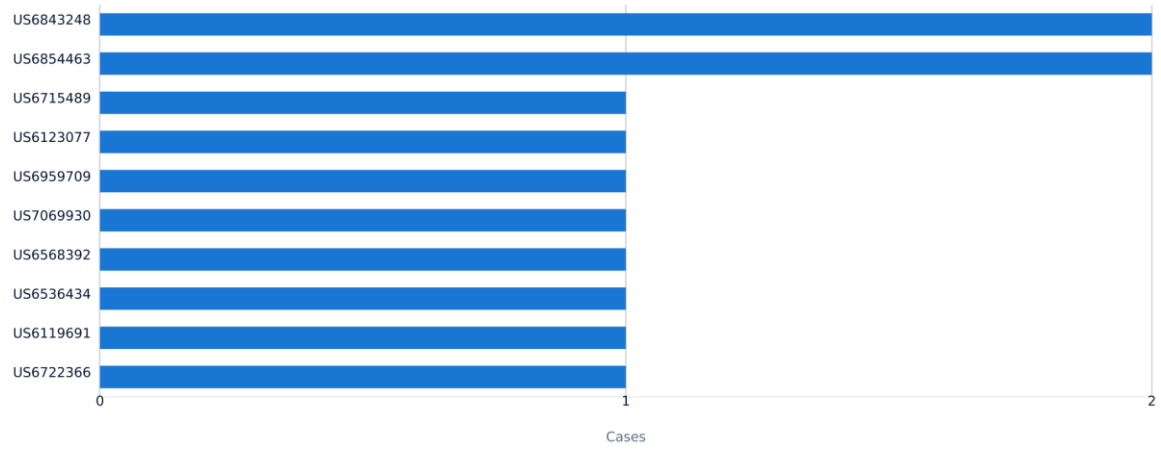

Figure 12. Most Litigated Patents.

The last visualization tool we are showing is the patent landscape. The landscape resembles a 3D geographic map, where there are mountains, hills and lagoons. The white and brown areas represent the zone with the highest concentration patents, green and sandy colors mean less patents, while the blue lagoon areas are low density. The map is created based on keyword and IPC codes. The frequency of keywords determined the proximity of the patents, that at the same time are clustered based on their main IPC code. Because in this projection the intensity of colors signifies patent density, the lagoons can potentially be white spaces. A white space is an area where there are few patents and these are carrying disruptive technologies, therefore it can indicate where a company should concentrate its R&D efforts. However, not all the lagoon areas in a landscape are white spaces, most often these are just areas where there is not space for technology development. In addition, it is important to notice that there is no universal definition of a white space and, because each person performs patent analysis differently, there are no two identical landscapes either. Nevertheless, the white space analysis can be a tool in mapping new opportunities for a company and impeding threats from competitors.

Figure 13 shows the landscape for facemasks, where the active patents from 3M are colored in red, and the ones from O&M Halyard are colored in blue. We can see how the red dots cover almost the entire surface of the landscape, and from that, we can infer that 3M patent strategy is fairly defensive, because it does not allow the competitors to get too close to their technology.

Last, green and red labels highlight some of the patents on the landscape. The green label indicates the patents that have the highest market value (according to PatSnap™), while the red ones mark the patents that have been involved in litigation. In both the litigation cases the plaintiff was 3M and the verdict was of infringement with the order to the defendants to stop manufacturing the products connected to 3M's patents. The market value of the green labeled patents is above $1.8M and the way it is assigned is based in key factor such as technology maturity, ease to design around, number of claims and claim construction, market value and how the patent has financially contributed to its assignee.

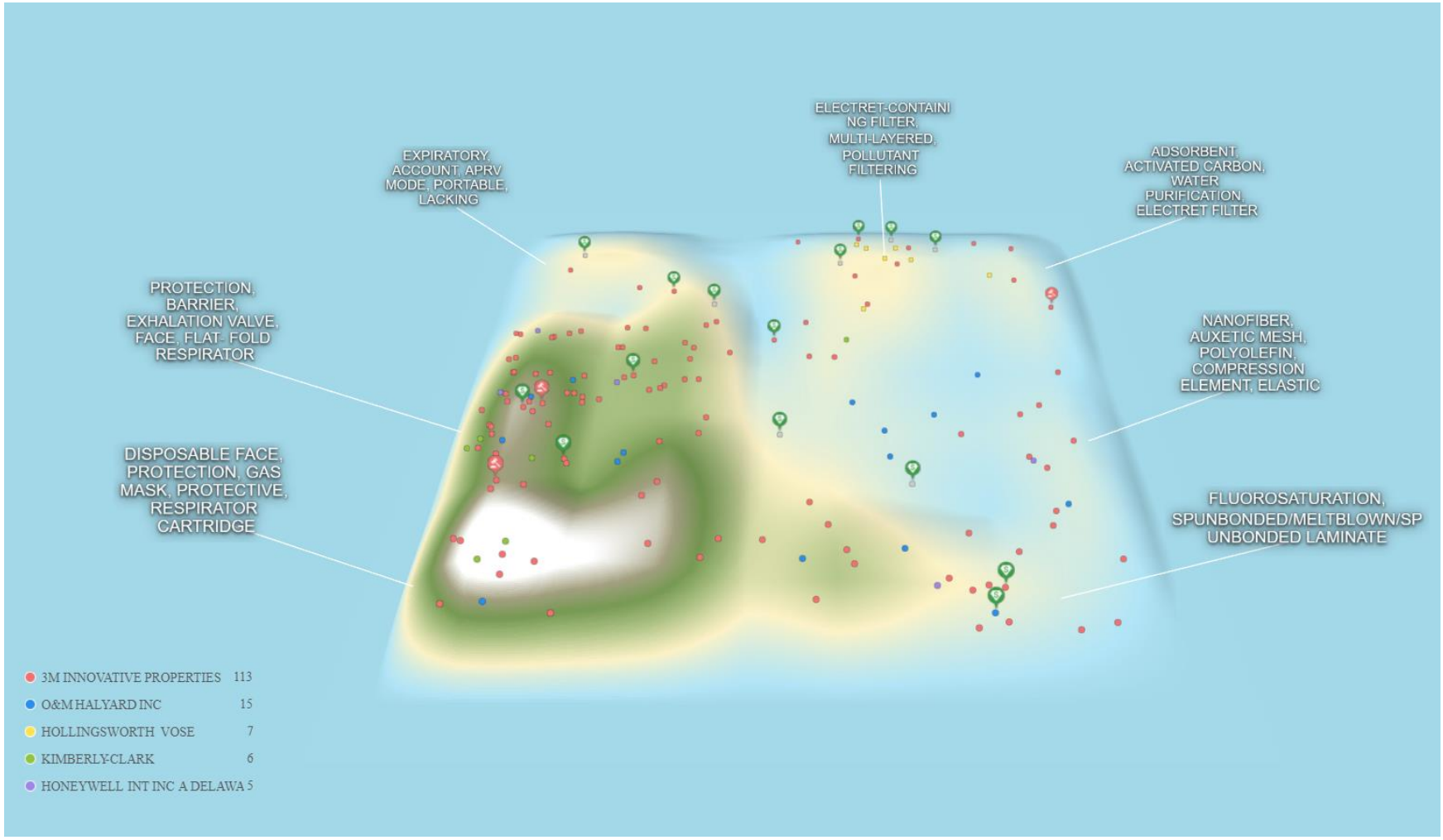

Figure 13. Landscape for facemasks.

4.1.3. Data analysis

To map technology, we downloaded from Patsnap™ an Excel spreadsheet that included all patents of interest, their publication year, and their claims. We transferred the patent numbers and their claims to a Word document, whose search function is able to highlight single words in each claim. We selected the keywords used for the search based on all possible variations of the technology of interest, which included meltblown, spunbond, electrospun, wet-lay, air-lay, spunlace, and charging. We created a technology column in the spreadsheet for each technology analyzed. The keywords used were “blow”, “spun”, “laid”, and “charg-”. We inspected each result in the Word document to assess its pertinence to the search, and, in case of positive outcome, we copied the sentence including the keyword to the original spreadsheet in the designated technology column and in the corresponding patent cell. Once we populated all technology columns, we used the logic function “IF” from Excel to return a “1” or a “0” for each cell in the technology columns in case they were populated or not, respectively. To obtain a final count of patent related to a specific technology, we summed all cells in each technology column and created the technology map. We also grouped results from common technology combinations, such as meltblown and spunbond, and meltblown and charging (Figure 14).

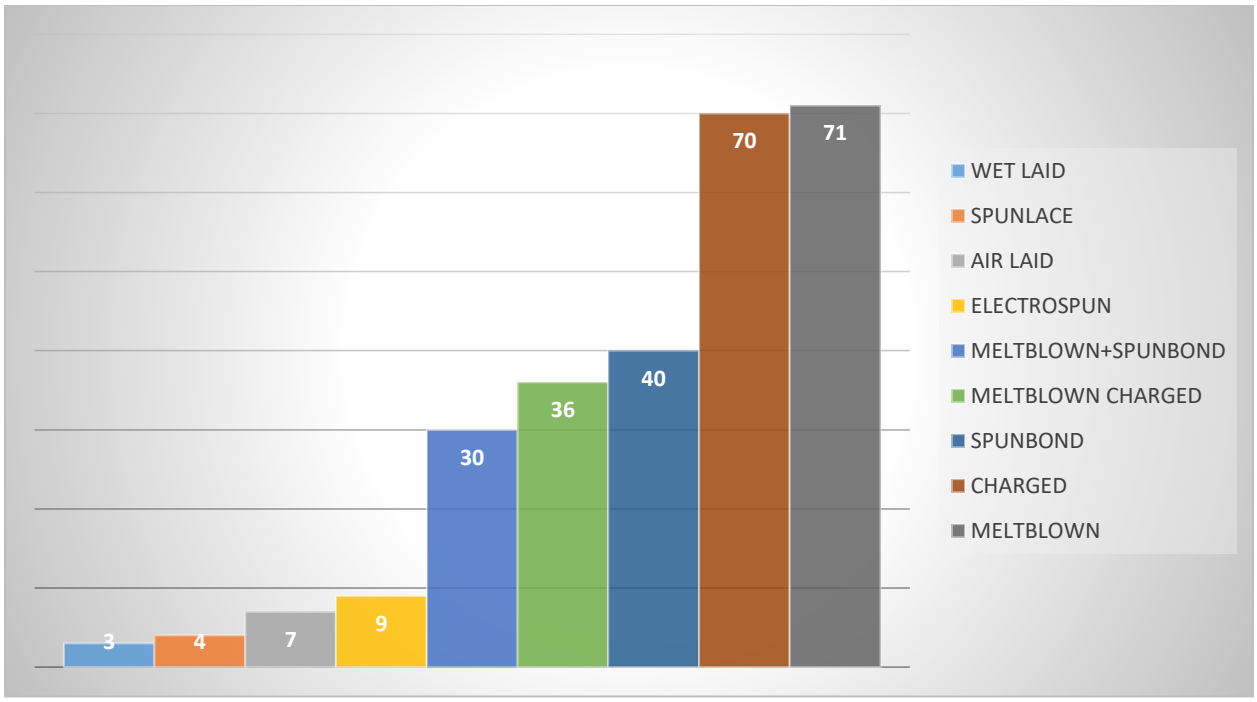

Figure 14. Technology mapping

For timescale mapping, we selected only the patents whose meltblown technology column was populated, and we copied their publication year to another sheet. We divided the entire time period under consideration in 5-year blocks and counted how many patents were published in each block (Figure 15).

The time scale mapping for meltblown patents (Figure 15) shows a decrease in the number of patents involving meltblown facemasks in the years 2011-2015, followed by a rapid increase in the years 2016-2020. In particular, the least prolific years in these two time frames were 2011 and 2012, when no patents involving meltblown facemasks were published, while the most prolific year was 2018 with 5 patents published. It is interesting to note a different trend for the IPC sub-groups in Figure 9, which shows that the most prolific years are between 2014 and 2016 (especially for protective facemasks and filters for respirators), with a rapid and steady decrease of applications afterwards. We can understand that in the years 2014-2016, the number of patents

involving nonwoven face masks increased, but the patents involving meltblown facemasks were steady (2 in 2015, 1 in 2015, 3 in 2016), which means that the percentage of patents with meltblown facemasks decreased and other processes were attracting the majority of face mask patents. In recent years (2017-2020), there was an opposed trend, with the aforementioned IPC sub-groups showing a decrease in number of published patents, while there is an increase with meltblown facemasks patents.

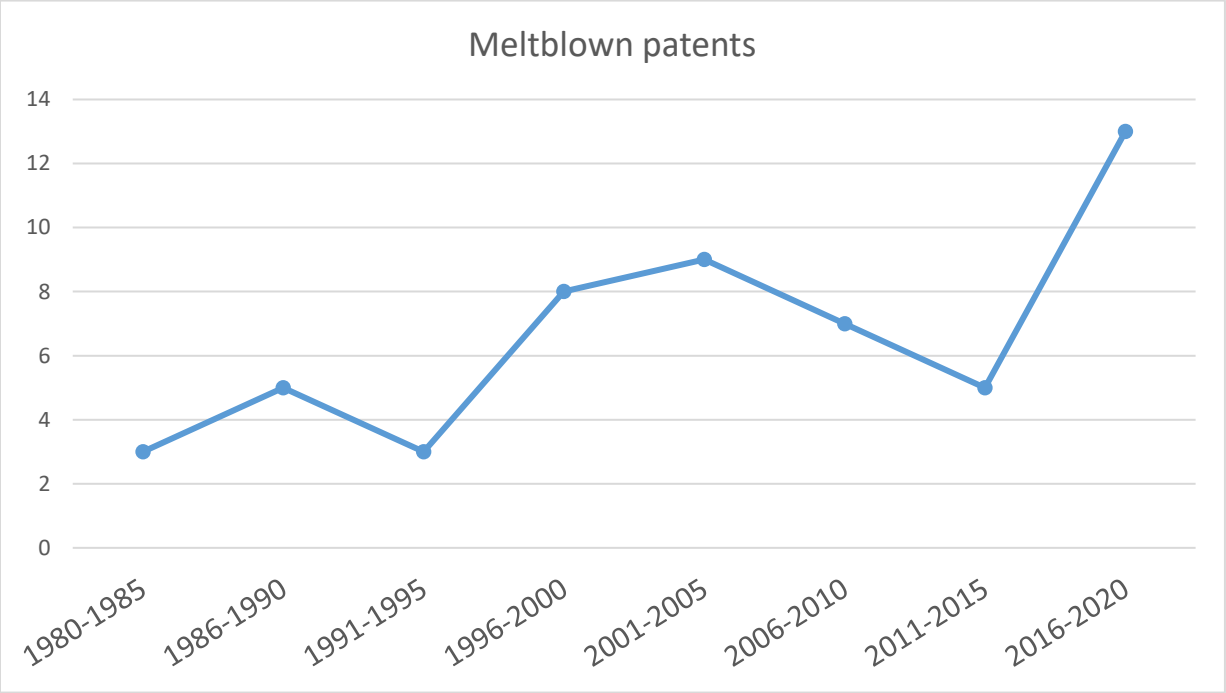

Figure 15. Time Scale Mapping

4.2. Commodity wipes

Industrial nonwovens wipes are disposable or reusable fabric pieces which when treated with gentle cleansing agent are used for cleansing purposes by adult and children for a variety of applications, including baby care, hand washing, feminine, removing makeup, and applying

products such as deodorants and sunless tanners. Wipes can be wet or dry and may be impregnated with ingredients for specific purposes, such as polishing, cleaning, or removing bacteria.

