Chapter

Comparison and Analysis of Colorant in Toner Cartridges: A Material Safety Data Sheet Study

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Abstract

Nowadays, electronic devices such as mobile phones and tablets are gadgets that have become common in most people's daily lives. Although people often use tablets to read files, newspapers, or other papers, printing some documents is still necessary and convenient for most people. Therefore, a printer is one of the basic machines that many people use for work or to learn. Toner cartridges are the main components that print high-quality images or text on paper and are therefore of research value. Existing literature lacks research on performance of different printers and toners. Therefore, this study investigated and analyzed different types and brands of toners. In the study, toner cartridges provided by the four major suppliers were compared with data provided in material safety data sheets (MSDS) based primarily on different products. A comprehensive review and analysis of the concentration, function, definition, and impact involved in the product was conducted in this study.

Keywords: toner, dyes, pigment, MSDS, health

1. Introduction

The toner cartridge is a part of a laser printer and it contains a complex powder used for printing images and text on paper. Besides laser printers, it is also used in compound printers and fax machines based on electronic photography technology. The chemicals in a toner are a mixture of colored pigments, plastic resins, and other ingredients.

Empty toner cartridges are a waste and their reuse and recycling have attracted much attention in recent years. Printers and toner cartridges have serious problems, from the manufacturing process to the eventual throw away and recycling of materials. Most chemicals in toner cartridges have the potential to cause damage to the environment [1–3] and humans [4–7]. Discarded toner cartridges may cause damage to the environment as they can contaminate soil and water when sent to landfills. In fact, carbon black in toner is classified as a potential carcinogen because the devastating effects of toner cannot be properly addressed [8].

In order to compare and analyze different contents of toner cartridges, this study selected four well-known brands that are sharing key markets, based on the global printer market share of suppliers from 2015 to 2018. The main objectives of the study are:

1. To analyze components of toners and compare the toner cartridges of the four brands based on the material safety data sheet (MSDS).

2. To study the hazardous impacts to the environment and human health caused by waste toner cartridges.

2. Methodology

2.1 Selection of toner cartridge brands

Based on Staista 2019 [9], four printer brands (Labeled Brand A, Brand B, Brand C, and Brand D) together having a total market share in excess of 50% between 2015 and 2018 were selected for the study. Basically, printer sales are directly related to toner cartridge sales because they constitute the relationship between major products and sub-products.

2.2 Material safety data sheet

The material safety data sheet (MSDS) is a document that provides safety and health measures that need to be followed when using different components of the product(s). It is a commonly used system for listing information about chemicals, compounds, and chemical mixtures. The MSDS contains instructions for safe use and potential hazards associated with a particular product or material. The composition of toner and its potentially dangerous effects on human health can be found in MSDS. Typically, each toner cartridge has a MSDS that is included in the package or displayed on its official website. Most of the data in this study was obtained from MSDS.

2.2.1 Procedure of collecting data from material safety data sheet

1. All MSDS of toner cartridges of each brand were obtained from official websites of the brands.

2. MSDS was studied and the percentage of each component in each toner cartridge was recorded.

2.3 Search the health and environment impacts based on collected data

Names of different chemicals contained in toners are listed in MSDS and the precautions that need to be taken for avoiding adverse health effects are briefly described. Based on the data collected, these preventive measures are analyzed to determine health and environmental impacts.

3. Result and discussion

3.1 Result of data collected from MSDS

Data were collected for 1473 toner cartridges. As shown in **Table 1**, there were 668 cartridges of Brand A, 353 of Brand B, 296 of Brand C, and 156 cartridges of Brand D. In **Table 1**, the data show that black color accounts for about 50% of the total for each brand, while the other three colors account for about 15% each, of the total. In daily use, black color is the main color used in work, study, or printing. As a result, most companies have introduced black color as the main type of toner.

3.2 Analysis of the main chemicals in toner cartridges

Ingredients in all toner brands are not the same, though they are similar. **Table 2** lists all chemicals in toner cartridges of the four chosen brands. Brand A cartridges contain 42 types of chemicals. In addition, Brand A contains most of the chemicals in all the four brands. Only Brand A contains green, red, and translucent white colors in addition to the four main colors. Brand B has 17 types, Brand C has 21 types and Brand D has 20 types. Cyan, magenta, yellow, and black are the four main colors in different toners.

The numbers in brackets indicate the total number of cartridges in which the particular chemical was found.

