What does the cosmetics industry look like?

The global cosmetics industry is one of the largest industries in the world. Before the coronavirus pandemic hit, it was expected to make $429.8 billion dollars in just 2 years and is rapidly growing (Rajput et al., 2019). The biggest consumer of cosmetics products in the world is the United States, while France is the largest exporter (Kumar et al., 2005). Over the past decades, the growth of the global economy, as well as increase in disposable incomes, had led to rising demands for cosmetics products. General market growth has shifted from the west to the east; however, western nations are currently experiencing increasing demand for herbal, natural, and organic products, which has contributed to rapid growth in the cosmetics industry and also offers potential areas for further growth in the coming years (Kumar et al., 2005, Rajput et al., 2019). Undoubtedly, the global pandemic of 2020 has had a significant impact on the industry as it is so heavily reliant on disposable income. Despite initial cuts to profit, beauty companies have reported significant growth in e-commerce. Additionally, experts believe that the industry will recover within the next 5 years, as the beauty industry is relatively more stable and secure than other consumer industries (Utroske et al., 2020).

There are hundreds of brands of cosmetics products around the world. However, there are a few mega-companies that control most of the industry. In fact, together, L’Oreal, Estee Lauder, Procter & Gamble, Coty Inc., Shiseido, and Johnson & Johnson own 182 cosmetics brands (Willett). All of these companies but Johnson & Johnson are also in the top ten list of global cosmetics companies in 2020. The number one company is L’Oreal, with sales of $29.4 billion dollars annually. The company owns several luxury brands and has acquired many
global beauty brands, including Valentino, Nyx Cosmetics, and Ralph Lauren, which are what currently fuel the company’s overall growth. The next top 9 companies, in order, are: Estee Lauder, Procter & Gamble, Coty Inc., Cosmax, Shiseido, Beiersdorf, Amore Pacific, Kao Corporation, and Intercose S.P.A. (Cosmetics ODM Market, 2019).

Over the past decade, skincare has consistently represented the biggest percentage of products sold in the cosmetics market; in 2019, skincare represented about 40% of all products sold. The skincare industry has benefited significantly from movements towards natural products and has a much faster growth rate than the overall market. The most popular brand in the 2010s was Olay Regenerist, which sells a variety of lotions and creams and is owned by Procter & Gamble. The makeup industry is made up of several different products, with foundations making up the biggest proportion of the market share in the United States (Shahbandeh et al., 2019).

Chemistry of Skincare

Skincare is a powerful, lucrative industry that can be broken down into a few different sectors: skincare (including acne medication, wrinkle creams, and skin pigment creams) and makeup. Within skincare, there are more limited FDA oversight as compared to more aggressive pharmaceutical products, thereby leading to possible effects in their efficacy (something that is normally heavily regulated by the FDA). As a result, understanding the base chemistry can prove to be especially effective in attempting to understand the way that the FDA may shed light on the relative effectiveness of various techniques.

Benzoyl peroxide is one of the most widely used over-the-counter treatments for acne and is regarded as safe and effective by the FDA. When applied to the skin, it enters the sebum-secreting pores (Dutil et al., 2010). There, it breaks down into free radicals which oxidize and kill the acne-inducing bacteria Propionibacterium acnes, or P. acnes. Due to this mechanism of action, P. acnes is unable to develop resistance to benzoyl peroxide like other antibiotic treatments (Tanghetti & Popp et al., 2009). The harmless product benzoic acid is excreted through the urine (Dutil et al., 2010). Benzoyl peroxide is commercially available in many topical forms, with gels being the most common, with concentrations ranging from 2.5% to 10%. Currently, there is no statistically significant proof that efficacy increases with concentration, although lower concentrations have been shown to cause fewer negative side effects such as skin irritation or dryness (Brandstetter & Maibach et al., 2013).

Another common topical treatment for acne, among other skin conditions such as warts,
lesions and calluses, is salicylic acid. Although its chemical structure resembles that of a β-hydroxy acid, its aromaticity gives it unique properties including lipophilicity, which allows it to dissolve in sebum. Once absorbed in the skin, salicylic acid is thought to disrupt intracellular connectors in the outer layer of the skin, resulting in an exfoliating effect while removing excess sebum. This mechanism can result in skin irritation and dryness (Arif et al., 2015). Toxic amounts of salicylic acid in the bloodstream can result in salicylism, which, while rare, has in extreme cases resulted in death (Madan & Levitt et al., 2014). As a result, over-the-counter acne treatments only contain concentrations ranging from 0.5% to 2%, although prescribed acne medications can be as high as 10% and treatments for other skin conditions can be as high as 40% (Akhadan & Bershad et al., 2003).