Wipes intended for cleansing or moisturizing the skin, such as those for baby care, hand washing, and other personal cleansing, as well as wipes for applying products are regulated as cosmetics, *i.e.* they do not need FDA approval before being commercialized. Wipes for a therapeutic purpose, such as killing germs on skin, are drugs under the law and need to be FDA approved, while wipes to disinfect inanimate surfaces are regulated by the Environmental Protection Agency.

Raw materials comprised in wipes may include as polyester, polypropylene, cotton, wood pulp, or rayon fibers. The fiber mats may be moistened with water and other ingredients, such as cleansing and moisturizing agents and may contain germicides.

4.2.1. Market

Personal hygiene and household cleaning sectors are the main drivers for the global dry and wet wipes market, which is expected to see significant gains in North America by 2025, when the global skin care business is estimated to be $189.3 billion. Owing to the increase in demand of "green" products, manufacturers have started using natural fibers and water instead of alcohol in the manufacturing of wipes, which will likely increase the market growth. India has increased the average expenses for children, which will drive up the market for cleaning wipes, of which the country is a major producer. On the other side, China is one of the largest markets for baby health and hygiene products and has documented lately recorded large sales of baby hygiene products. Global dry and wet wipes industry is fragmented with major players including Procter & Gamble, Kimberly-Clark, Johnson & Johnson, Pampers, Cotton Babies, Babisil Products, and Kirkland.

Several manufacturers have focused on expanding their capacity, especially during the 2020 COVID-19 pandemic.

In the next five years, wipes will be a significant market opportunity for nonwovens because of improvements of market and technology factors globally. The volume of nonwovens converted into wipes is expected to rise by 6.3% per year from 1.20 million tons in 2018 to 1.63 million tons in 2023, by which its global value is estimated to reach $2.84 billion (Smithers Pira, 2018).

Wipes market is diversified, with Procter & Gamble (P&G) being the largest global supplier but with only 14.5% of worldwide value and the next four largest firms holding ~20% of the market. The quick expansion of specific markets has stimulated the sales of specific nonwoven technologies. For example, both Andritz and Voith/Trützschler developed a wetlaid hydroentangling technology to provide the ability to hydroentangle smaller fibers and 11 new hydroentangled wetlaid spunlace lines have been added from 2015 to 2018 due to increase in demand for flushable consumer wipes (Steed & Pira, 2018). Technology mapping and market analysis will be useful to understand how different companies can maximize returns from these investments.

As we will see below, wetlaid and airlaid technologies hold the same number of patents relative to wipes in the analyzed period. However, while sales of wetlaid lines have increased, a series of airlaid lines have seen problems in capacity or even closures in the past few years from companies like Georgia-Pacific or Fiberweb (Steed & Pira, 2018). Other companies, like Glatfelter, with high-capacity airlaid lines may seem to take advantage of these shortcomings.

Consumer packaged goods companies already in the wipes market are introducing new products, but other companies with adjacent products take part in the wipes market growth.

Nonwoven wipe sales to end users are forecast to grow to $12.1 billion by the end of 2021 (INDA, 2017), The consumer wipes segment, which accounted for 78% of the dollar sales in 2016 (Figure 16), includes baby, personal care and home care wipes.

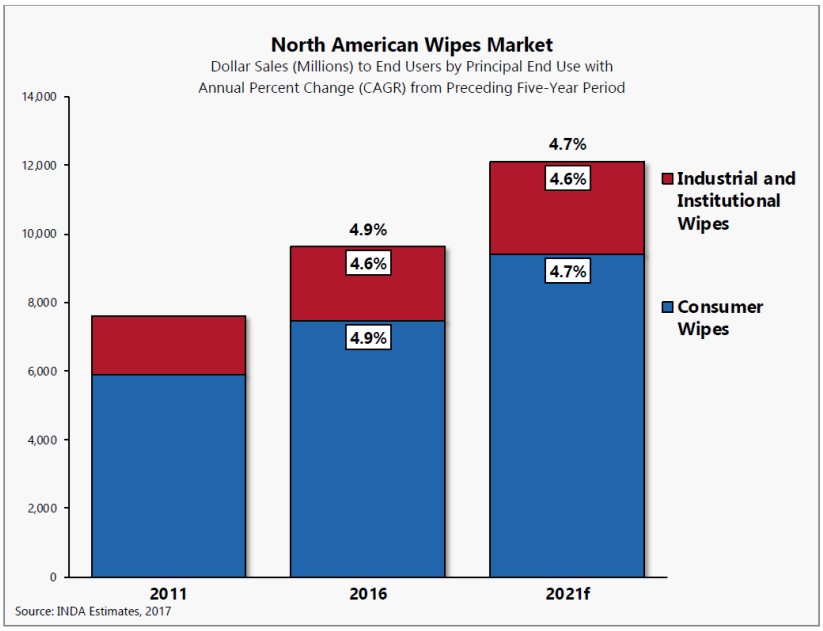

Figure 16. Dollar and unit sales to end users in the wipes market (INDA, 2017).

Baby wipes is the dominant segment accounting for 74% of total value in consumer wipes in 2018; but it is also the most mature and will lose relative marketshare to wipes for personal care and use in the home across the next three years. This is mostly due to the rapidly growing personal care wipes segment, led by moist toilet tissue and cosmetic/facial cleaner wipes, which is now higher than the baby wipes segment in terms of sales (INDA, 2017). As far as wipes consumption in North America is concerned, baby wipes is the largest consumer wipes category (50.2%) (Figure 17).

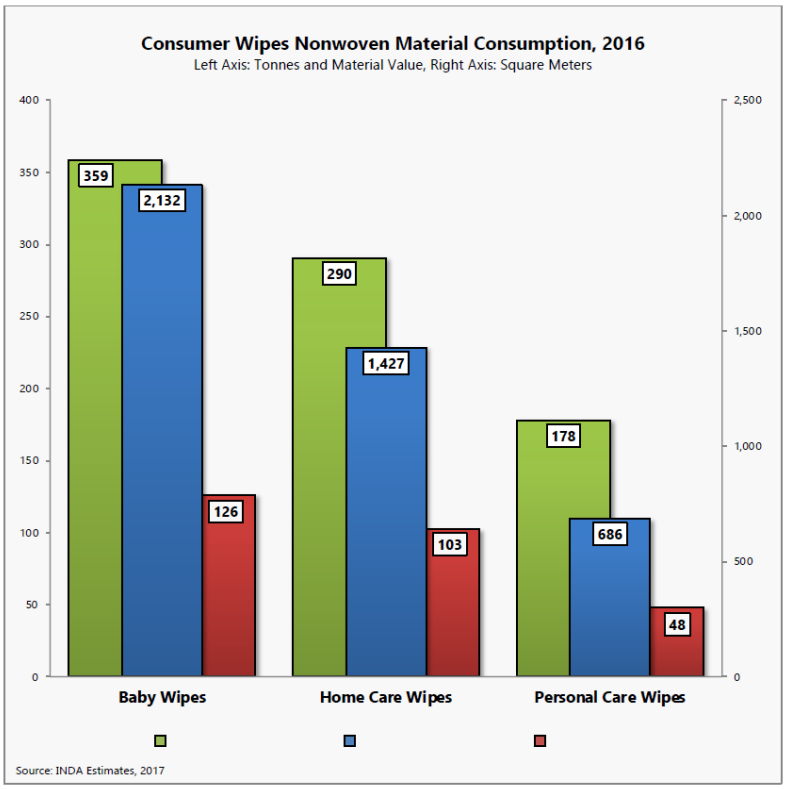

Figure 17. Consumer Wipes Nonwoven Material Consumption, 2016 (INDA, 2017).

Among other drivers, sustainability is playing an important role. In the case of wipes, it can range from biodegradable, discarded materials after use, to carbon footprint reduction. Consumer are leaning toward more disposable wipes with a potential to curtail sales with the rise of environmental concerns. On the contrary, a growing number of consumers are driving the market for flushable wipes. The joint action of industry bodies INDA and EDANA in formulating guidelines on flushability has helped combine the two themes of sustainability and flushability.

The fundamental drivers for home care wipes remain convenience and timesaving.

Cleaning/disinfectant wipes is a large sub-segment for home care wipes. Worth over $1.5 billion in 2018, the global 2020 COVID-19 pandemic has had an enormous effect on these

products, which are now considered necessary by consumers because of concerns about germs and viruses in the household and in public places.

Industrial wipes or institutional wipes have followed a similar trend. In 2018, industrial wipes were worth $3.38 million just over 20% of the total global wipes value. Food service wipes is a fast-growing segment, which has also increased significantly during the 2020 pandemic.

4.2.2. Data visualization

To investigate the wipes market, we used the workspace in PatSnap™ to collect relevant patents, which have been retrieved using the search queries shown in Table 7. All patent data was reduced so that the following data is based on the 754 patents.

The top assignees (Figure 18) are the companies with the largest patent portfolios in the technology field. The two most prolific companies in terms of patents relative to wipes are Procter & Gamble and Kimberly-Clarke, with a combined 59% of the total patents and patent applications. While 3M and Uni-Charm have both at least 20 patents relative to wipes, the other top assignees have lower than 11 patents each.

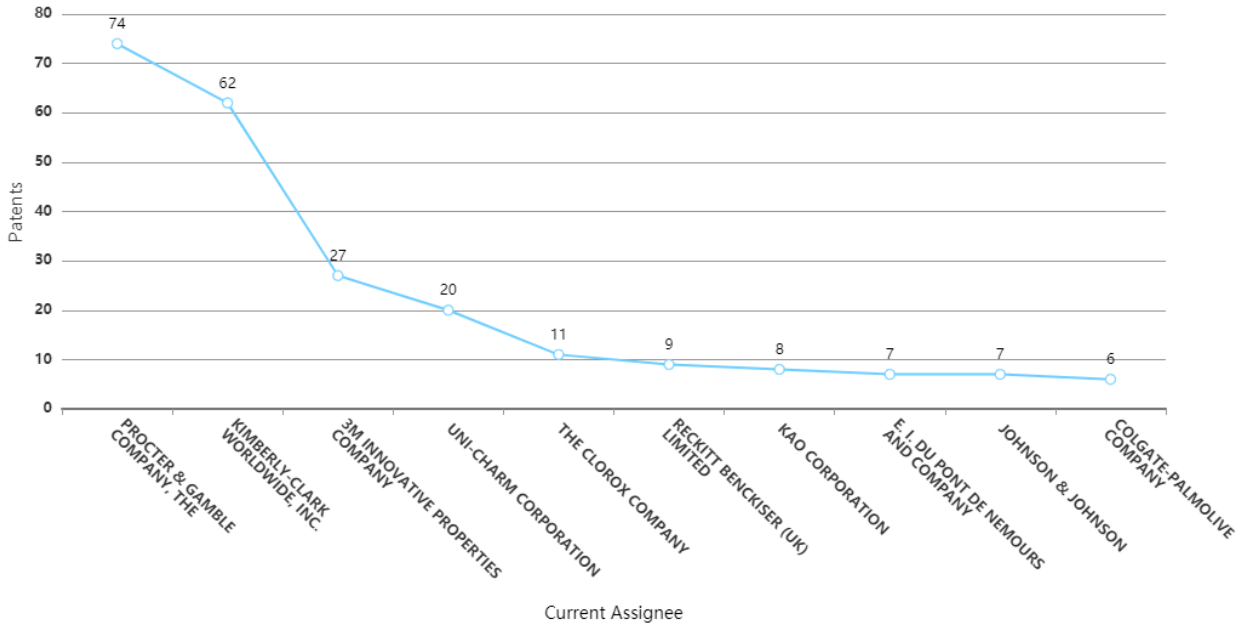

Figure 18. Top current assignees for wipes patents.

It is important to note that even if Procter & Gamble, the largest global supplier of wipes, holds the majority of intellectual property; it only has a 14.5% of market value. Wipes market is diversified, and the next four largest firms hold ~20% of the market combined, which means that with the right technology, the barriers to entry are low.

Next step of the analysis is to look at the most prominent inventors. In every company, some groups are more creative than others, leading to writing more patents. By sorting the data by top inventor names (Figure 19), we can look at the most prolific groups and identify the company divisions to focus the attention for next-generation of wipes. In the present research, it is notable that all the top inventors expect for Y. Tanaka who works for Uni-Charm, are part of Procter & Gamble, some in the baby care or in the global surface care divisions. Even if Kimberly-Clark or 3M hold a fairly high number of patents relative to wipes, there are no top inventors from this

companies, probably due to a high turn-over or mobility of people through different divisions in these companies.

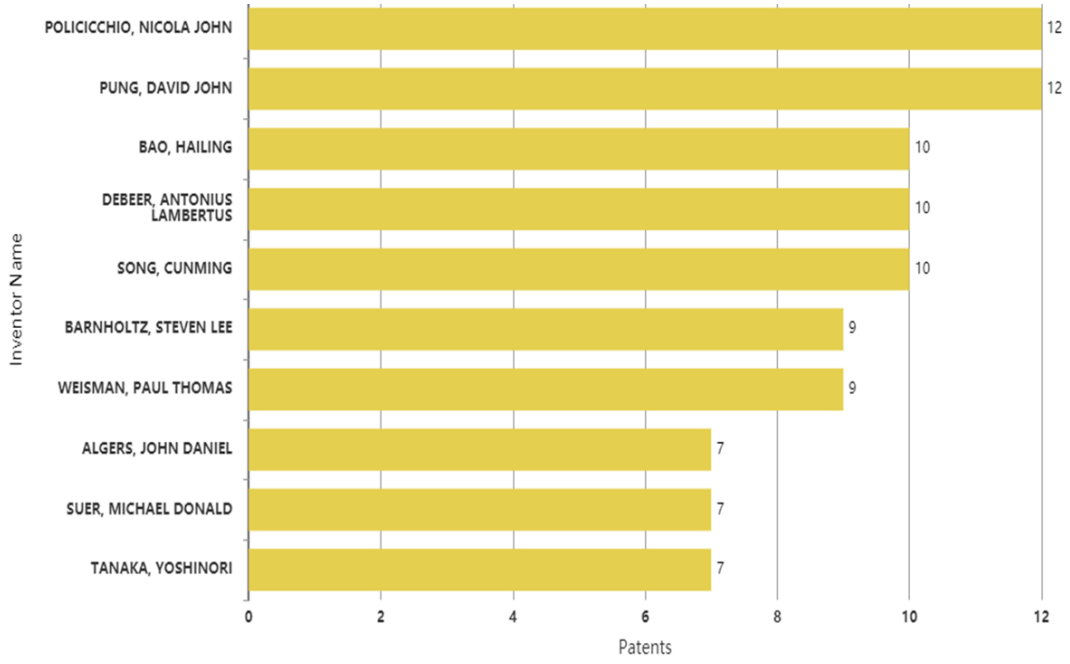

Figure 19. Top inventor names for wipes.