Brand A (668 cartridges) contained 42 types of chemicals; the highest number of chemicals used by one brand in the four Brands. The main chemicals in Brand A cartridges were glycerin and water inside the toner, found in 475 and 496 cartridges, respectively, or over 70% of cartridges of the same model. Other chemicals found were 1,2-benzisothiazol-3(2H)-one, 2-Pyrrolidinone and glycol, found in 261, 224, and 292 cartridges, respectively.

Brand B is using 17 types of chemicals; 353 cartridges were examined. This was the least number of types compared with the other three brands. Basically, there are six types of chemicals used in over 50% of the cartridges: carbon black, fatty acid ester, PMMA, silicon dioxide, styrene-acrylate copolymer, and styrene-acrylate resin.

Brand C is using 21 types of chemicals in 296 toner cartridges, in which amorphous silica, styrene acrylate copolymer, and wax are the most used chemicals, found in 215, 255, and 220 cartridges, respectively.

Lastly, Brand D uses four main types of chemicals: carbon black, paraffin wax, polyester resin, and silica. Obviously, the ingredients are slightly different from the

Brand	No. of Model	*Type of Chemical	Cyan Color	Magenta Color	Yellow Color	Black Color	**Other Colors
A	668	42	116	117	90	311	34
B	353	17	36	36	36	245	0
C	296	21	54	54	55	133	0
D	156	20	18	20	19	99	0

Type of chemical is the total amount of chemical used in the brand. Some cartridges are classified as having other colors such as green and red.*

Table 1.
Basic information.

Brand A
1,2-benzisothiazol-3(2H)-one (261); 2-Pyrrolidinone (224); 3-Methyl-1,5-pentanediol (17); Ammonia derivative (40); Ammonium benzoate (7); Amorphous silica (130); Black pigment (1); Calcium nitrate (1); Carbon black (72); Diethylene glycol (73); Ethylene glycol (Glycol) (79); Ethylene urea (137); FD&C Yellow No. 6 (2); Ferrite (14); Ferrite including manganese (8); Ferrite including Zinc (12); Glycerin (475); Glycol (292); Iron oxide (30); Isopropyl alcohol (64); Lactam (73); Magenta dye (9); Magenta pigment (8); Magnesium nitrate (9); Pigment (80); Polyester resin (31); Pyridine azo dye (22); Pyridone dye (2); Quinoline derivative (10); Styrene polymer (3); Styrene-acrylate copolymer (139); Substituted anthraquinone derivative (8); Substituted naphthalene sulfonic acid (11); Substituted naphthol azo dye (4); Substituted phthalocyanine salt (43); Thiadiazole azo dye (7); Thiodiglycol (8); Titanium dioxide (34); Triazine derivative (6); Triol (15); Water (496) Wax (104)
Brand B
1,2-benzisothiazol-3(2H)-one (1); Carbon Black (bound) (245); Diethylene glycol (1); Fatty Acid Ester (225); Glycerol (1); Paraffin wax (40); Pigment (108); Pigment – 1 (19); Pigment – 2 (19); PMMA (255); Polyester resin (98); Rosin, fumarate (51); Silicon dioxide (amorphous) - 112,945-52-5 (218); Silicon dioxide (amorphous) - 844,491-94–7 (165); Styrene-acrylate copolymer (254); Styrene-acrylate resin (181); Water (1)
Brand C
Aluminum alloy (1); Amorphous silica (215); Aryl amine derivative (1); Carbon black (61); Ceramic materials (9); Copper compound (14); Coating materials (4); Cyan pigment (4); Ferrite (21); Ferrite including zinc (2); Iron oxide (56); Magenta pigment (4); Paraffin wax (22); Pigment (141); Polyester resin (54); Silica (16); Silicon dioxide (5); Styrene acrylate copolymer (255); Titanium dioxide (80); Wax (220); Yellow pigment (4)
Brand D
Carbon black (108); Carnauba wax (27); Ceramic material (29); Coating materials (24); Cyan pigment (18); Ester wax (2); Ethylene wax (33); Ferrite (3); Magenta pigment (20); Paraffin wax (122); Pigment (9); Polyester (3); Polyester resin (100); Silica (135); Silicon dioxide (5); Styrene-acrylic resin (53); Tin (IV) oxide (2); Titanium dioxide (38); Wax (6); Yellow pigment (19)

Table 2.
All chemicals list.

other three brands. The main ingredient is a chemical compound, which is, in all the four brands, the main ingredient.