Topical retinoids are widely considered some of the most effective treatments of acne, as they target multiple contributing factors of acne. Retinoids are derivatives of vitamin A. Within cells, retinoids bind to nuclear hormone receptors for retinoic acid, a metabolite of vitamin A, and regulate the expression of certain genes (Thielitz & Gollnick et al., 2008). One result is increased surface skin cell turnover, which clears the skin of clogged pores and impedes new clogs from forming. This effect also discourages the proliferation of P. acnes, which thrive in closed, anaerobic pores (Wolf et al., 2002). Additionally, retinoids exhibit an anti-inflammatory effect by inhibiting certain immune-response receptors and pathways. As with many acne treatments, irritation and dryness are common side effects (Thielitz & Gollnick et al., 2008). The retinoids currently approved by the FDA for topical use are tretinoin, adapalene, and tazarotene. They are offered in concentrations ranging from 0.02% to 0.3% depending on the retinoid (Akhadan & Bershad et al., 2003), and only adapalene is available over the counter. Clinical studies have shown tazarotene to be the most effective against acne, and adapalene to have the least adverse effects on the skin (Thielitz & Gollnick et al., 2008).

Despite their success as acne treatments, retinoids are known to have several more severe side effects. Orally prescribed retinoids are well-established teratogens due to their effects on cell growth. Although no link has been made between topical retinoids and birth defects, it is not advisable to use them during pregnancy due to the potential risk (Panchaud et al., 2012). Isotretinoin is controversial for its possible association with depression and suicide. The drug's ability to cross the blood-brain barrier suggests its potential to interfere with brain receptors. Despite its reputation, reviews have not found a statistically significant link between the medication and adverse mental health effects, although monitoring patients is recommended (Huang & Cheng 2017). Other retinoids have not been associated with increased risk of depression.

Due to the wide range of physical manifestations and severity of acne, there is no catch-all treatment. Acne is a multifaceted condition with several targets for medication. An overproduction of sebum and skin cells clogs skin pores, causing P. acnes to flourish, triggering an immune response and inflammation (Leyden et al., 2003). In mild to moderate cases, combination treatments of the aforementioned topical medications are often recommended to treat multiple aspects of acne formation. For example, benzoyl peroxide in combination with tretinoin has proven to be an effective treatment (Leyden et al., 2003). Tretinoin works to prevent initial pore clogging while benzoyl peroxide targets P. acnes, resulting in a multipronged prevention of acne. Clinical studies have shown that increased risk of skin irritation from treatments like this can
be averted by applying topical treatments at different times of day (Leyden et al., 2003). Topical antibacterial medications such as clindamycin are often prescribed alone or in combination with other treatments to combat acne, as they target P. acnes proliferation. However, the development of bacterial resistance to these treatments is a concern. Combination treatment of antibiotics and benzoyl peroxide can combat this problem, as P. acnes cannot become resistant to benzoyl peroxide (Seidler & Kimball et al., 2010). Acne is generally very treatable if patients are able to match the correct available medications to their individual condition.

Alpha lipoic acids, an antioxidant, were discovered and isolated in 1951 as a part of the enzymatic complex that was involved in oxidative metabolism (Perricone et al., 2000, Sherif et al., 2014). When the alpha lipoic acid is applied to the skin topically, the substance is reduced to become dihydrolipoate, which is itself an effective reducing agent that can then eliminate toxic superoxide, hydroxyl, and nitric oxide radicals (Matsugo et al., 2011). This reducing agent can also increase the production of antioxidants and prevent lipid peroxidation (Podda et al., 2001, Zhang et al., n.d.). It is a powerful agent that can act against not only against UV light due to its protection against radicals, but it can also inhibit NF-kB signaling, thereby giving it potent anti-inflammatory capabilities as well (Puizina-Ivić et al., 2010).

Alpha hydroxy acids are a class of compounds that consist of carboxylic groups substituted with hydroxyl groups on the alpha (adjacent) carbon (Babilas et al., 2012). These organic acids are naturally occurring in many fruits, but also can be synthetically created – as they are in many skincare products. Alpha hydroxy acids are commonly used in skin moisturizing serums or wrinkle reduction creams due to their ability to increase water holding capacity, thereby also increasing skin hydration and skin turgor (Edison et al., 2004, Green et al., 2009). AHAs also induce desquamation, plasticization, and normalization of epidermal differentiation (through interference with intercellular ionic bonding), which then can reduce corneocyte cohesion and facilitate keratolysis (Kornhauser et al., 2012). Alpha hydroxy acids are used in home-use skin peelings, and their common forms include lactic acid, citric acid, mandelic acid, glycolic acid, tartaric acid, ascorbic acid, and malic acid (Tung et al., 2000).