By visualizing patents according to their IPC sub-groups during the last 20 years (Figure 20), we see a peak in patent applications in years 2000-2003 for most sub-groups, and another broader peak in years 2011-2018, but this time mostly for cloths/pads and implements for cleaning floors sub-groups. An interpretation of this data is that the technology patented in years 2000-2003 was innovative enough to be stable on the market in the following years for most sub-groups. However, new technology for cloth/pads and implements for cleaning floors was probably required by the market in years 2011-2018. The decline of trends after the second peak is an indication that the market is now mature and stable for the next few years, and new technology is still in the development stage.

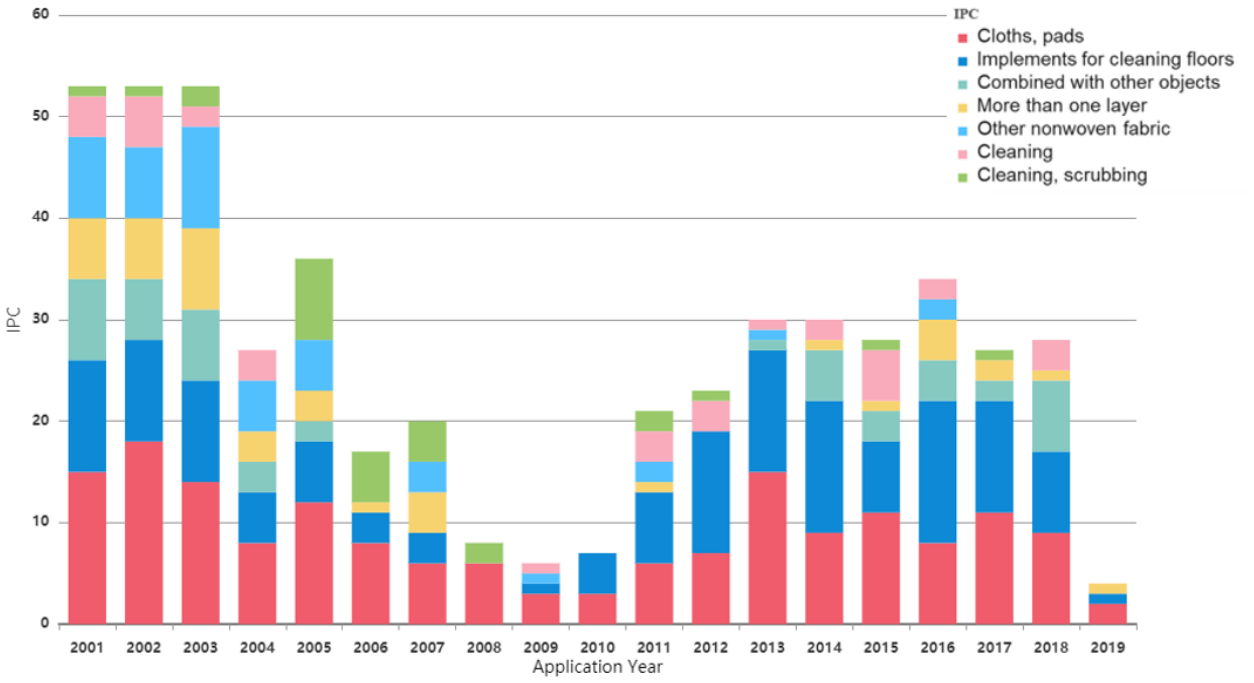

Figure 20. Application trend of IPC sub-groups in wipes.

Figure 21 shows the ten most cited patents. Their visualization helps to understand which patents are more prolific and have their technology built upon others. These patents are important because they tend to contain important ideas upon which the most relevant patents nowadays have been built.

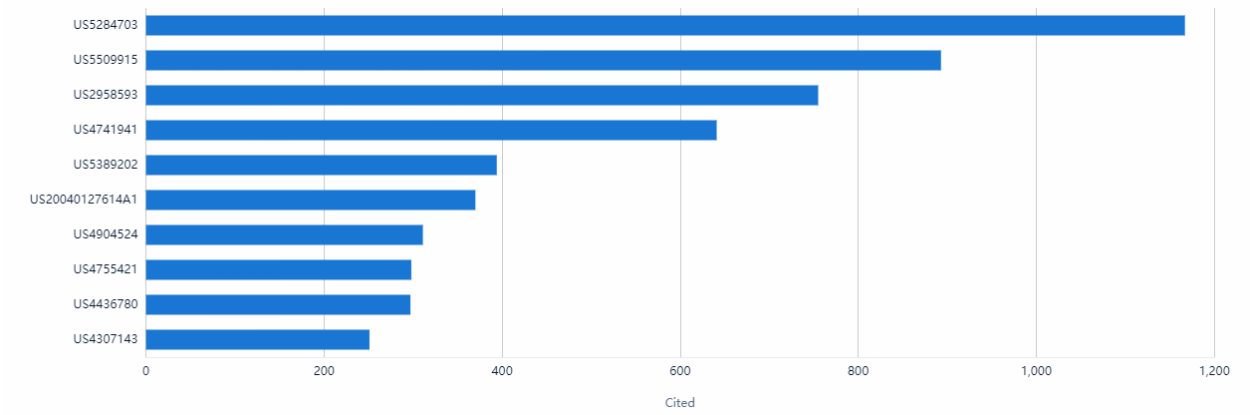

Figure 21. Most Cited Patents for wipes.

Only six of these patents have an in-depth description of the absorbent layers in the body of the wipes, the process or the polymer used to build wipes. We report below the information and abstract of these six patents, upon which the wipes technology is built.

US5284703A High pulp content nonwoven composite fabric - Kimberly Clark Worldwide Inc - 1994

A high pulp content nonwoven composite fabric is disclosed. The composite fabric contains more than about 70 percent, by weight, pulp fibers which are hydraulically entangled into a continuous filament substrate. This high pulp content composite nonwoven fabric may be used as a heavy-duty wiper or as a fluid distribution material, cover material, and/or absorbent material in an absorbent personal care product. Also disclosed is a method of making the high pulp content nonwoven composite fabric.

US5509915A Thin absorbent article having rapid uptake of liquid - Kimberly Clark Worldwide Inc – 1996

Generally stated, the present invention provides a distinctive absorbent article comprising a backsheet layer, and a topsheet layer which is disposed in facing relation with the backsheet layer. An absorbent body is interposed between the backsheet layer and topsheet layer. The absorbent body includes a retention portion which comprises a matrix of substantially hydrophilic fibers having a distribution of high-absorbency particulate material therein. The hydrophilic fibers and high-absorbency particles can be provided in a fiber-to-particle weight ratio within the range of about 70:30 to about 30:70. A surge management layer, comprising bicomponent fibers having a denier of not more than about 3 d, is located adjacent at least one major, facing surface of the topsheet layer, and can

cooperate with the article components to provide for a liquid Penetration Rate index of not less than about 2.67 ml/sec.

US2958593A Low density open non-woven fibrous abrasive article - 3M Co – 1960

The present invention relates to non-woven fibrous abrasive articles of extremely open structure having an extremely high void volume (i.e., low density), which articles have a special utility in the floor maintenance trade, in hand scouring operations such as performed in domestic kitchens by homemakers, as well as in various industrial abrasive operations.

US4741941A Nonwoven web with projections - Kimberly Clark Worldwide Inc – 1988

Nonwoven web and method of making including interbonded thermoplastic fibers in an array of hollow projections extending outwardly from at least one surface of said web. The projections are separated by land areas of interbonded fibers, and the fiber orientation is greater in the projections than in the land areas. Either the projections or the land areas may be perforated as desired for controlled porosity and fluid flow properties. The nonwoven webs of the invention may be made by a number of processes but, preferably, are made by forming directly on a surface with corresponding projections with or without apertures and a vacuum assist or by forming on an apertured surface with a pressure differential sufficient to draw the fibers through the apertures forming the projections. The disclosure includes such webs with added fiber layers and as components of a wide variety of products including personal care items such as liners for sanitary napkins, household products such as cleaning materials and wipers, in the service product area such as towels, washcloths and bathmats, in the marine and automotive area as scrubbing and protective applicators, and in the hospital and veterinary areas as wipes and dispensing cloths. The

method and apparatus disclosed may be varied as to steps and configuration to impart desired web constructions and properties, and preferred embodiments are disclosed.

US5389202A - Process for making a high pulp content nonwoven composite fabric - Kimberly Clark Worldwide Inc – 1995

A high pulp content nonwoven composite fabric is disclosed. The composite fabric contains more than about 70 percent, by weight, pulp fibers which are hydraulically entangled into a continuous filament substrate. This high pulp content composite nonwoven fabric may be used as a heavy duty wiper or as a fluid distribution material, cover material, and/or absorbent material in an absorbent personal care product. Also disclosed is a method of making the high pulp content nonwoven composite fabric.

US20040127614A1 - Polyolefin adhesive compositions and articles made therefrom – ExxonMobil Chemical – 2004

Embodiments of the present invention relate to article comprising a polymer comprising one or more C3 to C40 olefins, optionally one or more diolefins, and less than 5 mole % of ethylene having a Dot T-Peel of 1 Newton or more, a branching index (g') of 0.95 or less measured at the Mz of the polymer; and an Mw of 100,000 or less. This invention further relates to a process to produce an olefin polymer comprising: 1) selecting a first catalyst component capable of producing a polymer having an Mw of 100,000 or less and a crystallinity of 20% or less; 2) selecting a second catalyst component capable of producing polymer having an Mw of 100,000 or less and a crystallinity of 40% or more; 3) contacting the catalyst components in the presence of one or more activators with one or more C3 to C40 olefins, in a reaction zone.

Last, Figure 22 shows the patent landscape for wipes. As we previously saw in Figure 13, in these two landscapes we have only one area with very high density. Our search targets a very specific product category; therefore, it is clear that the projection reflects the lack of diversity. In Figure 22, P&G's active patents are marked in red and Kimberly-Clark's in blue. It is interesting to notice that in the high-density area there are a few patents from 3M and Unicharm as well, differently from the landscape for facemasks, where 3M dominated most of the higher density portion of the map.

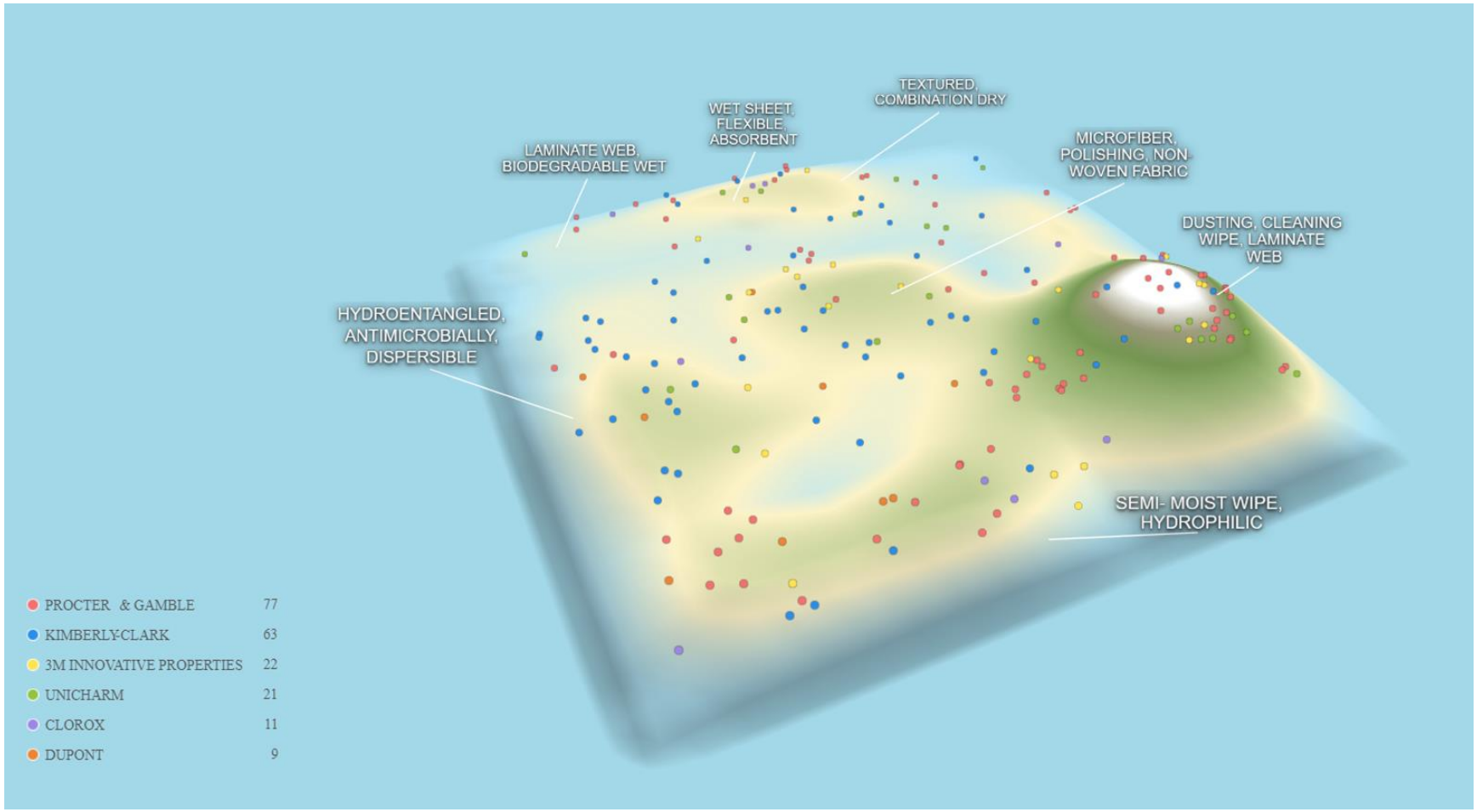

Figure 22. Landscape for wipes.

4.2.3. Data analysis

To map the technology we again collected all the patents of the database in an Excel spreadsheet that included all the relevant information, such as title, abstract, publication year, main IPC, and claims. We transferred the patent numbers and their claims to a Word document, whose search function is able to highlight single words in each claim. We selected the keywords used for the search based on all possible variations of the technology of interest, which included meltblown, spunbond, electrospun, wet-lay, air-lay, spunlace, coform, carding, hydroentangling, and charging. Differently from the case of facemasks, almost none of the patents contained the words "electrospun" or "charged", which were then excluded from the results. The keywords used were "blow", "spun", "laid", "card-", "coform"/ "co form"/ "co-form", and "hydroentangl-". We inspected each result in the Word document to assess its pertinence to the search, and, in case of positive outcome, we reported the results in the original spreadsheet in the designated technology column and in the corresponding patent cell. Figure 23 shows even with wipes, the most used technology is meltblown, but differently from facemasks, spunbond technology is equally mentioned in patents. In wipes, the combination of spunbond and meltblown is more frequent (meltblown+spunbond >50% of meltblown/spunbond) than in facemasks. We also note a more significant presence of other technologies, such as air laid, wet laid, and carding, almost absent in facemasks. The diversified technology mapping is probably the consequences of a more diversified market and manufacturing compared to facemasks.