Basically, all brands of toner cartridges contain similar but different ingredients. Different chemicals can have the same function in the printing process. For example, iron oxide and silica are completely different in physical and chemical properties, but they have similar functions in a toner. **Table 3** shows chemicals present in these target brands. In particular, carbon black, polyester resin, and silica are the only three chemicals that are present in each brand.

The value of carbon black is between 10.8 and 69.4%. The quantity and percentage indicate that carbon black is the main chemical in these toners. Brand B and Brand D are relatively high in carbon black because they contain about 70% carbon black and are valued on the color capacity of toner. Because carbon black is the main ingredient in the black toner cartridge, most toner brands use it as the primary source of color.

Polyester resin is used in different ratios in these four brands because it is used as a toner binder in laser printers. The percentage of polyester resins is between 4.6 and 64.1%. Brand A contains 4.6% polyester resin, which is not the main component of the control binding and release properties. By contrast, Brand D has 64.1% polyester resin because it relies on one chemical to produce high mechanical strength and excellent viscous elasticity.

Brand	A		B		C		D	
Chemical	**Amount**	**Percentage***	**Amount**	**Percentage***	**Amount**	**Percentage***	**Amount**	**Percentage***
Carbon black	72	10.8%	245	69.4%	61	20.6%	108	69.2%
Polyester resin	31	4.6%	98	27.8%	54	18.2%	100	64.1%
Titanium dioxide	34	5.1%	0	0%	80	27.0%	38	24.4%
Paraffin wax	0	0%	40	11.3%	22	7.4%	122	78.2%
Wax	104	15.6%	0	0%	220	74.3%	6	3.8%
Silica	130	19.5%	0	0%	16	5.4%	135	86.5%
Silicon dioxide	0	0%	232**	65.7%	5	1.7%	5	3.2%
Iron oxide	30	4.5%	0	0%	56	18.9%	0	0%
Ferrite	34***	5.1%	0	0%	23	7.8%	3	1.9%

**The amount of material divided by total number of cartridges. **Includes all silicon dioxide in different cartridges. ***Includes all ferrite in different metals.*

Table 3.
Same materials between four brands.

Silicon dioxide, silica, iron oxide, and ferrite have essentially the same function in the process of printing. In this study, the percentage of these chemicals was found to be between 29.1 and 91.6%. Brand D's percentage is considered satisfactory because most models use these chemicals as carriers to bind the right position of the rotating drum.

3.3 Discussion of chemicals with high percentages in MSDS

Most of the chemicals collected are represented as a percentage range. Percentage refers to the concentration of chemicals in toner, which impacts efficacy in terms of high or low values. This section discusses major chemicals with a high percentage as stated in the MSDS.

3.3.1 Carbon black

As shown in **Table 4**, the percentage of carbon black in toner cartridges of the four brands is in the range of 1–10%. Obviously, carbon black is not the main ingredient of toner as it only provides color. However, it is still the main content used for coloring in every brand. In Brand A cartridges, carbon black content is only in three different ranges, which is the smallest number, and the values of the three types of percentages are more uniform. In contrast, Brand D has different percentage ranges, with 16 types found in MSDS, with primary concentrations ranging from <1 to <5%.

[1] Brand A		Brand B		Brand C		Brand D	
Concentration	**Amount**	**Concentration**	**Amount**	**Concentration**	**Amount**	**Concentration**	**Amount**
< 1%	24	1–5%	16	< 1%	4	0.1%	3
1–5%	22	1–10%	1	< 2%	4	0.3.%	1
5–10%	26	2.5–5.5%	61	< 6%	14	1–5%	1
		3–10%	21	< 8%	4	1–6%	20
		4–7%	25	< 10%	33	1–10%	1
		4–14%	11	< 15%	2	2–5%	2
		5–7%	106			2–8%	6
		5.5–6.5%	4			3–5%	5
						3–8%	2
						10–15%	2
						< 1%	20
						< 4%	17
						< 5%	24
						< 7%	1
						< 8%	2
						< 10%	1
Total	**72**	**Total**	**245**	**Total**	**61**	**Total**	**108**

Table 4.
Percentage of carbon black.

