

How Hazardous Chemicals Present in Low-Cost Products from Popular Chinese Online Commerce Shops Can Affect Human Health

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Abstract

Globally, Chinese e-commerce companies such as AliExpress, Shein, and Temu are rapidly expanding their popularity. This paper identifies hazardous chemicals – phthalates, formaldehyde, lead, and cadmium – in low-cost products from Chinese e-commerce and examines their potential effects on the human body. It will focus on testing clothing, toys, and household items to assess the presence and levels of harmful substances such as phthalates, lead, formaldehyde, and cadmium. The study will compare the results to international safety standards to determine whether these products comply with health and safety regulations. The goal is to highlight short-term and long-term health risks these chemicals may pose to consumers. Ultimately, the findings will help inform both consumers and policymakers about the safety concerns related to these popular low-cost online platforms.

Introduction

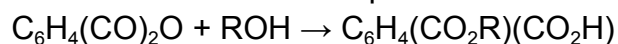
Over time, global online marketplaces gradually gained popularity, allowing for direct purchases by customers in different countries, leading to the “fast fashion” trend to emerge [1]. “Fast fashion” refers to low-cost clothing collections that replicate current luxury fashion trends, allowing young consumers to follow the fashion trend [2]. In particular, the popularity of Chinese e-commerce shops has skyrocketed. At an extremely low price, their products are more than affordable for almost every consumer. For example, Shein, one of the leading Chinese e-commerce companies, has a C2M (consumer to manufacturer) model, allowing Shein to remove intermediaries and enabling customers to buy products at a lower cost. Shein’s accessories averaged the price of \$6.56, for instance, whereas other companies had about \$10 on average [3]. In 2020, Chinese e-commerce transactions reached \$2.29 trillion, with more than 710 million online consumers accounting for about 50% of the world’s transactions [4]. According to data provided by Statistics Korea, Chinese e-commerce companies accounted for approximately 4.85 trillion won (\$3.51 billion) of the total 8.08 trillion won (\$5.85 billion) of overseas direct purchases in South Korea in 2024, a 47% increase from 2023 [5]. Depending on the companies, their products are not only limited to fashion but also include household items, toys, and other daily items. Unlike any other Chinese-made products in non-Chinese markets, purchases from these e-commerce shops deliver products directly from Chinese manufacturers to consumers’ residences. These products often do not meet U.S. safety regulations due to restricted chemicals such as phthalates and formaldehyde, resulting in the sale of unsafe goods [6]. In 2024, the Korean government attempted to ban the overseas shipping of products without Korean Certification (KC), which is a certification of compliance of products with Korean safety regulations [7], yet failed to do so due to its impracticality: the number of purchases from overseas commerce extremely outnumbers the capacity of the product inspection and global

overseas e-commerce companies are not obligated to obey Korean safety regulations [8]. Nevertheless, various studies have found that their products contain high levels of toxic chemicals. Numerous toys have been found to contain phthalates [9], clothes with PFAS [10], and other hazardous substances present in household items [11].

This paper identifies common hazardous chemicals that are present in low-cost products. The paper explains several health risks of exposure to those chemicals. Thus, this paper aims to inform mainly consumers, perhaps policymakers, of the risk of purchasing those products.

Phthalates

Phthalates are the most widely used plasticizers, composed of a variety of families of industrial compounds that increase the durability, flexibility, and workability of polymers. Phthalates are the esters of phthalic acid, also known as 1,2-dibenzene dicarboxylic acid. Phthalate esters are produced by the reaction of phthalic anhydride with an excess of branched or normal alcohols in the presence of a catalyst:



Their properties of low melting point and high boiling point allow them to be used as heat transfer fluids, carriers, and children's toys. Common plasticizers are di-2-ethylhexyl phthalate (DEHP), dibutyl phthalate (DBP), diisononyl phthalate (DiNP), diisodecyl phthalate (DiDP), and diisobutyl phthalate (DiBP) [12]. In addition to its function as a plasticizer, phthalates have properties that can be used as viscosity modifiers, solidifiers, stabilizers, lubricants, and emulsifiers, so they are used in electronics, paint pigments, adhesives, food containers, shampoos, perfumes, cosmetics, and pharmaceuticals.

However, plasticizer exposure has numerous possible health risks. Phthalates cause endocrine disruption when they enter the body. Specifically, phthalates act as analogs or inhibitors of steroid hormones such as estrogen and androgen that induce abnormal hormonal action or interfere with normal hormonal action. These disruptions of physiological functions lead to decreased fertility in both men and women, causing sperm damage in men, precocious puberty, premature puberty, and infertility in women. Phthalates are known to disturb not only sex hormone action but also thyroid hormone action, and cause breast and liver cancer. In addition, it has been reported that phthalate exposure during pregnancy affects fluctuations in pregnancy and fetal development. Moreover, the association between early childhood phthalate exposure and neurodevelopment, intelligence decline, and mental diseases such as Attention Deficit/Hyperactivity Disorder (ADHD) has been steadily proposed [13].

According to the U.S. Environmental Protection Agency, di-2-ethylhexyl phthalate (DEHP), diisodecyl phthalate (DiDP), diisononyl phthalate (DiNP), Butyl benzyl phthalate (BBP), diisobutyl phthalate (DiBP), dibutyl phthalate (DBP), and Dicyclohexyl phthalate (DCHP) "present an unreasonable risk of injury to human health" [14] [15] [16] [17] [18] [19] [20]. Thus, exposure to products that contain phthalates poses a strong danger to humans.