Copper peptides, an anti-aging component, the most common of which is glycyl-l-histidyl-l-lysine or GHK, stimulates blood vessel and nerve outgrowth, and supports the function of dermal fibroblasts (Li et al., 2016, Pickart et al., 2008, Pickart et al., 2018). It additionally has potent anti-cancer and anti-inflammatory capabilities (through inhibition of NFkB signaling) (Pickart et al., 2015). Dermatologists have conducted multiple controlled studies on aged skin to show that GHK has potent effects in tightening skin, improving elasticity and skin firmness, reduction of fine lines, wrinkles, photodamage and hyperpigmentation (Mazurowska et al., 2008). GHK complexes with copper activate...
many remodeling processes including those related to macrophages and mast cells, and also stimulate the synthesis of collagen, elastin, metalloproteinases, anti-proteases, vascular endothelial growth factor, fibroblast growth factor 2, nerve growth factor, neutrotropins 3 and 4, and erythropoietin (Pickart et al., 2015).

Dimethylaminoethanol (DMAE), an agent commonly used in anti-wrinkle medications, is an analog of the B vitamin choline and a precursor of acetylcholine (Liu et al., 2014). DMAE is a potent anti-inflammatory agent that has effects on acetylcholine synthesis, storage, secretion, metabolism, and receptivity (Clares et al., 2010). When evaluated in a placebo-controlled trial, DMAE was shown to be efficacious (as well as safe) in the mitigation of forehead lines and periorbital fine lines, improving lip shape and lip fullness, as well as the overall appearance of aging skin (Tadini et al., 2009).

Hydroquinone has been used since the 1950s in over the counter skin lightening serums but was stopped in the early 2000s due to health concerns (Boyle et al., 1986). It was mainly stopped due to the presence of arbutin. Although there are many other products on the market that contain arbutin, many of which are hair products, commercial availability for skin lightening was discontinued (Matsumoto et al., 2016, O’Donoghue et al., 2006). Its skin lightening capabilities stem from its use as a polymerization inhibitor, which removes circulating melanin and lightens skin (Andersen et al., 2010, Schwartz et al., 2020).

Kojic acid is a naturally occurring metabolite that is produced by fungi that has the ability to inhibit catecholase and tyrosinase activity (Burnett et al., 2010). Kojic acid functions as an antioxidant in skin lightening that acts in a time-dependent fashion, which, like hydroquinone, reduces the amount of circulating melanin (Cabanes et al., 1994). This time-dependence, which is unaltered by prior incubation of the enzyme with the inhibitor, is consistent with a first-order chemical reaction involving catecholase inhibition. In addition to skin-lightening, kojic acid has been used in antioxidant, anti-proliferative, anti-inflammatory, radio protective capacities (Saeedi et al., 2019).

L-ascorbic acid is a water-soluble enantiomer of vitamin C that has several proven functions within the skincare industry (Crisan et al., 2015). It has proven to be an effective antioxidant which destroys free radicals and strengthens protection against UV light, as well as removes discoloration and helps in fighting melasma, post-acne discoloration and pigmentation (Dulinska-Molak et al., 2019). L-ascorbic acid also functions as an immunostimulant by strengthening the immunity of the skin, which is weakened under the influence of UV rays, meaning that it also prevents carcinogenic changes to the skin (Al-Niaimi et al., 2017). However, the most prolific quality of this molecule is its anti-wrinkling agency to stimulate collagen synthesis, something that decreases with age (Fitzpatrick et al., 2002). It additionally increases density of skin, improves skin elasticity, and shallows minor surface wrinkles (Elmore et al., 2005). On a more biochemical level, it inhibits MMP-1 activity, an enzyme of the metalloproteinases class that causes collagen and elastin degeneration (Telang et al., 2013).