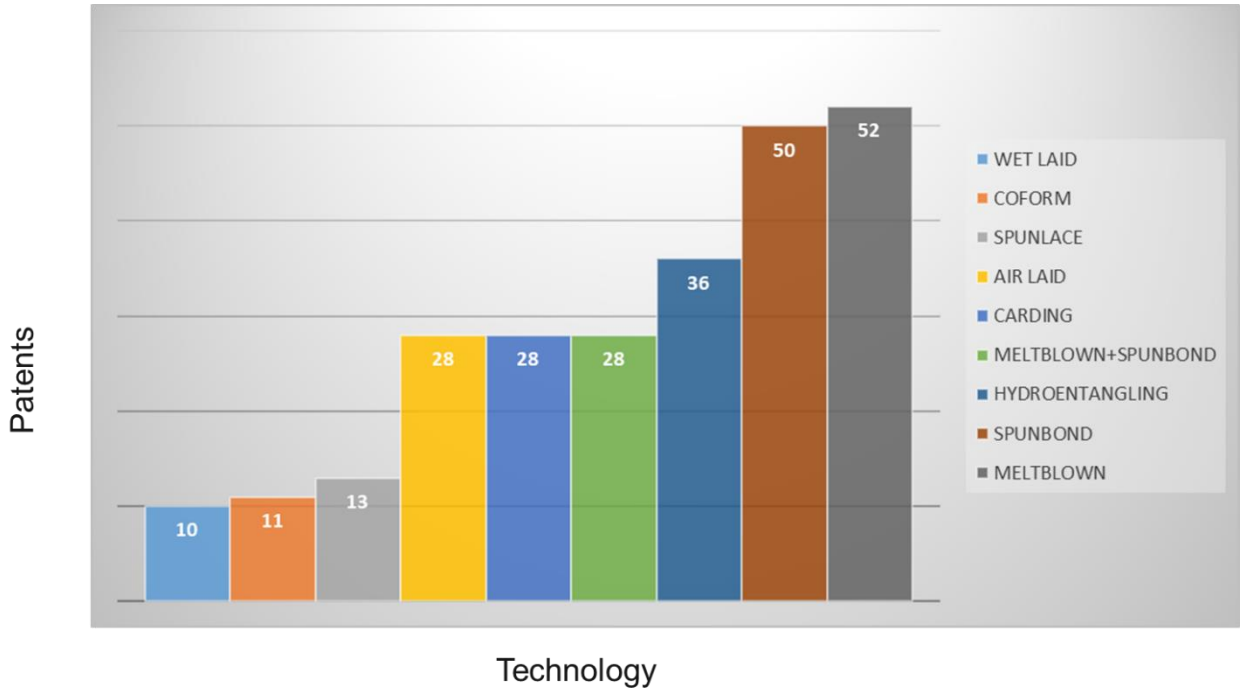

Figure 23. Technology mapping in wipes.

For timescale mapping, we selected the most recurring technologies, *i.e.* meltblown and spunbond, and we plotted the number of all relevant patents published for each 5-year block (Figure 24).

We can identify three peaks for each technology. Meltblown technology came first, with several publications in the late 80s, followed by a rise in spunbond publications in the mid-90s. Both technologies show a major peak in publications in years 2000-2005, which is a similar result to the trends of IPC sub-groups (Figure 20). Because in those years there was also a peak in publications for cloth/pads and implements for cleaning floors, we can conclude that the technologies used to produce them were mostly meltblown and spunbond. Despite the prolific 2000-2005 block, the next 5 years still saw a significant number of publications. However, the third and last peaks in both curves show that a new trend for the production of wipes involved first the spunbond technology (years 2011-2015), followed by a rapid increase of published patents of

meltblown wipes in recent years. This result is similar to the trend of the IPC sub-groups for cleaning and for wipes combined with other objects. We can conclude that the next five years will see a rise in sells of meltblown and spunbond lines for increased capacity, followed by an increase in sells of wipes for cleaning surfaces and combined with other objects.

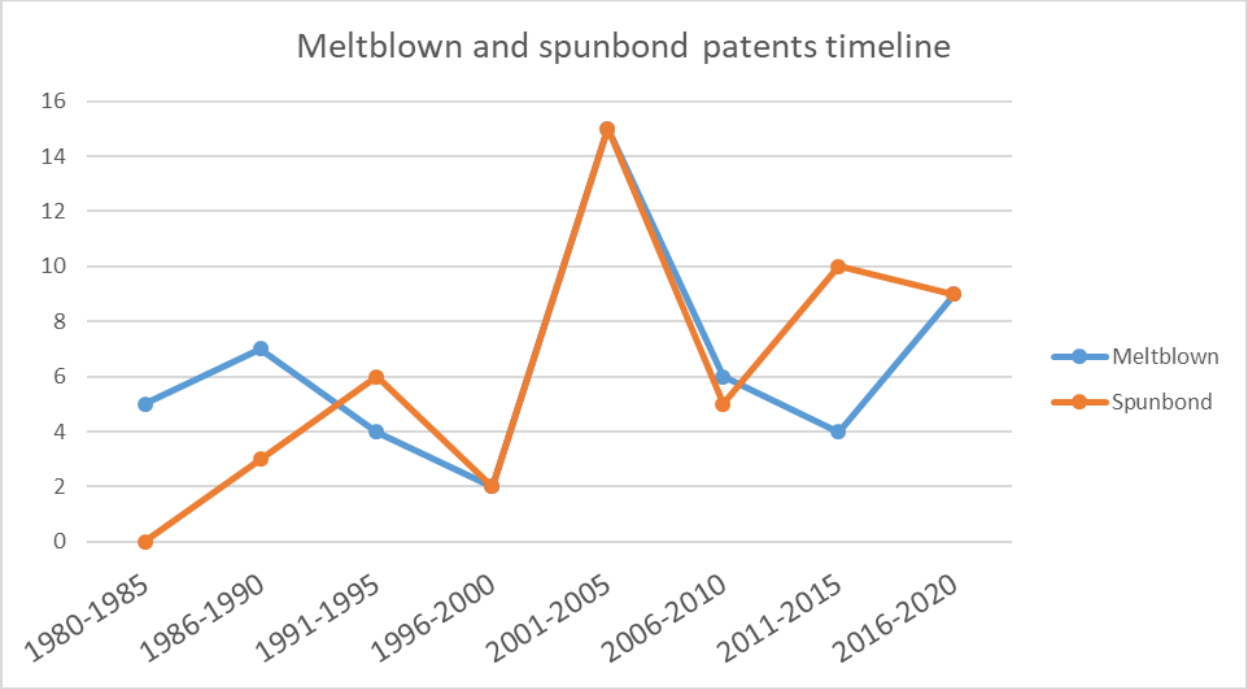

Figure 24. Time Scale Mapping for wipes.

5. PATENT STRATEGY

5.1. Language utilization in patents

When law and science interact in the form of patents, the dialogue between these two disciplines can be extremely challenging. The current patent system is based on a tradition where the language in patents is often complex and almost impossible for lawyers to decode and connect with the theory of the law. When the legal actors lack the capacity to develop doctrinal adaptations and test those adaptations, their ability to create effective legal doctrine can break down (Feldman, 2008). The communication between law and science could be improved, however not exactly fixed, by the adoption of plain language patents, meaning that patent drafters are required to describe technological and scientific issue in plain language. Often, legal actors invested in the field of patent law do not have a scientific background (Feldman, 2008), therefore their understanding of the subject and of the technical terms can limit their capacity of considering the legal questions and the precedents. In the same way, plain language patents would benefit district court judges charged with patent interpretation and jurors, who decide on other elements of patent cases.

Moreover, legal actors with a scientific background may be trained in disciplines that are different from the one at stake, and their studies can be obsolete compared to the technology of the moment. It can be noted that knowledge in a specific scientific field does not confer the ability to decipher all the issues related to other scientific fields.

The process of drafting patents and claims confers to the patentee the right to use the language in the way they see most fit. Patentees can be their own lexicographer. Patent drafters are free to create words and use jargon as they want, as long as the words in the claims are defined in the specification and they must use it consistently with that. Where the inventor or the patent

drafter fail to define a new word they have used in the claims, or fail to indicate that they have adopted an uncommon or new definition of that word, the word must be interpreted based on the understanding of its common meaning to someone of ordinary skill in the art. In other words, the specification should be considered a dictionary for interpreting the claims.

Code-like communication is the standard in patents. For example, there is a patent that describes an invention as comprising the components x, y, and z; someone might think that the invention is made up of only x, y, and z. However that is not an accurate assumption because "comprising" is in an open-ended code word representing the fact that the invention could include elements not actually listed (Feldman, 2008). On the other hand, the word "consisting" is a code word used to indicate that the elements listed are the only elements. One idea to keep in mind is that language is fluid and will always be subject to varying interpretations, no matter how clear and plain it is intended to be. Moreover, patents by their very nature describe something innovative. Many patent drafters find themselves in the difficult position of trying to use existing language to describe something that did not exist when the language was developed. It is also true that an invention described in a patent often must be compared to products that did not exist at the time of the patent. This makes patent drafting a particularly challenging enterprise, which means that there is no perfect solution to solve the problem of the difficult use of the language that is found in patents.

The issue of difficult uniform interpretation in patent law was also reflected in the court system. Many courts would handle patent cases and the variety of interpretations would pose a serious danger to the doctrine of stare decisis of the American system. To help solve this problem, the US Congress created the Court of Appeals for the Federal Circuit in 1982 and designated, among other things, that the court would hear all circuit level patent appeals. The Federal Circuit

it is the only appellate-level court other than the Supreme Court with the jurisdiction to hear patent case appeals, and it was intended to bring rationality and uniformity to federal patent appeals, on the theory that an appellate group with greater experience in this challenging area could produce a more coherent body of law. In particular, Congress was concerned about the inconsistency with which federal appeals courts upheld or overturned the validity of patents. Additionally, the Court of Appeals for the Federal Circuit has nationwide jurisdiction to hear appeals in specialized cases, such as those involving patent laws, and cases decided by the U.S. Court of International Trade and the U.S. Court of Federal Claims.

5.2. Patent Claims

The patent claims are the heart of the patent because they define the scope of protection given to an invention and define the exclusive right granted to the patent applicant. The claims are usually the first and most addressed part of a patent application reviewed by the patent examiner. These are also the first thing that is drafted by the patentee (or the patent agent, or the inventor). When writing the claims first, the patentee matures a clear idea of what needs to be addressed in the specification. In the specification, precisely in the detailed description, the patentee should support the claims, for instance if a high abstract term is used in the claims, this term should be addressed and explained in the description. Moreover, the description should provide sufficient depth so that the claims can be interpreted in the narrow sense during a patent prosecution to avoid prior art (Jelsch, 2016). While patent claims represent the heart of the patent and define what is actually granted to the patent owner, the specification and the drawings are there to help facilitate the understanding of the invention disclosed.

Drafting the claims starts with the concept of “antecedent basis”, that means that all the elements mentioned in the claims must be introduced using the indefinite articles “a” or “an” the

first time these are mentioned. Later on, when we refer to these elements for a second time, we will address them as “the” or “said (object)”. This technique helps in connecting the different elements.

When first drafting patent claims, the patentee includes both broad and narrow claims to have a range of options. Broad claims will catch a wider group of infringers, and at the same time, narrow claims will be more likely to be “valid” in light of prior art not known during prosecution (Jelsch, 2016). Patent drafters must be creative in order to receive the maximum protection possible!

Patent claims must define the invention for which patent protection is being sought, be clear and concise, and be supported by the description and drawings drafted in terms of technical features of the invention.

An example of the language used in drafting patent claims is the US patent no. 8962501B2, with title “Nonwovens and articles containing submicron fibers” by P&G, 2015.

> *1. A nonwoven web product comprising at least one fibrous web comprising sub-micron fibers which comprise a polyolefin polymer, wherein the sub-micron fibers comprise a fibrillated polyolefin polymer melt film product obtained from a system at a polymer throughput of more than 1 gram per minute per orifice and have a standard deviation of fiber diameter distribution that is less than 0.5 micron, the fibrous web having a shot amount below an average of 10 shot particles per square-millimeter and no amount of web pinhole shot-created defects as determined at 10× magnification, wherein the shot comprises discrete polymer mass in spherical, ellipsoidal, or combined shapes thereof with a largest dimension ranging from 10 microns to 500 microns, and the fibrous web has a mean pore diameter of less than about 15 microns.*

2. The nonwoven web product of claim 1, wherein the polyolefin polymer comprises a polypropylene polymer.

3. The nonwoven web product of claim 1, wherein the sub-micron fibers of said fibrous web have a standard deviation of fiber diameter distribution that is less than about 0.3 micron.

4. The nonwoven web product of claim 1, wherein the sub-micron fibers have an average fiber diameter of from about 0.1 micron to below about 0.9 micron.

5. The nonwoven web product of claim 1, wherein 35% or more of fibers of the at least one fibrous web are polyolefin-containing sub-micron fibers.

6. The nonwoven web product of claim 1, wherein 75% or more of fibers of the at least one fibrous web are polyolefin-containing sub-micron fibers.

7. The nonwoven web product of claim 1, wherein 95% or more of fibers of the at least one fibrous web are polyolefin-containing sub-micron fibers.

8. The nonwoven web product of claim 1, wherein the nonwoven web product has a basis weight of from about 0.01 gsm to about 200 gsm.

9. The nonwoven web product of claim 1, wherein said polymer throughput is more than 50 grams per minute per orifice.

10. An article comprising a nonwoven web product according to claim 1 in combination with at least one different layer.

11. The article of claim 10, wherein said different layer comprises a spunbond layer.

12. The article of claim 10, wherein the article is selected from the group consisting of filters, medical apparel, medical cleaning wipes, housewrap construction materials,

bandages, protective clothing, battery separators, catalyst carriers, diapers, training pants, adult incontinence pads, catamenial products, feminine care pads, and pantiliners, tampons, personal cleansing articles, personal care articles, personal care wipes, baby wipes, facial wipes, body wipes, and feminine wipes, and combinations thereof.

The drafting of this claim first shows how independent and dependent claims relate to each other. The first claim is an independent claim, the only one in this patent. The invention is described as a nonwoven web product made of a fibrous web that comprises submicron fiber. The claim then proceeds to broadly mention the polymer category, polyolefin, employed and the process, with details about the system throughput and the fibers dimensions. The following claims, from 1 to 12, add more details to the features described in claim 1 and for this reason these are called dependent claims.

This patent in particularly suitable for showing how to investigate the patent strategy of a company from its patent claims. If we look at claim 12, we see that it covers a very high range of applications. Most likely, the company will not pursue all those applications, however the purpose of this drafting technique is to prevent the competitors from using this technology. Thanks to PatSnap™, we can also compare the claims of patent US8962501B2 with the ones originally presented in the application number US20110147301A1. During the patent prosecution process, the patent examiners rejected two independent claims, number 15 and 20.