3.3.2 Paraffin wax

Table 5 shows that paraffin wax content is in the 2–15% range in these brands. Paraffin wax is a key substance that lubricates other components to improve friction resistance. Brand B and Brand B's toner cartridges contain more uniform ranges. However, Brand D has various ranges, which are higher than the other half. For Brand A, a similar chemical type is wax, so paraffin is replaced by wax in toner cartridges.

3.3.3 Polyester resin

According to **Table 6**, all the four brands contain more than 50% polyester resin, the main chemical in toner. About 60% of the toner comprises polyester resin as it is used for melting the ingredients during printing. The data show that this percentage matches the market products. Some percentages are hidden by Brand B because the concentration of polyester resin may be an important survival skill and secret in the printer market.

3.3.4 Silica

Because functions of silica and iron oxide are similar, **Table 7** can be compared with **Table 8**. The range of silica in **Table 7** is approximately 1–3%. However, in **Table 8**, the range of iron oxide is approximately 40–50%. Iron oxide accounts for about 40% of the ingredients, matching what the data tell. It is worth mentioning that the less is the silica content, the more is the effect of iron oxide.

3.4 Discussion of function of main chemicals in toner cartridges

MSDS does not explain all chemicals. It only provides concentrations and percentages of chemicals in toner cartridges. According to MSDS, pigment, wax, silicon dioxide (silica), polymer, and water are the main chemicals in toner cartridges.

Brand A		Brand B		Brand C		Brand D	
Concentration	**Amount**	**Concentration**	**Amount**	**Concentration**	**Amount**	**Concentration**	**Amount**
		2–3%	10	< 2%	10	0.5–2%	3
		2–4%	18	< 5%	1	0.5–3%	1
		3–4%	4	< 8%	3	0.5–5%	1
		3–5%	4	< 10%	3	1–2.5%	2
		4–5%	4	< 15%	5	1–5%	22
						5–8%	12
						5–10%	41
						8–15%	5
						< 2%	23
						< 3%	12
Total	**0**	**Total**	**40**	**Total**	**12**	**Total**	**120**

Table 5.
Percentage of paraffin wax.

Brand A		Brand B		Brand C		Brand D	
Concentration	**Amount**	**Concentration**	**Amount**	**Concentration**	**Amount**	**Concentration**	**Amount**
5–10%	7	75–90%	21	0.2 < 1%	1	5.6%	4
45–55%	7	**	71	< 10%	19	55–95%	1
80–90%	2			< 50%	6	60–74%	5
85–95%	15			< 55%	20	75–95%	11
				< 65%	2	80–90%	4
				< 74%	5	80–95%	9
				< 85%	1	85–95%	8
						90–95%	5
						< 8.5%	8
						> 81%	2
						> 82%	1
						> 87%	13
						> 88%	29
Total	**31**	**Total**	**98**	**Total**	**54**	**Total**	**100**

***The exact percentage is hidden by Brand B.*

Table 6.
Percentage of polyester resin.

Brand A		Brand B		Brand C		Brand D	
Concentration	**Amount**	**Concentration**	**Amount**	**Concentration**	**Amount**	**Concentration**	**Amount**
< 2%	4			< 1%	10	0.2%	4
1–3%	126			< 2%	3	0.5–1%	3
				< 3%	3	0.5–2%	4
						1–2%	12
						1–3%	40
						1–4%	5
						1–5%	15
						1–11%	1
						2–4%	8
						< 2%	31
						< 3%	12
Total	**130**	**Total**	**0**	**Total**	**16**	**Total**	**135**

Table 7.
Percentage of silica in four brands.

3.4.1 Pigment

Pigments are one of the most popular colorants in toner and play a vital role in providing color on paper. Cyan, Magenta, Yellow, and Black are the four basic colors.

Brand A		Brand B		Brand C		Brand D	
Concentration	**Amount**	**Concentration**	**Amount**	**Concentration**	**Amount**	**Concentration**	**Amount**
30–40%	3			< 40%	7		
35–45%	3			< 45%	4		
40–50%	23			< 50%	41		
45–55%	1			< 55%	4		
Total	**30**	**Total**	**0**	**Total**	**56**	**Total**	**0**

Table 8.
Percentage of iron oxide.

Every color is a product of mixing of these four colors in different proportions. These four colors are used separately in the toner.

3.4.2 Wax

The data show that different types of waxes, such as paraffin, ester wax, and ethylene wax are used in toners. Toner contains wax additives and has physical properties such as friction resistance, solvent or grease corrosion resistance. In addition, the coefficient of friction is controlled to control the slip resistance. In other words, wax is a lubricating substance.