Chemistry of Makeup

Eye makeup comes in a variety of bright colors; everything from neutral browns to neon pinks and greens. However, eye makeup has existed for thousands of years. In Ancient Egypt, men and women used kohl - a paint like substance containing lead, metal, and ash- to paint dark circles around their eyes to ward off disease. In Ancient Egypt, men and women used kohl - a paint like substance containing lead, metal, and ash- to paint dark circles around their eyes to ward off disease.
A quick scan of a standard eyeshadow palette will most likely reveal the top ingredient is either talc or mica. Talc is a naturally occurring mineral made from magnesium, sodium and oxygen. It is the lowest mineral on Oh's scale, making it one of the softest minerals in the world (King, Talc: The Softest Mineral, n.d.). Talc is added to powders and creams as a filler. In cosmetics, talc is ground into a fine powder that can be added to eye makeup in order to ensure the product slides on smoothly and makes color opaquer (Goins, 2012). However, talc, while not inherently harmful, has the potential to become a carcinogen. Johnson and Johnson were recently in the news due to lawsuits that claim that Johnson and Johnson's talc baby powder resulted in ovarian cancer (Rabin, 2020). Talc, like all minerals, is harvested from deposits in the Earth. However, talc deposits often run near or intersect with asbestos deposits. Asbestos is a group of minerals that is known to cause lung, throat, and ovarian cancer. If talc is not carefully inspected, asbestos can contaminate cosmetic properties (Asbestos Exposure and Cancer Risk, 2017). On the other hand, mica is a metallic sheet mineral. Like talc, mica can be added to makeup as a filler and to help products apply smoothly. However, mica can also be used to help add color to the makeup since mica comes in a variety of natural colors (Goins, 2012). It also does not risk the same contamination issues of talc.

Another common ingredient in eye makeup is zinc stearate. Zinc stearate is a zinc salt of a fatty acid. Fatty acids are carboxylic acids that contain a long chain of carbons and hydrogens. In the case of a salt, part of this fatty acid is negatively charged and associated with a positive ion such as zinc. Zinc derivatives are often added to eye makeup in order to act as adhesives as well as a thickening agent (Zinc Stearate, Cosmetics Information). Some makeup may use Magnesium derivatives instead of zinc, but the effects are the same. Cosmetic companies also usually add a “slip” to eye makeup in order to improve the texture. A common slip in the eye
makeup is dimethicone. Dimethicone is a man-made silicone polymer. Silicones are a family of polymers made from siloxane monomers and consist of a long chain of non-carbon atoms. Silicones have many useful properties including a high heat resistance and (Britannica, 2020). As such, they are found in everything from medicine to cookware. However, in the case of cosmetics, silicones are valued for their flexibility. The backbone of a silicone polymer consists of a central silicon atom bound to an oxygen atom. The silicon oxygen bond has a very low rotational barrier, meaning that the bond can rotate ‘freely’ in space (Polymer Properties Database). As a result, silicone products are often very flexible and smooth. This unique flexibility means that silicones can vastly improve the texture of eye makeup, allowing eye makeup to glide onto the eyelid with relative ease. As with much of the cosmetics industry, the exact slip varies based on company and there is no universal formula. Some companies may elect to use silicone alternatives such as the fatty ester ethylhexyl palmitate.

In modern cosmetics, the bright colors in eye makeup come from color additives. The Federal Food and Drug act of 1938 regulates the color additives that can be used in cosmetics and only a sub portion of this list are approved for use on the eye. The list is extensive and includes everything from aluminum powder to FD&C Yellow No. 5 (Center for Food Safety and Applied Nutrition, 2017). However, some companies have found that the pigments approved for use FDA cannot give them all the colors they desire. Therefore, in recent years, there has been an increase in eye makeup marked “not safe for use around the eyes.” In this case, these pigments have been approved for use in cosmetics but are not approved for use around the eye due to increased risk of staining and allergic reactions (Lebsack, 2019).

The last component of eye makeup is the preservatives. Although there has been a recent push to minimize the amount of preservatives in products, preservatives are vital to ensuring cosmetics are not contaminated with bacteria. A common family of preservatives in cosmetics are parabens, with methylparaben and butylparaben being widely distributed. Parabens are currently approved for use by the FDA (and are often found in haircare and some skin care due to their effectiveness and low price) but concerns have been raised about correlations between parabens and cancer (Ross, 2019). In 2004, researchers found a concentrated number of parabens in breast cancer tissue, launching debates about whether parabens were promoting cancer growth (Harvey, 2004). Since parabens can act as hormone disruptors, some researchers are concerned about the potential effects of increased parabens levels in the body (Ross, 2019). However, recent human clinical studies have found no correlation between parabens and cancer, and the CDC has declared there is insufficient evidence to be concerned about paraben use (Ross, 2019). Nonetheless, parabens have begun to fall out of favor and are being replaced with other preservatives. Two popular alternatives are Glycol, a water-soluble preservative that can also act as a moisturizer, and Tocopherol, a vitamin that is also found in skincare (Seladi-Schulman, 2018).