15. A process for making a nonwoven web product comprising: flowing at least one polymer fluid stream through at least one bounded polymer passage which ends in at least one opening in a heated wall of at least one of a first and second opposing walls of a slot, wherein each polymer fluid stream extrudes in the form of a film from each said opening to provide an extruded polymer film on a heated wall surface, wherein aggregate polymer

throughput of the slot is from about 10 kg/hr/m to about 200 kg/hr/m; combining each extruded polymer film with a pressurized gas stream flowing within a gas passage confined between the first and second opposing walls to fibrillate the polymer film to form fibers comprising sub-micron diameter fibers which exit from an exit end of the gas passage, forming a fibrous web comprising the sub-micron fibers, wherein the sub-micron fibers of said fibrous web have a standard deviation of fiber diameter distribution that is less than about 0.5 micron, and the fibrous web having a shot amount below an average of 10 shot particles per square-millimeter, wherein the shot comprises discrete polymer mass in spherical, ellipsoidal, or combined shapes thereof with a largest dimension ranging from 10 to 500 microns, and the fibrous web has a mean pore diameter of less than about 15 microns.

16. The process of claim 15, wherein the sub-micron fibers of said fibrous web having a standard deviation of fiber diameter distribution that is less than about 0.3 micron.

17. The process of claim 15, wherein 35% or more of the fibrous web is comprised of the sub-micron fibers.

18. The process of claim 15, wherein the nonwoven web product has a basis weight of from about 0.1 gsm to about 50 gsm.

19. The process of claim 15, wherein the sub-micron fibers are comprised of a polymer selected from the group consisting of polyolefins, polyesters, polyamides, biodegradable polymers, polyurethanes, polystyrenes, alkyd resins, poly-hydroxyalkanoic acids, and combinations thereof.

20. A process for making a nonwoven web product comprising: flowing at least one polymer fluid stream through at least one bounded polymer passage which ends in at least one opening in a heated wall of at least one of a first and second opposing walls of a slot, wherein each polymer fluid stream extrudes in the form of a film from each said opening to provide an extruded polymer film on a heated wall surface, wherein aggregate polymer throughput of the slot is from about 10 kg/hr/m to about 200 kg/hr/m; combining each extruded polymer film with a pressurized gas stream flowing within a gas passage confined between the first and second opposing walls to fibrillate the polymer film to form fibers comprising sub-micron diameter fibers which exit from an exit end of the gas passage, forming a fibrous web comprising the sub-micron fibers, wherein said gas passage comprises a first, upstream section into which the gas enters from a supply end, a transition region, and a second, downstream section in which the gas flows to the exit end, wherein the transition region fluidly connects the first section to the second section, and the gas passage ends at the exit end of the second section, and wherein said first section of the gas passage having a decreasing cross-sectional area from the supply end to the transition region, and said second section of the gas passage having an increasing cross-sectional area from the transition region to the exit end of the second section, wherein the sub-micron fibers of said fibrous web have a standard deviation of fiber diameter distribution that is less than about 0.5 micron, and the fibrous web having a shot amount below an average of 10 shot particles per square-millimeter, wherein the shot comprises discrete polymer mass in spherical, ellipsoidal, or combined shapes thereof with a largest dimension ranging from 10 to 500 microns, and the fibrous web has a mean pore diameter of less than about 15 microns.

Both these claims provided a detailed description of the process employed to make the microfibers.

5.2.1. Claim interpretation

Rules of claim interpretation have been developed to ensure that the relevant meaning of the patent is understood with care. As a general rule, during a lawsuit, the court interprets the words in a claim as one skilled in the art at the time of invention would understand them. Factors that determine if someone is a person skilled in the art are: the level of education of the inventor, the level of education of those working in the industry, types of problems encountered in the art, prior art solution to the problems, how quickly advances are made, and the sophistication of the technology.

Some words that seem ambiguous, such as “about”, “approximately”, “essentially”, “close to”, “substantially”, or “relatively”, although imprecise, these terms are not found legally indefinite, as long as the patent specification provides enough information to guide someone skilled in the art in determine the scope of the claim.

There are general rules of patent interpretation (Moore *et al*, 1999).

> *1. Claims should be interpreted such that the preferred embodiment falls within their scope. According to the Federal Cicuit, (Victronics vs. Conceptronic Inc., 1996), an interpretation of a claim which would not include the preferred embodiment disclosed in the specification is “rarely, if ever, correct”.*
>
> *2. A patent claim is not necessarily limited to the preferred embodiment/limitations from the written description should not be read into the claims. Limitations from the preferred embodiment disclosed therein should not be read into the claims, meaning that the invention cannot be limited by what appears*

in the specification or specific examples, (for instance, by numbers mentioned in examples in the specification).

3. The doctrine of claim differentiation. Two claims in the same patent should be interpreted as having different scope. This simply means that when looking at patent claims, the reader should assume that there is a difference in scope among them. This doctrine, however, cannot allow to broaden the claims beyond their scope as determined in the specification and prosecution history. Moreover, the absence of such difference in scope between the claims would make them superfluous.

4. Claims should be interpreted so as to preserve their validity. This rules often find its use in infringement lawsuit, where the alleged infringer would assert that the patent fails to prove obviousness and for this reason should be deemed invalid.

5. When there is an equal choice between a broad and a narrow claim construction, the narrow one should always be adopted. Claim construction is the process in which courts interpret the meaning and scope of patent claims. Since the claims "define the invention to which the patentee is entitled the right to exclude," construing the claims can be a critical step in determining the outcome of almost all patent litigations. When a claim is suitable for two possible interpretations, the narrowest one should be taken into consideration, so that this results in a penalty for the patentee's ambiguity.

6. A term used repeatedly in a claim should be interpreted consistently. If a word appears in more than one claim, the assumption is that the meaning does not change.

7. A claim preamble is a limitation when it "breathes life" and meaning into the claims. The claims can be divided in three main parts: preamble, transition and body. The preamble is the beginning portion of the claim that provides the general technical background to the topic. Usually the preamble does not limit the scope of a patent, although there are two exceptions: (a) if a claim terms gets its meaning from the preamble: and (b) if the preamble is essential to define the invention described in the claims.

8. The patentee (patent drafter) is their own lexicographer. Since the description of new inventions can often require a different use of words that are already known, the patentee is free to give meaning to such words as long as they clearly indicate the new definition in the patent and they use it consistently in the specification. The specification should be considered a dictionary when writing and interpreting the claims.

5.3. Portfolio strategies

The most important part of any business or university related intellectual property management is a strong strategy. When approaching this topic there a few questions that need to be answered (Gilmore, 1991 INDA Protecting nonwovens…).

i. How do we want to protect our technology from the competition? Choosing the right IP tool is of utmost importance, (for instance patent, trademark, trade secret, or a combination).
ii. What are our key areas of technology?
iii. Are we interested in foreign protection?
iv. Who is responsible for the protection of intellectual property assets?

v. If we rely on trade secrets, how should we use them? For example, should we keep the process a secret while obtaining a patent on the end product?

vi. Last, how we will police our patents? Do we have the means to sue for patent infringement when the occasion arises?

These questions can help in developing a strategy for protecting the technology of interest. As for most things in life, there are no right answers to these questions. The best strategy depends on the kind of technology and product involved. Moreover, the type of institution, (*i.e.* university) or company determines the appropriate strategy to pursue. For example, large multinational companies like 3M will have a vast and aggressive patent strategy, where small companies and universities will carefully choose which inventions to patent because of the high costs associated with patent prosecution. The same concept applies when looking at the enforcement of patent rights. Companies like 3M will have a more "aggressive" strategy in which they sue the alleged infringers, while smaller entities have to take into consideration the very high costs of patent litigation.

Patent litigation in the US has two major stages: claim construction and a trial for infringement and damages. In a vast majority of cases, once the claim construction is completed, the writing is done and the companied tend to go for a settlement (Krajec, 2020). The American Intellectual Property Lawyer's Association (AIPLA) issues a bi-annual survey of IP-related costs (last accessed on the AIPLA website on 11/21/2020). In the latest survey, the claim construction portion of a patent litigation ranges from $250,000 for less than $1M at risk to $2.375M for cases where $25M or more is at risk. For the entire trial, the AIPLA says that for less than $1M at risk, the trial will cost $700,000, while the very high value cases will cost $4M or more.

Back to patent strategy. There are three general strategies that this dissertation will address, however these are not to be considered exhaustive due to the unique perspective that each company or institution has.

1. Proprietary strategy. Patents are often seen as "the most powerful benefit" for companies (Somaya, 2012), because they work as a shield to protect company's assets from be duplicated by the competitors. Patent litigation also offers remedies, such as injections and lost profits, that encourage the use patents to protect technological advancements. Proprietary strategy can be "offensive", meaning that drafters write the patents with the purpose of creating obstacles to the reproduction of the invention. For example, when a company has several patents that cover different ways to solve the same problem, it is using a proprietary strategy to keep the competitors distant from their technology. In other words, firms may patent potential substitute and follow-on technologies themselves and ensure that their patents are legally robust. They will keep this patent carefully maintained. Companies will not license out these patents, but often they will partner and license their technology to other companies that have complementary assets. In summary, a proprietary strategy means that the patent owner seeks to obtain a tight protection of a technology through the use of multiple patents. This kind of approach can be used for the core technology of a company, or an invention that can create significant market opportunities, or an invention that offers a unique position because there a few substitutes.

2. Defensive Strategy. The need for defensive strategies arises because a patent confers only the right to exclude others, not an affirmative right to use the

patented technology. Therefore, firms can be constrained from using even their own inventions if patents on other inventions required for commercialization are asserted against them. In turn, the owners of such patents can bargain for very substantial rents by holding up the putative infringer with the threat of a court-mandated injunction. The goal of a defensive strategy is to retain for the firm the freedom to operate and commercialize their technologies without hindrance from patents that belong to others. In prior work, defensive patent strategy is reflected in terms such as portfolio patenting, (defensive) blocking and preemption, (defensive) thickets, validity challenges.

3. Leveraging strategy. The central logic of leveraging strategies is that the bargaining advantages conferred by the exclusionary power of patents allow the company to pursue direct and indirect profit opportunities. The most obvious direct opportunities are from patent licensing revenues. Some of the patents may be in technologies that are not central to its strategy or core competence but are nonetheless valuable. Even when a company engages in the cross-licensing of entire patent portfolios, it may be able to obtain offsetting compensation for its stronger or more valuable patents (relative to the cross-licensing partner). The goal of the firm in a patent leveraging strategy is to use its patent rights to bargain effectively for rents in different contexts. Therefore, it is not necessary for the firm to patent every substitute technology or to have watertight patent protection.

5.4. Looking at the major players in the markets for facemasks and wipes

This section is dedicated into looking at the major players in the markets for facemask and wipe. It answers the questions asked in chapter two (2.2). In the previous chapters we have

identified 3M, an American multinational conglomerate of companies, and the leading character in the facemask market segment. Here we only address the US patents to be coherent with the work previously done. According to the data retrieved from PatSnap™, 3M is the standardized current assignee of 30,933 patents in the US, and 219,363 worldwide. In this pool, 29,215 are utility patents and 1,718 are design patents. As Figure 25 simplifies, 19, 226 of the patents retrieved are inactive (10,150 due to expiration and 6,456 due to non-payment), 10,088 are active and 1,617 are pending. The reason behind the high number of inactive patents relates to the choice of not limit the search in time, so that when we look at the application trend, the results provide a more accurate depiction of the technological evolution of the company through its history. In addition, as shown in Table 8, the top IPC codes relate to 8 adhesives, layered products (polyester), abrasive materials and optical elements.

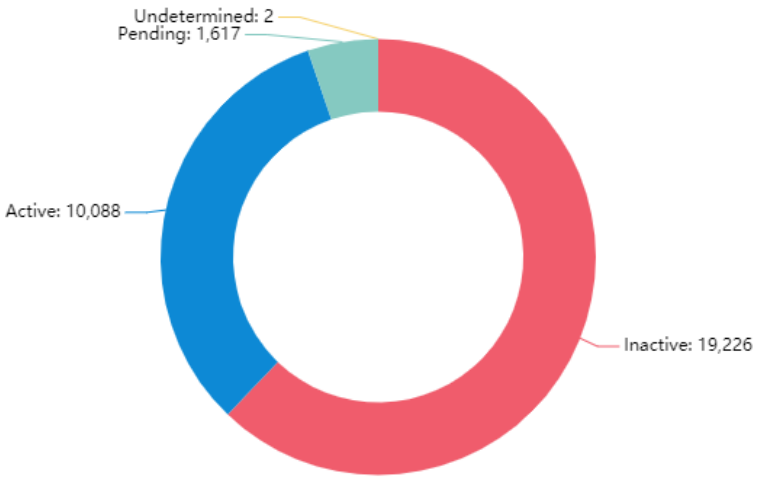

Figure 25. Simple Legal Status of 3M patents.

Table 8. Main IPC codes for 3M patents.

IPC	Code explanation	Patent No.
C09J7/02	Adhesives in the form of films or foils	1240
B32B7/12	Layered products with an interconnection of layers using interposed adhesives or interposed materials with bonding properties	709
B24D11/00	Constructional features of flexible abrasive materials; Special features in the manufacture of such materials	636
G02B5/30	Optical elements other than lenses with polarizing elements	589
B32B27/08	Layered products essentially comprising synthetic resin	511
G02F1/1335	..... Structural association of cells with optical devices, e.g. polarizers or reflectors	480
F21V8/00	Use of light guides, e.g. fiber optic devices, in lighting devices or systems	441
B32B27/36	Layered products essentially comprising synthetic resin comprising polyesters	434
C09K3/14	Anti-slip materials; Abrasives	386
G02B5/124	Reflex reflectors (plural reflecting elements forming part of a unitary plate or sheet)	385

In this last year of 2020, the company has 127 patent applications and 8 patents that have been granted. The percentage of granted patents in the last 20 years is shown in Figure 26.

Figure 26. Application and grant trend of 3M patents in the last 20 years.

Of all the patents of 3M we have identified the ones that mention the world nonwoven, and these are 6,519 documents, of which 1,965 contained the world filter. From this dataset we have isolated the 8 patents that have as application year 2020, that are shown in Table 9. Interestingly there is not one patent that is about facemasks.

Table 9. Patent Applications of 3M in 2020.

Pub. Number	**Title**	**Pub. Date**	**Main IPC**
US20200332515A1	Easy to apply air and water barrier articles	2020-10-22	E04B1/62 B32B7/12
US20200261274A1	Eye-protection headgear	2020-08-20	A61F9/06 A42B3/22
US20200254369A1	Filter cartridge for translational insertion and rotational engagement of a manifold	2020-08-13	B01D35/153 B01D35/30
US20200224367A1	Flexible fibrous material, pollution control device, and methods of making the same	2020-07-16	D21H13/36 B01D39/20 D21H27/00
US20200209123A1	Ligand-functionalized substrates with enhanced binding capacity	2020-07-02	G01N1/40 B01J20/32 B01J20/28

Table 9. Continued.