3.4.3 Silicon dioxide (Silica)

Silicon dioxide, also known as silica, is used to increase the chemical level of the charged portion. It develops the performance of ink absorption, drying speed, vivid reproduction of color, and so on. It functions like iron oxide. However, the amount of iron oxide reported was found to be too low, with only about 86 of the 1473 cartridges having it. Since iron oxide was an early mixture, silicon dioxide was developed to replace it. Therefore, silicon dioxide is one of the common materials in toner, not iron oxide.

3.4.4 Polymer

The polymer in the toner can melt and bond to the paper at high temperatures. Polyester resins, styrene acrylate copolymers, or styrene butadiene copolymer are examples of polymers used, depending on the manufacturer. However, there is a slight difference between styrene acrylic copolymers and polyester resins. Styrene acrylate copolymers have good adhesion to many surfaces, making them thermoplastic in nature, and polyester resins are used as adhesive resins in toners for high-speed printers.

3.4.5 Water

Water is a major component of Brand A cartridges and is related to the state of the toner. In general, water is good at dissolving ions and polar molecules, but is poor in

dissolving non-polar molecules. Because of the polarity of its molecules, it interacts with charged polar matter differently from electrode-banded matter. Therefore, it acts as the primary medium and allows all other substances to dissolve each other. In addition, some dye particles can be dissolved in water, causing saturation color on the paper.

Table 9 summarizes and introduces the functions of main chemicals in different brands.

3.5 Health and environment impact of toner cartridge

Toner contains hazardous substances, which are flammable and toxic. They pose a huge risk to human health and environment [10–14]. Therefore, the toner industry is

	Chemicals	Function
Brand A	1,2-benzisothiazol-3(2H)-one	It is used as a preservative in products such as inks and photographic processing solutions.
	2-Pyrrolidinone	It is an intermediate in the manufacture of polymers and it can prevent the ink from evaporating into the air.
	Glycerin	It provides a good pigment dispersion stability and good wet-fastness and dry rub-fastness.
	Glycol	It improves the duration of time for which the substance mix stays mixed with water inside the ink cartridge.
	Water	It acts as the primary medium and allows dissolution of all other substances with each other.
Brand B	Carbon Black	It is the common name of black pigment and it appears black.
	Fatty Acid Ester	It improves the storage stability of the ink.
	PMMA	It acts as a plastic for melting in the printing process.
	Styrene-Acrylate Copolymer	It has good adhesion to many surfaces and makes it thermoplastic.
	Styrene-Acrylate Resin	It can impart good fixing and offset properties to provide good printing performance.
	Silicon Dioxide	It develops a strong performance of ink absorption, quick drying, vivid reproduction of color.
Brand C	Amorphous Silica	It develops strong performance of ink absorption, quick speed of drying, vivid reproduction of color.
	Pigment	It provides color onto the paper.
	Styrene Acrylate Copolymer	It has good adhesion to many surfaces and make it thermoplastic.
	Wax	It is for lubrication.
Brand D	Carbon Black	It is the common name of black pigment and appears black.
	Paraffin Wax	It is for lubrication.
	Polyester Resin	It is used as toner binder resin in high-speed printers.
	Silica	It develops a strong performance of ink absorption, quick drying, vivid reproduction of color.

Table 9.
Function of the main chemical in four brands.

supervised by the government and MSDS is prepared for each product. MSDS not only provides the information of chemicals and ingredients, but also prescribes some precautions.

These precautions are normally divided into five sections for safety regulations. They are "first aid measures," "firefighting measures," "accidental release measures," "handling and storage," and "exposure controls/personal protection." Understanding the precaution parts can help identify the health and environment impacts of toner cartridges because it involves outcomes of toner. Thus, "accidental release measures" and "handling and storage" are the parts for analysis of impacts.

Toner contains flammable and toxic harmful substances that pose great risk to human health and the environment. Therefore, all toner manufacturers are supervised by the government to prepare MSDS for each product. Understanding precautionary measures can help identify the health and environmental effects of toner cartridges, as they relate to toner results. Therefore, "accidental release measures" and "handling and storage" are the parts for analysis of impact.