Many of the ingredients of eye makeup carry over into face makeup. Face makeup comes in many different forms and there is a large variation in formula. This section will focus on liquid face products, such as foundation or concealer. Much like eye makeup, face makeup begins with a base to help the ingredients stay together and apply smoothly on the skin. In the modern cosmetics market, most face makeup uses a water-silicone base. As in eye makeup,
dimethicone is most commonly used as the silicone component due to its ability to cover skin imperfections and improve the texture of the product (Kimbrough, 2013). However, dimethicone is a hydrophobic molecule. As a result, a water-silicone base should begin to separate as silicone molecules repel the water molecules. In order to combat this, face makeup does not simply contain silicone and water mixed together in solution. Instead, silicone and water are bound through emulsifiers, preventing the product from breaking up (Kimbrough, 2013). A common emulsifier is dimethicone crosspolymer. In dimethicone crosspolymer, dimethicone and water are linked through covalent bonds, preventing the components of the base from separating even if they repel one another (Dimethicone Crosspolymer, 2020). Dimethicone crosspolymer is specifically useful for face makeup because the crosslinked polymers will form a film over the skin in order to keep the active ingredients in contact with the skin (Dimethicone Crosspolymer, 2020). Face makeup has a much wider array of possible ingredients compared to eye makeup, and other emulsifiers such as polysilicone 11 may be used for similar effects.

Aside from texture, the pigment of face makeup is vital. Consumers are searching for the perfect shade and won’t buy face makeup that doesn’t match their skin tone. The most common way for face products to get pigment is iron oxide and titanium dioxide. Iron oxide is the main colorant used in face makeup and naturally occurs in several colors, primarily red, yellow, and black (Iron Oxides, 2020). However, Iron Oxide is produced synthetically for cosmetics, allowing a much wider shade range. Synthetic Iron Oxides can be mixed in different color combinations or added to other colorants like titanium oxide until the desired shade is reached (Iron Oxides, 2020).

The last major category of cosmetics is lip makeup. While the first lip product most people think of is a traditional lipstick that spins up from a small compartment. However, lip products also include lip gloss, lip balm, bullet lipsticks, and multiple other “specialized” lip makeup that companies market to consumers. For simplicity, the traditional lipstick will be examined. Lipsticks can be broken down into three main ingredients: waxes, oils, and emollients (Freeman, 2009). The waxes are the foundation of any lipstick and allow lipstick to be molded into the well-known cylindrical shape. The most common waxes for lipstick are beeswax, paraffin and carnauba wax (Freeman, 2009). The next ingredients are oils, such as lanolin oil or cocoa butter. The oils allow lipsticks to deposit color onto the lips without crumbling and falling apart (Freeman, 2009). However, the real fun in lipstick is the color. The color in lipsticks can come from a variety of natural or synthetic ingredients similar or identical to the color additives found in eye makeup. Perhaps the most popular lipstick color is red. The red coloring in lipstick most commonly comes from a compound called Carmine. Carmine is a deep red color that is produced from carminic acid. Carmine is not just found in makeup but for food coloring as well (Yoquinto, 2013). However, some consumers have begun to avoid carminic acid because it is produced by crushing and soaking cochineal beetles in an acidic solution. Companies who want to be vegan or cruelty free turn to other synthetic...
red dyes. However, some synthetic dyes such as Red No.6 are derived from petroleum or other problematic issues (Yoquinto, 2013)

Conclusion

The cosmetics industry commands billions of dollars a year has products that appear to target the inherent machinery of the cells in order to achieve a result that is altered from the pre-treatment condition. Of the multi-billion-dollar market – much of which relies on heavy social media marketing through ads, celebrity endorsement, and other testimonials – 23% of the market is skincare (second only to haircare) (Dobric, 2020). The skincare market is is largely dominated by conglomerates that offer at-home treatments for conditions that range from acne to wrinkles to dark spots, among others. The beauty industry is not far behind, however, as it is cosmetic’s most profitable branch – with makeup and eyeshadow contributing most to this trend (Dobric, 2020). While there has been a recent push toward eco-friendliness among products, there has been a more limited effort in understanding just how the products are eco-friendly. Along those lines, there is also a limited understanding and limited attempt to understand the chemistry behind the cosmetics industry. Due to the limited attempts at understanding this and the limited FDA oversight of more topical treatments (that make up the majority of the cosmetics industry) these massive makeup empires have arisen (Cosmetics ODM Market, 2019). Understanding the inherent cellular machinery and medical manipulation of said machinery is key to ensuring the correct cosmetic investment – more widespread knowledge of the methods may shed light on the efficacy and may result in altered consumer choices.

References