US20200199796A1	**Mat having long and short inorganic fibers**	**2020-06-25**	**D04H1/4218 F01N3/28 D04H13/00**
US20200190365A1	Adhesive articles permitting damage free removal	2020-06-18	C09J7/21
US20200141300A1	Thermally insulated components	2020-05-07	F01N13/14 F01N13/18 D06M11/79

Moving to the wipes segment, we our patent search has identified two companies that dominate this segment, The Procter & Gamble Company and Kimberly-Clark Corporation.

The Procter & Gamble Company is an American multinational consumer good corporation based in Cincinnati, Ohio and founded in 1837. From the data retrieved by PatSnap™, P&G is the standardized assignee of 22,368 US patents, of which 12,633 are inactive, (6,040 are expired and 3,799 are due to non-payment), 8,163 are active and granted, while 1,572 are pending. This is simplified in Figure 27. When looking at the patent type we can see that 19,634 of the documents are utility patents and 2,734 are design patents. From the main IPC codes of P&G patents, (Table 10), we can infer that most of the R&D and patent activity relates to absorbent materials, such as pads, diapers and tampons, and soaps and detergents.

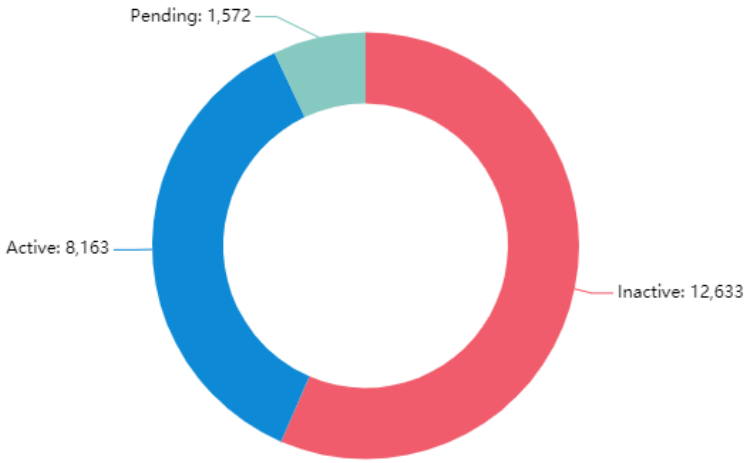

Figure 27. Simple legal status of P&G patents.

Table 10. Main IPC codes of P&G patents.

IPC	Code explanation	Patent No.
A61F13/15	. Absorbent pads, e.g. sanitary towels, swabs or tampons for external or internal application to the body (non-absorbent catamenial receptacles A61F 5/44); Supporting or fastening means therefor; Tampon applicators [2006.01]	2856
C11D3/37	.. Polymers [2006.01]	1473
A61F13/49	... specially adapted to be worn around the waist, e.g. diapers, nappies [2006.01]	1338
C11D3/00	Other compounding ingredients of detergent compositions covered in group C11D 1/00 [2006.01]	1329
C11D17/00	Detergent materials or soaps characterised by their shape or physical properties (shaping soap C11D 13/14) [2006.01]	1241
C11D17/04	. combined with or containing other objects [2006.01]	1060
C11D11/00	Special methods for preparing compositions containing mixtures of detergents [2006.01]	1035
C11D3/20	.. containing oxygen [2006.01]	994
A61K8/34	.... Alcohols [2006.01]	923
A61K8/02	. characterised by special physical form [2006.01]	755

When we narrow our search down using keywords such as nonwoven, the system retrieves 7,116 records. Adding more keywords to narrow it down even further with terms such as wipes and cleaning cloths, we find 2,718 records. In the year 2020, P&G has applied for 256 patents in the US, where 56 of these that relate to nonwovens and wipes. The application and grant trend, Figure 28, shows that in 2020 14 patents have been granted.

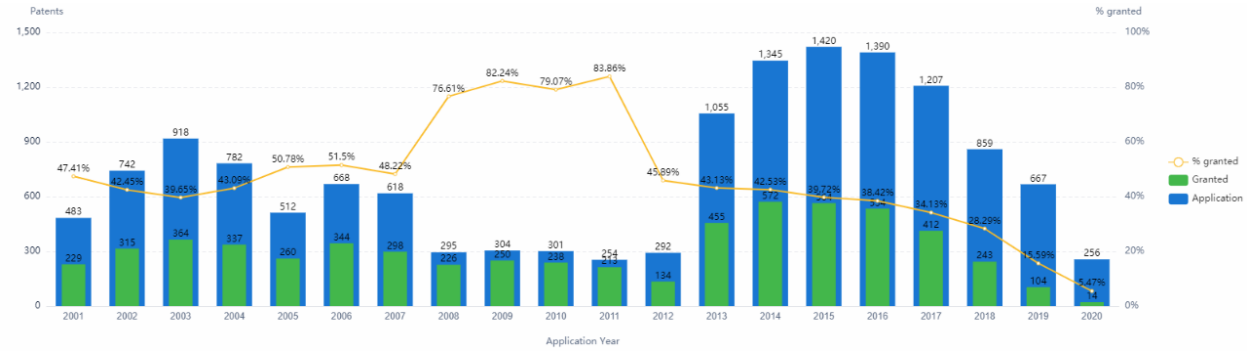

Figure 28. Application and grant trend of P&G patents in the last 20 years.

The patent number, title and publication date of these documents are listed in Table 11. Ten of these patents are design patents relating to the shape of a bottle, an air freshener cartridge and an over the counter medicinal container. The two utility patents in this list cover an oral care composition for active agent delivery, and a method for isolation a broken elastic strand in diapers.

Table 11. Patent applications of P&G in 2020.

Pub. Number	Title	Pub. Date	Main IPC
USD901300S1	Bottle	2020-11-10	
USD901299S1	Over the counter medicinal container with surface ornamentation	2020-11-10	
USD901301S1	Bottle	2020-11-10	
USD899248S1	Over the counter medicinal container with surface ornamentation	2020-10-20	
US10780032B1	Oral care compositions for active agent delivery	2020-09-22	A61K8/02 A61K8/22 A61Q11/00
USD894363S1	Air freshener cartridge	2020-08-25	
USD893309S1	Bottle	2020-08-18	
USD893302S1	Bottle	2020-08-18	
USD893301S1	Bottle	2020-08-18	
US10730715B2	Apparatus and method for isolating a broken elastic strand	2020-08-04	B65H54/00 A61F13/49 A61F13/15
USD887849S1	Bottle	2020-06-23	
USD886616S1	Bottle	2020-06-09	
USD886615S1	Bottle	2020-06-09	
USD886625S1	Bottle	2020-06-09	

The last of the three major players analysis is Kimberly-Clark Corporation (KCC herein after). KCC is a is an American multinational personal care corporation that produces mostly

paper-based consumer products. The company manufactures sanitary paper products and surgical and medical instruments. It was founded in 1872 and its headquarters are in Irving, Texas.

Thanks to PatSnap™ we know that KCC is the standardized current assignee of 8,289 patents in the US, and 70,933 worldwide. In this pool, 7,729 are utility patents and 560 are design patents. As Figure 29 simplifies, 5,214 of the patents retrieved are inactive (2,521 due to expiration and 1,935 due to non-payment), 2,087 are active and 268 are pending. In addition, as shown in Table 12, the top IPC codes relate to adhesives, layered products (polyester), abrasive materials and optical elements.

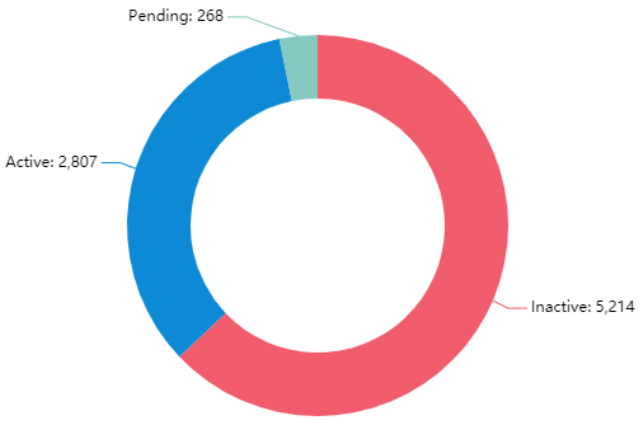

Figure 29. Simple legal status of KCC patents.

Table 12. Main IPC codes of KCC patents.

IPC	Code explanation	Patent No.
A61F13/15	. Absorbent pads, e.g. sanitary towels, swabs or tampons for external or internal application to the body (non-absorbent catamenial receptacles A61F 5/44); Supporting or fastening means therefor; Tampon applicators [2006.01]	2198
A61F13/20	.. Tampons, e.g. catamenial tampons; Accessories therefor [2006.01]	593
A61F13/49	... specially adapted to be worn around the waist, e.g. diapers, nappies [2006.01]	524
A61F13/56	.. Supporting or fastening means [2006.01]	430
D04H13/00	Other non-woven fabrics [2006.01]	352
A61F5/44	. Devices worn by the patient for reception of urine, faeces, catamenial or other discharge (absorbent pads, e.g. sanitary towels, A61F 13/15; drainage appliances for wounds A61M 27/00); Colostomy devices (adhesives for colostomy devices A61L 24/00; materials for colostomy devices A61L 28/00) [2006.01]	311
A61L15/16	. Bandages, dressings or absorbent pads for physiological fluids such as urine or blood, e.g. sanitary towels, tampons [2006.01]	277
D21H27/00	Special paper not otherwise provided for, e.g. made by multi-step processes [2006.01]	268
B32B5/26	... another layer also being fibrous or filamentary [2006.01]	249
D21F11/00	Processes for making continuous lengths of paper, or of cardboard, or of wet web for fibreboard production, on paper-making machines [2006.01]	228

In this last year of 2020, the company has 15 patent applications and 1 patent that has been granted. The percentage of granted patents in the last 20 years is shown in Figure 30.

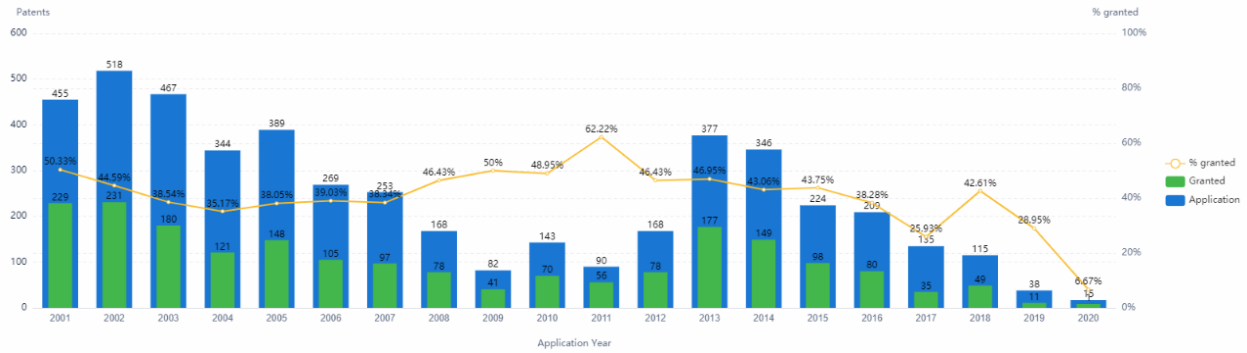

Figure 30. Application and grand trend of KCC patents in the last 20 years.

In this dataset we have we have identified the patents that mention the word nonwoven, and these are 4,832 documents, of which 1,814 contained the world wipe. Here, we have isolated the 15 patents that have as application year 2020, that are shown in Table 13.

Table 13. Patent applications of KCC in 2020.

Pub. Number	Title	Publication Date	Main IPC
US20200354591A1	Anti-adherent composition	2020-11-12	C09D7/63
USD899587S1	Absorbent article	2020-10-20	-
US20200311626A1	System and Method for Instructing Personnel on Washroom Maintenance Requirements	2020-10-01	G06Q10/06
US20200297546A1	Absorbent article with a fastening system with reduced waste and method of manufacturing the same	2020-09-24	A61F13/15
US20200297169A1	Product use acoustic determination system	2020-09-24	A47K5/12
US20200276060A1	Absorbent article with body conforming structure	2020-09-03	A61F13/472

Table 13. Continued.

US20200268569A1	**Diaper pants having a partial non-overlapping waist panel structure free of inner material and elastics**	**2020-08-27**	**A61F13/49**
US20200268567A1	Elasticated materials with directional stretch properties	2020-08-27	A61F13/496
US20200240085A1	Soft high basis weight tissue	2020-07-30	D21H27/00
US20200197973A1	Adhesive applicator with rotary valve	2020-06-25	B05C5/02
US20200187725A1	Multi-ply resilient tissue products	2020-06-18	A47K10/16
US20200170844A1	Method of manufacturing bridged absorbent structures	2020-06-04	A61F13/15
US20200170461A1	Optical product use determination system	2020-06-04	A47K10/44
US20200157740A1	Laminated papermaking belt	2020-05-21	D21F7/08
US20200157744A1	Smooth and bulky tissue	2020-05-21	D21H27/00

6. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

6.1. Conclusions

The first purpose of this research was to understand the process behind patent searching and provide a systematic guide that shows how to do patent landscape analysis when addressing nonwoven products. To achieve this goal the literature review was conducted to understand the tools of patent searching, as well as the main strategies that help in retrieve accurate results. In Chapter 3, we explain what a patent search is and how to perform this task using PastSnap™, a proprietary software. Then we show examples of how to start the patent searching process for nonwoven products, specifically facemasks and wipes.

The second purpose of the study was to identify technology drivers when addressing a specific product in the nonwovens market. When addressing this task, we use the patents collected in the dataset that we have created, we isolate the processes using a keyword search in the claims, and project their development through time. For instance, when analyzing patents related to facemasks, we look at the technology employed to make the filtration layer, and then create a graph where we show the technology trend of the last 20 years.

The third and last purpose of the study was to investigate the topic of patent strategy, specifically relating to the language of patents and claim drafting. In Chapter 5, we address this task starting with investigating the importance of using plain language in patents. We move on to the topic of patent claims, where we explain how these are interpreted, often during the litigation of the patent, and then we show an example of claim drafting of patent on an invention related to nonwovens.

The answers to the research objectives and questions can be summarized as follows:

Objective 1: Create a systematic guide into patent search for nonwoven products

- Research question 1: How can we select accurate keywords?

First, we find a definition of the product of interest, for example the definition of respirators given by the FDA, and then we build the table of concepts, that supports the brainstorming of keywords based on the different features, function, materials, and manufacturing process of the product.

- Research question 2: What is the role of classification codes in the search and what are the criteria to choose a patent classification?

Classification codes are indispensable tools that combined with keywords; assist in retrieving accurate results, which match the product or process of interest. For the purpose if this research, we chose the International Patent Classification because it is the most used by patent offices worldwide. This research is limited to US; however it can be extended to patents worldwide easily because the same search queries can be employed.

Objective 2: Explain the role and importance of technology (or technological) market drivers.

- Research question 3: Can we identify nonwoven technology drivers through patent analysis?