3.5.1 Accidental release measures

"Personal precautions," "environmental precautions," and "methods and materials for containment and cleaning up" are the three parts in accident release measures. Description of precautions is relevant when the chemicals are released. **Table 10** shows a comparison between precautions suggested by the four brands, integrated by all MSDS. **Table 1** shows that Brand A has the largest number of chemical types, but its statement of precautions is the smallest. In other words, because of simple statements, Brand A has more potential influencing factors to humans and the environment. In addition, these chemicals mainly cause irritation in the context of personal health because they are also described as avoiding inhalation of dust. For the environment, these chemicals pollute water bodies, as companies warn people to keep chemicals away from water.

3.5.2 Handling and storage

The methods of storage depend upon properties of different chemicals. **Table 11** shows a comparison of the four brands in terms of processing and storage. In general, all the four brands have listed similar precautionary statements in MSDS. Prevention of generation of dust is the focus of general reminders because these powders irritate the body, especially the skin and eyes. These chemicals are kept away from direct sunlight, heat, and oxidants because they are flammable chemicals, and dangerous to humans and the environment. Therefore, safe storage of chemicals is an important process to keep chemicals safe.

3.5.3 Chemical safety issue

This instruction can help the user prevent unexpected release and storage problems from occurring in severe conditions. All statements of accidental release measures and storage in **Tables 10** and **11** are based on the characteristics of the chemicals. Therefore, these properties can be divided into different categories. There are seven categories (**Table 12**) that are used to integrate the two categories in **Tables 10** and **11** for simple interpretation based on local statutory regulation (factories and industrial undertakings (dangerous substances) regulations) [15].

Personal precautions	**Brand A**	• Avoid contact with skin, eyes and clothing.
	Brand B	• Avoid generation of dust
		• Do not breathe dust.
		• A suitable dust mask or dust respirator with filter type A/P may be appropriate
	Brand C	• Minimize dust generation and accumulation.
	Brand D	• Avoid inhalation of dust.
		• Wash thoroughly after handling.
		• Wear appropriate personal protective equipment. Ensure adequate ventilation.
Environmental Precautions	**Brand A**	• Keep out of waterways.
	Brand B	• Prevent substance entering sewers.
		• Washings must be prevented from entering surface water drains.
		• Prevent entry into waterways, sewers, basements or confined areas
	Brand C	• Do not flush into surface water or sanitary sewer system.
	Brand D	• Avoid dispersal of spilled material and contact with soil, ground and surface water, drains and sewers.
Methods and material for containment and cleaning up	**Brand A**	• Wipe up with adsorbent material (e.g. cloth, fleece).
	Brand B	• Sweep the spilt toner or remove it with a vacuum cleaner and transfer into sealed container carefully.
		• Sweep slowly to minimize generation of dust during cleanup.
		• If a vacuum cleaner is used, the motor must be rated as dust explosion proof.
		• Potential for very fine particles to be taken into the vacuum only to be passed back into the environment due to pore size in the bag or filter.
	Brand C	• Slowly vacuum or sweep the material into a bag or other sealed container. Clean remainder with a damp cloth or vacuum cleaner.
		• If a vacuum is used, the motor must be rated as dust explosion-proof.
		• Fine powder can form explosive dust-air mixtures.
		• Dispose of in compliance with federal, state, and local regulations
	Brand D	• Small spill: Remove source of ignition. Carefully wipe off with paper or wet cloth, avoiding inhalation of fine dust.
		• Large spill: Wear protective gear: respirator, rubber gloves, goggles. Do not use vacuum cleaner when a large amount is released.
		• This mixture like most finely divided organic powders, may create a dust explosion. Wipe up remainder with a wet cloth.

Table 10.
Accidental release measures.

Precautions for safe handling	**Brand A**	• Avoid contact with skin, eyes and clothing.
		• Clean contaminated surface thoroughly.
		• Ensure adequate ventilation.
	Brand B	• Keep out of the reach of children.
		• Avoid generation of dust.
		• Avoid inhalation of high concentration of dust.
		• Avoid contact with eyes.
	Brand C	• Keep out of the reach of children.
		• Avoid inhalation of dust and contact with skin and eyes.
		• Use with adequate ventilation.
		• Keep away from excessive heat, sparks, and open flames.
	Brand D	• Avoid breathing dust and contact with skin, eyes and clothing.
		• Handle in well ventilated work space.
		• Wash thoroughly after handling.
		• Treat from upwind position.
		• Keep away from excessive heat, spark, and open flame
Conditions for safe storage, including any incompatibilities	**Brand A**	• Keep in a dry, cool and well-ventilated place. Keep out of the reach of children.
		• Keep away from direct sunlight.
		• Keep away from heat and sources of ignition.
	Brand B	• Keep away from oxidizing agents.
		• Keep containers tightly closed in a dry, cool and well-ventilated place.
	Brand C	• Keep out of the reach of children.
		• Keep tightly closed and dry.
		• Store at room temperature.
		• Store away from strong oxidisers.
	Brand D	• Store in cool, dry and well-ventilated place.
		• Avoid direct sunlight.
		• Keep away from oxidizing materials.
		• Keep out of reach of children.