The answer to the third research question is yes. We have intended the technology drivers as the manufacturing processes for nonwovens products that are currently the most adopted. In Chapter 4, we have shown and the explained the process for identifying the technology drivers for both facemasks and wipes.

- Research question 4: Which are the technology drivers in the nonwovens industry?

We have found the meltblowing process to be technology drivers for the facemasks market segment, and both meltblowing and spunbonding for the wipes segment.

Objective 3: Explore the concept of patent strategy.

- Research question 5: What is the importance of the use of plain language in patents?

The use of language, specifically the English language, in patent drafting is different from the common use. Patent drafters can be their own lexicographers and it is important that they use the specification of the patent as a dictionary of what meaning they intend for the words they use.

- Research question 6: What are the patent strategies of major players for facemasks and wipes?

In the last part of Chapter 5, we have looked into the patent applications of the major players of the facemasks and wipes markets in the last year.

6.2. Research Contribution

The work conducted in this dissertation is essentially the first academic attempt to approach the patent landscape analysis of nonwovens. The investigation illustrated the development of a systematic guide into patent search tools and techniques for searching patents in the nonwovens industry. The research findings show the major players in the markets for facemasks and wipes, and the technology drivers. In addition, the dissertation aims to show the basics of claim construction and interpretation, providing an example of the claims of a nonwoven patent when the prosecution processes started and when the patent was granted.

The guide is meant to help students, and anyone who is not familiar with patent search, to perform meaning searches and understand why claims are written in the way they are.

6.3. Recommendation for Future Studies

The following are recommendations for future studies related to this research.

1. Expand the search to international databases. Because of time limitations, we could only address the US patents.

2. Compare the results with the ones obtained using a different platform. Patent searching tools are different in the way the documents are retrieved. Future research can compare the data retrieved from other platforms and develop an understanding of the differences between them.

3. Cleaning data with an automated method. The cleaning of data in this research has been done manually; all the patents have been checked before entering the dataset. The screening has been done mainly using the information contained in title, abstract and claims. For a future research it would be interesting to clean data using an automated method, for example Text Mining, compare the results with the present dissertation and look at advantage and disadvantage of both methods.

4. In 2020, the COVID-19 pandemic in 2020 had a huge impact on both the facemasks and wipes market segments. The present research is completed before it is possible to see this impact reflect in the patent application trends and the market data reports available to NC State users. It would be very interesting to pursuing this study in the next three years.

7. REFERENCES

Abbas, A., Zhang, L., & Khan, S. U. (2014). A literature review on the state-of-the-art in patent analysis. In World Patent Information (Vol. 37, pp. 3–13). https://doi.org/10.1016/j.wpi.2013.12.006

Abood, A., & Feltenberger, D. (2018). Automated patent landscaping. Artificial Intelligence and Law, 26(2), 103–125.

Abraham, B. P., & Moitra, S. D. (2001). Innovation assessment through patent analysis. Technovation. https://doi.org/10.1016/S0166-4972(00)00040-7

Adams, D. (2015). Patents Demistified. ABA Publishing.

Adams, S. (2001). Comparing the IPC and the US classification systems for the patent searcher. World Patent Information, 23(1), 15–23. https://doi.org/10.1016/S0172-2190(00)00110-1

Alcácer, J., & Gittelman, M. (2006). Patent Citations as a Measure of Knowledge Flows : The Influence of Examiner Citations Author (s): Juan Alcácer and Michelle Gittelman Source : The Review of Economics and Statistics , Vol . 88 , No . 4 (Nov ., 2006), pp . 774-779 Published by : The M. The MIT Press, 88(4), 774–779.

Alexander, J. (2020). N95 vs FFP3 & FFP2 masks - what's the difference? https://fastlifehacks.com/n95-vs-ffp/

Altuntas, S., Dereli, T., & Kusiak, A. (2015). Forecasting technology success based on patent data. Technological Forecasting and Social Change, 96, 202–214. https://doi.org/10.1016/j.techfore.2015.03.011

Anick, P., Verhagen, M., & Pustejovsky, J. (2014). Identification of technology terms in patents. Proceedings of the 9th International Conference on Language Resources and Evaluation, LREC 2014, 2008–2014.

Aristodemou, L., & Tietze, F. (2018). A literature review on the state-of-the art on Intellectual Property Analytics (IPA). World Patent Information, Special Is(Forthcoming).

Asche, G. (2017). “80% of technical information found only in patents” – Is there proof of this? In World Patent Information (Vol. 48, pp. 16–28). Elsevier Ltd. https://doi.org/10.1016/j.wpi.2016.11.004

Ba1azy, A., Toivola, M., Adhikari, A., Sivasubramani, S. K., Reponen, T., Grinshpun, S. A., & Poland, W. (2006). Do N95 respirators provide 95% protection level against airborne viruses, and how adequate are surgical masks? AJIC. https://doi.org/10.1016/j.ajic.2005.08.018

Basberg, B. (1987). Patents and the measurement of technology change: A survey of the literature. Research Policy, 16, 131–141.

Baudour, F., Bodart, P., Bourbon, E., Bourgeois-Tassanary, M., Boyer-Joubert, C., Delannoy, G., Hutsebaut, S., & Windels, F. (2016). Patent Information Professional: Swiss army knife chameleon? In World Patent Information (Vol. 47, pp. 75–82). Elsevier Ltd. https://doi.org/10.1016/j.wpi.2016.09.005

Berg, S., Wustmans, M., & Bröring, S. (2018). Identifying first signals of emerging dominance in a technological innovation system: A novel approach based on patents. Technological Forecasting and Social Change, July, 0–1. https://doi.org/10.1016/j.techfore.2018.07.046

Braga, E. J., Ribeiro de Souza, A., Leal de Lima Soares, P., & Rodrigues, R. C. (2018). The role of specification in patent applications: A comparative study on sufficiency of disclosure. World Patent Information, 53, 58–65. https://doi.org/10.1016/j.wpi.2018.05.008

Brouthers, K. D., Andriessen, F., & Nicolaes, I. (1998). Driving blind: Strategic decision making in small companies. Long Range Planning, 31(1), 130–138. https://doi.org/10.1016/S0024-6301(97)00099-X

Callaert, J., Van Looy, B., Verbeek, A., Debackere, K., & Bart, T. (2006). Traces of Prior Art: An analysis of non-patent references found in patent documents. Scientometrics, 69(1), 3–20. https://doi.org/10.1007/s11192-006-0135-8

Candelin-Palmqvist, H., Sandberg, B., & Mylly, U. M. (2012). Intellectual property rights in innovation management research: A review. In Technovation (Vol. 32, Issues 9–10, pp. 502–512). Elsevier Ltd. https://doi.org/10.1016/j.technovation.2012.01.005

Cho, H. P., Lim, H., Lee, D., Cho, H., & Kang, K. I. (2018). Patent analysis for forecasting promising technology in high-rise building construction. Technological Forecasting and Social Change, 128, 144–153. https://doi.org/10.1016/j.techfore.2017.11.012

Choi, D., & Song, B. (2018). Exploring technological trends in logistics: Topic modeling-based patent analysis. Sustainability (Switzerland), 10(8), 15–17. https://doi.org/10.3390/su10082810

Clancy, M. S. (2018). Inventing by combining pre-existing technologies: Patent evidence on learning and fishing out. Research Policy, 47(1), 252–265. https://doi.org/10.1016/j.respol.2017.10.015

Clarke, N. S. (2018). The basics of patent searching. World Patent Information, 54, S4–S10. https://doi.org/10.1016/j.wpi.2017.02.006

Comai, A. (2018). Beyond patent analytics: Insights from a scientific and technological data mashup based on a case example. World Patent Information, 55, 61–77. https://doi.org/10.1016/j.wpi.2018.10.002

Comins, J. A., Carmack, S. A., & Leydesdorff, L. (2018). Patent citation spectroscopy (PCS): Online retrieval of landmark patents based on an algorithmic approach. Journal of Informetrics, 12(4), 1223–1231. https://doi.org/10.1016/j.joi.2018.10.002

Curran, J. (2020). Respiratory Protection Equipment Manufacturing in the US, IbisWorld.

Dapurkar, D., & Telang, M. (2017). A patent landscape on application of microorganisms in construction industry. World Journal of Microbiology and Biotechnology, 33(7), 1–12. https://doi.org/10.1007/s11274-017-2302-x

David, C. (2017). Patent Law for Innovators: Protecting the technologies and products that drive growth in the textile industry.pdf. Specialty Fabrics Review, 102(6), 60–63.

Davies, G. (2005). Language and patents. ATRIP Congress, 2–12.

Deboys, J. (2004). Decision pathways in patent searching and analysis. World Patent Information, 26(1), 83–90. https://doi.org/10.1016/j.wpi.2003.09.001

Demey, Y. T., & Golzio, D. (2020). Search strategies at the European Patent Office. World Patent Information, 63(April), 101989. https://doi.org/10.1016/j.wpi.2020.101989

Dereli, T., & Durmuşoğlu, A. (2009). Classifying technology patents to identify trends: Applying a fuzzy-based clustering approach in the Turkish textile industry. Technology in Society, 31(3), 263–272. https://doi.org/10.1016/j.techsoc.2009.06.007

Dirnberger, D. (2011). A guide to efficient keyword, sequence and classification search strategies for biopharmaceutical drug-centric patent landscape searches - A human recombinant insulin patent landscape case study. World Patent Information, 33(2), 128–143. https://doi.org/10.1016/j.wpi.2010.12.003

Doran, P., & Webster, E. (2019). Who influences USPTO patent examiners? World Patent Information. https://doi.org/10.1016/j.wpi.2019.01.005

Ernst, H. (1998). Patent portfolios for strategic R&D planning. Journal of Engineering and Technology Management - JET-M, 15(4), 279–308. https://doi.org/10.1016/S0923-4748(98)00018-6

Ernst, H. (2003). Patent information for strategic technology management. World Patent Information. https://doi.org/10.1016/S0172-2190(03)00077-2

Fall, C. J., Benzineb, K., & Karetka, G. (2005). Automated Categorization in the International Patent Classification. www.wipo.int/classifications

Fattori, M., Pedrazzi, G., & Turra, R. (2003). Text mining applied to patent mapping: A practical business case. World Patent Information. https://doi.org/10.1016/S0172-2190(03)00113-3

Feldman, R. (2008). Plain Language Patents. Texas Intellectual Property Law Journal, 17(2), 289–304.

Foglia, P. (2007). Patentability search strategies and the reformed IPC: A patent office perspective. World Patent Information. https://doi.org/10.1016/j.wpi.2006.08.002

Fritsch, M., & Lukas, R. (2001). Who cooperates on R&D? Research Policy, 30(2), 297–312. https://doi.org/10.1016/S0048-7333(99)00115-8

Gao, Y., Zhu, Z., & Riccaboni, M. (2018). Consistency and trends of technological innovations: A network approach to the international patent classification data. Studies in Computational Intelligence, 689, 744–756. https://doi.org/10.1007/978-3-319-72150-7_60

Gex-Collet, A. (2018). Attitude and process – Key aspects for improving search performance. World Patent Information, 54, S11–S17. https://doi.org/10.1016/j.wpi.2017.04.004

Gilmore, T. F. (1991). Protecting nonwovens creativity the importance of patents.pdf. IndaTec91 - Book of Papers, 33–40.

Hall, B. H., Jaffe, A., & Trajtenberg, M. (2005). Market Value and Patent Citations. In Source: The RAND Journal of Economics (Vol. 36, Issue 1).

Han, Q., Heimerl, F., Codina-Filba, J., Lohmann, S., Wanner, L., & Ertl, T. (2017). Visual patent trend analysis for informed decision making in technology management. World Patent Information, 49, 34–42. https://doi.org/10.1016/j.wpi.2017.04.003

Harhoff, D., Scherer, F. M., & Vopel, K. (2003). Citations, family size, opposition and the value of patent rights. Research Policy. https://doi.org/10.1016/S0048-7333(02)00124-5

Harris, E. (2018). Immunotherapeutics for the treatment of prostate cancer : a patent landscape based on key therapeutic mechanisms of actions. Pharmaceutical Patent Analyst, 7(1), 47–57.

Hassan, M. A., Yeom, B. Y., Wilkie, A., Pourdeyhimi, B., & Khan, S. A. (2013). Fabrication of nanofiber meltblown membranes and their filtration properties. Journal of Membrane Science, 427, 336–344. https://doi.org/10.1016/j.memsci.2012.09.050

He, Z. L., Tong, T. W., Zhang, Y., & He, W. (2018). Constructing a Chinese Patent Database of listed firms in China: Descriptions, lessons, and insights. Journal of Economics and Management Strategy, 27(3), 579–606. https://doi.org/10.1111/jems.12186

Hitchcock, D. (2009). Patent Searching Made Easy (NOLO (15th ed.)).

Hoetker, G. (1999). Patterns in Patents: Searching the forest not the trees. EContent, 22(5), 37.

Hunt, D., Nguyen, L., & Rodgers, M. (2007). Patent Searching. Tools and Techniques. John Wiley and Sons, INC.

Huysamen, B., de Kock, I. H., & Bam, L. (2018). Developing A Challenges Landscape Relating To Drug Safety, Provision, And Distribution In Resource-Limited Settings For The Case Of HIV/AIDS B. Huysamen 1* , I.H. de Kock 1 & L. Bam 1 ARTICLE INFO. South

African Journal of Industrial Engineering, 29(November), 54–68. https://doi.org/http://dx.doi.org/10.7166/29-3-2048

Jeong, Y., & Yoon, B. (2015). Development of patent roadmap based on technology roadmap by analyzing patterns of patent development. Technovation, 39–40(1), 37–52. https://doi.org/10.1016/j.technovation.2014.03.001

Jiang, Q., & Luan, C. (2018). Diffusion, convergence and influence of pharmaceutical innovations: A comparative study of Chinese and U.S. patents. Globalization and Health, 14(1). https://doi.org/10.1186/s12992-018-0408-z

Joung, J., & Kim, K. (2017). Monitoring emerging technologies for technology planning using technical keyword based analysis from patent data. Technological Forecasting and Social Change, 114, 281–292. https://doi.org/10.1016/j.techfore.2016.08.020

Jürgens, B., & Herrero-Solana, V. (2017). Monitoring nanotechnology using patent classifications: an overview and comparison of nanotechnology classification schemes. Journal of Nanoparticle Research, 19(4). https://doi.org/10.1007/s11051-017-3838-2

K. H. Atckinson. (2008). Toward a more ration patent searching paradigm (pp. 37–40).

Karvonen, M., Kapoor, R., Uusitalo, A., & Ojanen, V. (2016). Technology competition in the internal combustion engine waste heat recovery: A patent landscape analysis. Journal of Cleaner Production, 112, 3735–3743. https://doi.org/10.1016/j.jclepro.2015.06.031

Kassicieh, S. K., Walsh, S. T., Cummings, J. C., McWhorter, P. J., Romig, A. D., & Williams, W. D. (2002). Factors differentiating the commercialization of disruptive and sustaining technologies. IEEE Transactions on Engineering Management, 49(4), 375–387. https://doi.org/10.1109/TEM.2002.807293

Kellie, G. (2016). Introduction to technical nonwovens. In Advances in Technical Nonwovens. https://doi.org/10.1016/B978-0-08-100575-0.00001-2

Khalil, B. (2017). North American Nonwovens Industry Outlook report 2017 (INDA Issue 919).

Kim, Y., Tian, Y., Jeong, Y., Jihee, R., & Myaeng, S. H. (2009). Automatic discovery of technology trends from patent text. Proceedings of the ACM Symposium on Applied Computing, 1480–1487. https://doi.org/10.1145/1529282.1529611

Kogler, D. F., Rigby, D. L., & Tucker, I. (2013). Mapping Knowledge Space and Technological Relatedness in US Cities. European Planning Studies, 21(9), 1374–1391. https://doi.org/10.1080/09654313.2012.755832

Kortov, S. V., Terlyga, N. G., Shulgin, D. B., & Unegova, I. E. (2019). Patent Strategy as a Key Component of Innovation Development in Universities. University Management: Practice and Analysis, 23(5), 85–96. https://doi.org/10.15826/umpa.2019.05.044

Krestel, R., & Smyth, P. (2013). Recommending patents based on latent topics. RecSys 2013 - Proceedings of the 7th ACM Conference on Recommender Systems, 395–398. https://doi.org/10.1145/2507157.2507232

Kumar, R., Tripathi, R. C., & Singh, V. (2016). Keyword Based Search and its Limitations in the Patent Document to Secure the Idea from its Infringement. Physics Procedia. https://doi.org/10.1016/j.procs.2016.02.086

Lahorte, P. (2018). Inside the mind of an EPO examiner. World Patent Information. https://doi.org/10.1016/j.wpi.2017.03.005

Lee, S., Lee, S., Seol, H., & Park, Y. (2008). Using patent information for designing new product and technology: Keyword based technology roadmapping. R and D Management, 38(2), 169–188. https://doi.org/10.1111/j.1467-9310.2008.00509.x

Lee, S., Yoon, B., & Park, Y. (2009). An approach to discovering new technology opportunities: Keyword-based patent map approach. Technovation. https://doi.org/10.1016/j.technovation.2008.10.006

Leydesdorff, L. (2008). Patent classifications as indicators of intellectual organization. Journal of the American Society for Information Science and Technology. https://doi.org/10.1002/asi.20814

Leydesdorff, L., Kogler, D. F., & Yan, B. (2017). Mapping patent classifications: portfolio and statistical analysis, and the comparison of strengths and weaknesses. Scientometrics, 112(3), 1573–1591. https://doi.org/10.1007/s11192-017-2449-0

Lim, D. (2018). Disruption and development: the evolving CRISPR patent and technology landscape. Pharmaceutical Patent Analyst, 7(4), 141–145. https://doi.org/10.4155/ppa-2018-0010

Littmann-Hilmer, G., & Kuckartz, M. (2009). SME tailor-designed patent portfolio analysis. World Patent Information, 31(4), 273–277. https://doi.org/10.1016/j.wpi.2008.12.003

Liu, S. J., & Shyu, J. (2006). Strategic planning for technology development with patent analysis. International Journal of Technology Management. https://doi.org/10.1504/ijtm.1997.001689

Lizin, S., Leroy, J., Delvenne, C., Dijk, M., De Schepper, E., & Van Passel, S. (2013). A patent landscape analysis for organic photovoltaic solar cells: Identifying the technology's development phase. Renewable Energy, 57, 5–11. https://doi.org/10.1016/j.renene.2013.01.027

Lobo, J., & Strumsky, D. (2019). Sources of inventive novelty: two patent classification schemas, same story. Scientometrics, 120(1), 19–37. https://doi.org/10.1007/s11192-019-03102-2

Luis Míguez, J., Porteiro, J., Pérez-Orozco, R., Patiño, D., & Rodríguez, S. (2018). Evolution of CO2 capture technology between 2007 and 2017 through the study of patent activity. In Applied Energy (Vol. 211, pp. 1282–1296). https://doi.org/10.1016/j.apenergy.2017.11.107

Madani, F., & Weber, C. (2016). The evolution of patent mining: Applying bibliometrics analysis and keyword network analysis. World Patent Information, 46, 32–48. https://doi.org/10.1016/j.wpi.2016.05.008

Mago, N., Deshpande, N., & Hirwani, R. R. (2017). A landscape of bioinformatics patents - Garnering of IPR in the field of bioinformatics. World Patent Information, 51, 66–78. https://doi.org/10.1016/j.wpi.2017.11.007

Mahlia, T. M. I., Syazmi, Z. A. H. S., Mofijur, M., Abas, A. E. P., Bilad, M. R., Ong, H. C., & Silitonga, A. S. (2020). Patent landscape review on biodiesel production: Technology updates. Renewable and Sustainable Energy Reviews, 118, 109526. https://doi.org/10.1016/j.rser.2019.109526

Masters, N. (2019). Personal Protective Equipment Manufacturing in the US, IbisWorld.

Mattos, L. H. S., & Speziali, M. G. (2017). Patent landscape: Technology development behind science in the flavor and fragrances (F&F) area. World Patent Information, 51, 57–65. https://doi.org/10.1016/j.wpi.2017.11.006

McNamee, R. C. (2013). Can't see the forest for the leaves: Similarity and distance measures for hierarchical taxonomies with a patent classification example. Research Policy, 42(4), 855–873. https://doi.org/10.1016/j.respol.2013.01.006

Meguro, K., & Osabe, Y. (2019). Lost in Patent Classification. World Patent Information, 57(November 2018), 70–76. https://doi.org/10.1016/j.wpi.2019.03.008

Meyer, M. (2000). What is Special about Patent Citations. Differences between Scientific and Patent Citations.pdf. Scientometrics, 49(1), 93–123.

Michel, J. (2006). Considerations, challenges and methodologies for implementing best practices in patent office and like patent information departments. World Patent Information, 28(2), 132–135. https://doi.org/10.1016/j.wpi.2005.08.005

Milanez, D. H., Faria, L. I. L. de, Amaral, R. M. do, & Gregolin, J. A. R. (2017). Claim-based patent indicators: A novel approach to analyze patent content and monitor technological advances. World Patent Information, 50, 64–72. https://doi.org/10.1016/j.wpi.2017.08.008

Montecchi, T., Russo, D., & Liu, Y. (2013). Searching in Cooperative Patent Classification: Comparison between keyword and concept-based search. Advanced Engineering Informatics, 27(3), 335–345. https://doi.org/10.1016/j.aei.2013.02.002

Moore, K. P., Michel, P. R., & Lupo, R. V. (1999). Patent Litigation and Strategy. West Group.

Mossoff, A. (2001). Rethinking the Development of Patents: An Intellectual History, 1550-1800, 52 Hastings L. Hastings Law Journal, 52(6), 1255–1322. https://repository.uchastings.edu/hastings_law_journal

Muller, A., & Välikangas, L. (2002). Extending the boundary of corporate innovation. Strategy & Leadership, 30(3), 4–9. https://doi.org/10.1108/10878570210427891

Nard, C. A. (2017). The Law of Patents (4th ed.). Wolters Kluwer.

Nijhof, E. (2011). Searching? Or actually trying to find something? - The comforts of searching versus the challenges of finding. World Patent Information, 33(4), 360–363. https://doi.org/10.1016/j.wpi.2011.06.007

Noh, H., Jo, Y., & Lee, S. (2015). Keyword selection and processing strategy for applying text mining to patent analysis. Expert Systems with Applications. https://doi.org/10.1016/j.eswa.2015.01.050

Norhasyima, R. S., & Mahlia, T. M. I. (2018). Advances in CO_2 utilization technology: A patent landscape review. Journal of CO2 Utilization, 26, 323–335. https://doi.org/10.1016/j.jcou.2018.05.022

Oldham, P., & Hall, S. (2018). Synthetic Biology - Mapping the Patent Landscape. BioRxiv, Preprint. https://doi.org/10.1101/483826

Oltra-garcia, R. (2012). Efficient situation specific and adaptive search strategies: Training material for new patent searchers. World Patent Information, 34, 54–61. https://doi.org/10.1016/j.wpi.2011.11.004

Ouellette, L. L. (2012). Do Patents Disclose Useful Information? Harv. J.L. & Tech., 25(2), 545. http://ssrn.com/abstract=1762793

Pao-Long Chang, C.-C. W. and H.-J. L. (2010). Using patent analyses to monitor the technological trends in an emerging field of technology: a case of carbon nanotube field emission display. Scientometrics, 82(1).

Pargaonkar, Y. R. (2016). Leveraging patent landscape analysis and IP competitive intelligence for competitive advantage. World Patent Information, 45, 10–20. https://doi.org/10.1016/j.wpi.2016.03.004

Pavitt, K. (1990). What We Know about the Strategic Management of Technology (pp. 17–26). California Management Review.

Pressman, D. (2011). Patent It Yourself (15th ed.). NOLO.

Quintella, C. M., Hatimondi, S. A., Musse, A. P. S., Miyazaki, S. F., Cerqueira, G. S., & Moreira, A. de A. (2011). CO2 capture technologies: An overview with technology assessment based on patents and articles. Energy Procedia, 4, 2050–2057. https://doi.org/10.1016/j.egypro.2011.02.087

Risch, J., & Krestel, R. (2019). Domain-specific word embeddings for patent classification. Data Technologies and Applications, 53(1), 108–122. https://doi.org/10.1108/DTA-01-2019-0002

Scott, J. R. M. (2007). When is a search not a search? The EPO approach. World Patent Information. https://doi.org/10.1016/j.wpi.2006.10.011

Simmons, H. J. E. (2014). Categorizing the Useful Arts: Past, Present, and Future Development of Patent Classification in the United States. Law Library Journal, 106(4), 2014–2031.

Smith, J. A., Arshad, Z., Trippe, A., Collins, G. S., Brindley, D. A., & Carr, A. J. (2018). The Reporting Items for Patent Landscapes statement. Nature Biotechnology, 36(11), 1043–1047. https://doi.org/10.1038/nbt.4291

Somaya, D. (2012). Patent Strategy and Management: An Integrative Review and Research Agenda. Journal of Management, 38(4), 1084–1114. https://doi.org/10.1177/0149206312444447

Somaya, D. (2016). How patent strategy affects the timing and method of patent litigation resolution. Advances in Strategic Management, 34(May 2016), 471–504. https://doi.org/10.1108/S0742-332220160000034014

Song, C. H., Han, J. W., Jeong, B., & Yoon, J. (2017). Mapping the Patent Landscape in the Field of Personalized Medicine. Journal of Pharmaceutical Innovation, 12(3), 238–248. https://doi.org/10.1007/s12247-017-9283-z

Song, K., Kim, K., & Lee, S. (2018). Identifying promising technologies using patents: A retrospective feature analysis and a prospective needs analysis on outlier patents. Technological Forecasting and Social Change, 128. https://doi.org/10.1016/j.techfore.2017.11.008

Song, K., Kim, K. S., & Lee, S. (2017). Discovering new technology opportunities based on patents: Text-mining and F-term analysis. Technovation. https://doi.org/10.1016/j.technovation.2017.03.001

Steed, J., & Pira, S. (2018). Four Trends Shaping the Future of Nonwoven Wipe Demand. Nonwovens Industry.

Takagi, Y. (2010). WIPO's new strategies on global intellectual property infrastructure. World Patent Information, 32(3), 221–228. https://doi.org/10.1016/j.wpi.2009.08.003

Taylor, E. (2010). Patent due diligence: Process and priorities - A Canadian patent attorney's perspective. World Patent Information, 32(3), 198–202. https://doi.org/10.1016/j.wpi.2009.08.002

Trappey, A. J. C., Trappey, C. V., Hareesh Govindarajan, U., Chuang, A. C., & Sun, J. J. (2017). A review of essential standards and patent landscapes for the Internet of Things: A key enabler for Industry 4.0. Advanced Engineering Informatics, 33, 208–229. https://doi.org/10.1016/j.aei.2016.11.007

Trappey, A. J. C., Trappey, C. V., Wu, C. Y., & Lin, C. W. (2012). A patent quality analysis for innovative technology and product development. Advanced Engineering Informatics, 26(1), 26–34. https://doi.org/10.1016/j.aei.2011.06.005

Trippe, A. (2015). Guidelines for Preparing Patent Landscape Reports. In WIPO - World Intellectual Property Organization. https://www.wipo.int/edocs/pubdocs/en/wipo_pub_946.pdf

Tseng, F. M., Hsieh, C. H., Peng, Y. N., & Chu, Y. W. (2011). Using patent data to analyze trends and the technological strategies of the amorphous silicon thin-film solar cell industry. Technological Forecasting and Social Change, 78(2), 332–345. https://doi.org/10.1016/j.techfore.2010.10.010

Tseng, Y. H., Wang, Y. M., Lin, Y. I., Lin, C. J., & Juang, D. W. (2007). Patent surrogate extraction and evaluation in the context of patent mapping. Journal of Information Science. https://doi.org/10.1177/0165551507077406

Uppal, R., Bhat, G., Eash, C., & Akato, K. (2013). Meltblown nanofiber media for enhanced quality factor. Fibers and Polymers, 14(4), 660–668. https://doi.org/10.1007/s12221-013-0660-z

Wagner, R. P. (2015). Introduction to patent law [PowerPoint presentation]. Canvas.

White, M. (2010). Patent Searching: Back to the Future. How to use patent classification search tools to create better searches. First Annual Conference of the Canadian Engineering Education Association.

White, M. A., & Bruton, G. D. (2007). The management of technology and innovation: a strategic approach (J. Szilagyi (ed.)). Thomson Higher Education.

Wittfoth, S. (2019). Measuring technological patent scope by semantic analysis of patent claims – An indicator for valuating patents. World Patent Information, 58, 101906. https://doi.org/10.1016/j.wpi.2019.101906

Wogan, M. (2015). Introduction to patent law. In Chapter 2. Rutgers University. http://crab.rutgers.edu/~mwogan/patent/2_History.htm

Wolter, B. (2012). It takes all kinds to make a world - Some thoughts on the use of classification in patent searching. World Patent Information, 34(1), 8–18. https://doi.org/10.1016/j.wpi.2011.08.001

Xie, Z., & Miyazaki, K. (2013). Evaluating the effectiveness of keyword search strategy for patent identification. World Patent Information, 35(1), 20–30. https://doi.org/10.1016/j.wpi.2012.10.005

Yang, Y. Y., Akers, L., Yang, C. B., Klose, T., & Pavlek, S. (2010). Enhancing patent landscape analysis with visualization output. World Patent Information, 32(3), 203–220. https://doi.org/10.1016/j.wpi.2009.12.006

Yu, X., & Zhang, B. (2019). Obtaining advantages from technology revolution: A patent roadmap for competition analysis and strategy planning. Technological Forecasting and Social Change, 145(July 2017), 273–283. https://doi.org/10.1016/j.techfore.2017.10.008

Zhang, G., Xiong, L., Duan, H., & Huang, D. (2020). Obtaining certainty vs. creating uncertainty: Does firms' patent filing strategy work as expected? Technological Forecasting and Social Change, 160(February), 120234. https://doi.org/10.1016/j.techfore.2020.120234