Table 11.
Handling and storage.

Categories	Statement
Corrosive	• Wear appropriate personal protective equipment. Ensure adequate ventilation.
Flammable	• Keep away from excessive heat, sparks, and open flames.
	• Keep away from direct sunlight.
	• If a vacuum cleaner is used, the motor must be rated as dust explosion proof.
	• Fine powder can form explosive dust-air mixtures.
	• Store at room temperature.
Harmful	• Avoid generation of dust
	• Minimize dust generation and accumulation.
	• Sweep the spilt toner or remove it with a vacuum cleaner and transfer into sealed container carefully.
	• Sweep slowly to minimize generation of dust during cleanup.
Irritant	• Avoid inhalation of dust. Wash thoroughly after handling.
	• Avoid inhalation of dust and contact with skin and eyes.
Organic substance	• Wipe up with adsorbent material (e.g. cloth, fleece).
Oxidizing	• Keep away from oxidizing agents
Polluted	• Keep out of waterways
	• Washings must be prevented from entering surface water drains.
	• Do not flush into surface water or sanitary sewer system. Avoid dispersal of spilled material and contact with soil, ground and surface water, drains and sewers.

Table 12.
Categories integrated by MSDS.

4. Conclusion

This study assembles, integrates, compares, and analyses data of 1473 toner cartridges of the four target brands. Most of the components in the target model are similar to search information. At the same time, the relationship between the percentage and function of major chemicals was studied. Finally, the health and environmental effects are discussed on the basis of safety measures suggested in MSDS of the four brands.

Brand A, Brand B, Brand C, and Brand D are well-known companies for professional products in the printing industry. Although raw materials used in toners are different, they maintain stable production for target customers. There are different chemicals, but most of them have the same function in the toner. For example, polyester resins, pigments, and waxes are essential chemicals in toner. The percentage in MSDS represents the weight of the chemicals in toner. The results show that some chemicals are changeable and can be combined with a variety of substances to remain competitive.

The disposal of waste toner has an absolute impact on human health and the environment. Basically, all MSDS contain some precautionary measures for helping customers avoid accidents and minimize the impact on environment. In addition, the manufacturers are aware of potential risks of toner cartridges and have provided some advice and recommendations to prevent hazards.

5. Limitations

All the data in this study were from MSDS documents accompanying each toner model. The number and percentage of chemicals to analyze were based on MSDS. Since MSDS is published on the company's official website, the actual composition may differ from the documentation. Due to the lack of data of all toner models, concentration of each component in the toner could not be determined; it was not possible to purchase 1473 cartridges for analysis. Studying 1473 cartridges with real products is a time-consuming process involving comparison of large quantities of chemicals.

In addition, there are many brands of toners and this study focused on only four brands. For the MSDS, although documents provide specific names of chemicals and other useful information, the chemicals used for a color cannot be identified clearly. MSDS of four brands provide the color types in the list but not all the color types are the same. In other words, there is a lack of standard colors so that the colorant is unable to be compared and identified clearly.

6. Recommendations

In the sampling of specimens, more toner brands should be selected for analysis so that the analysis is more in-depth and comprehensive. To understand the properties of toner, properties of chemicals should be tested through physical and chemical testing. In addition, components of toner can be identified by infrared spectroscopy or chromatography. There are machines for identifying and analyzing compounds, so most of the chemicals in toner can be compared to MSDS. Today, printing technology is becoming more and more advanced in the global market. The performance of toner is the main research to improve the customer base to increase the company's business.

Acknowledgements

This study is part of a final year project submitted by K.S.W. Kwan in partial **fulfillment** of the requirements for her BA (Hons) degree in Fashion and Textiles in Institute of Textiles and Clothing, The Hong Kong Polytechnic University. This work is financially supported by The Hong Kong Polytechnic University (Account code: ZJM8).

Conflict of interest

The authors declare no conflict of interest.

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