Formaldehyde

Formaldehyde is one of the most widely utilized chemicals throughout the world. It is a colorless gas at room temperature and pressure, typically produced by the reaction of methanol, steam, and air, with the addition of a catalyst. Formaldehyde is primarily sold as a 37-50% aqueous solution, known as formalin. It is a material used in various fields such as coal, acid-based, urea-based, melamine-based synthetic resin raw materials, adhesives, wood product manufacturing, fertilizers and pesticides, water-soluble paints, textiles, disinfectants, and preservatives [21]. Nonetheless, exposure to formaldehyde holds various health risks. It can cause skin and eye irritation as well as sensitization and toxic effects at the contact site. Beyond basic irritation, formaldehyde can cause allergic contact dermatitis, sensitization, and allergic reactions, especially in children and those with pre-existing skin conditions [22]. Moreover, according to the International Agency for Research on Cancer, there is sufficient evidence that formaldehyde is carcinogenic to humans, causing nasopharyngeal cancer, leukemia, and sinonasal cancer [23].

Lead

Lead is a chemical metal element, naturally found throughout the earth. It is commonly used in gasoline, paint, plumbing pipes, ceramics, solders, batteries, and cosmetics [24]. Due to its unique physical and chemical properties, lead is highly suitable for various applications. Yet, Lead toxicity has a destructive effect on the human body, affecting almost every function of the human body [25].

It is considered one of the most harmful heavy metals since it induces neurodegenerative diseases, cardiovascular and developmental disorders, kidney damage, hyperirritability, and decreased bone growth in children, and irreversible damage to the nervous system [24]. Children absorb up to 5 times as much lead as adults, making them more vulnerable to lead poisoning, and exposure to lead can lead to various permanent effects on a child's development and behavior. In particular, it can result in reduced attention span and intelligence quotient (IQ), increased antisocial behavior, and less educational attainment [26]. Inhalation, ingestion, or skin contact are common ways of exposure. When inhaled, up to 40% of lead dust is deposited in the lungs, and 95% of it enters the bloodstream [25].

In order to substitute PbCrO_4 (lead chromate) pigment due to its safety concerns, using a series of inorganic-organic hybrid pigments, with a main component of inorganic materials (SiO_2 , TiO_2 , and sepiolite), is one possible solution. The hybrid pigments possess similar properties to PbCrO_4 , having similar color performance, heat resistance, and photo stability, thus potentially substituting PbCrO_4 [27].

Cadmium

Cadmium is released as a by-product of refining zinc and other metals. It is commonly found in batteries, paints, and plastics. Through gastrointestinal and pulmonary absorption, Cadmium can cause severe damage to the human body [28]. It has a long biological half-life in

mammals, which means that Cadmium gets accumulated in mammals' bodies for a long period of time. Some laboratory records of exposure to cadmium in animals “include renal tubular damage, placental and testicular necrosis, structural and functional liver damage, osteomalacia, testicular tumors, teratogenic malformations, anemia, hypertension, pulmonary edema, chronic pulmonary emphysema, and induced deficiencies of iron, copper, and zinc.” Among those, several effects have been observed in humans due to accidental exposure [29]. Furthermore, according to the World Health Organization’s International Agency for Research on Cancer and the United States National Toxicology Program, Cadmium has been designated a human carcinogen. Supporting this, chronic inhalation of Cadmium to rats shows it causes pulmonary adenocarcinomas [30].

Possible replacement for Cadmium pigment is $\text{Bi}_{1-x-y}\text{Ca}_x\text{Zn}_y\text{VO}_{4-(x+y)/2}$ ($0 \leq x \leq 0.10$, $0 \leq y \leq 0.10$) pigments. Synthesized as novel inorganic yellow pigments, these pigments are environment and human-friendly. In addition to BiVO_4 being environmentally friendly, Ca and Zn being nontoxic elements, lead these pigments to be a safe and effective alternative [31].

Table

The following table summarizes the results of overseas retail product inspection conducted by the Seoul Electronic Commerce Center (SECC) from January to June 2025 [32].

Chemical	Number of products	Source/Product	Company	Detected Levels
Phthalate	~30%	Umbrellas, shoes, dolls, jeans, toys, pencils, notepads, pencil case	AliExpress, Temu	Up to 443.5 times above the legal limit
Lead	~20%	Umbrellas, shoes, blouses, toys, notepads, paints, pencil cases, pencils, accessories	AliExpress	Up to 231 times above the legal limit

Formaldehyde	~7%	Raincoats, jeans, skirts, and other clothing	AliExpress, Shein, Temu	Up to 32.55 times above the legal limit
Cadmium	~11%	Clothing, toys, pencils, notepads, pencil cases	AliExpress, Temu	Up to 5.61 times above the legal limit

More than half of the products that failed the inspection contained an illegal amount of chemicals that pose different health dangers to humans.

Conclusion/Analysis/Discussion

Hazardous chemicals are prevalent throughout industrial products. In particular, products from companies like AliExpress, Temu, and Shein are often exemplified for containing hazardous chemicals. This paper mainly focused on four chemicals: phthalate, formaldehyde, lead, and cadmium. Phthalates are industrial plasticizers that disturb endocrine function, affect fertility, fetal development, thyroid activity, and neurodevelopment, while also being linked to cancers. Formaldehyde exposure can cause skin and eye irritation, allergic reactions, and sensitization. The International Agency for Research on Cancer classifies formaldehyde as carcinogenic to humans, linking it to cancers such as nasopharyngeal cancer, leukemia, and sinonasal cancer. Lead exposure can cause neurodegenerative, cardiovascular, and developmental disorders, kidney damage, and irreversible nervous system. Children are especially vulnerable, absorbing more lead than adults, which can lead to reduced IQ, attention deficits, antisocial behavior, and long-term developmental impairments. Cadmium exposure can cause kidney, liver, bone, reproductive, and lung damage, along with anemia and hypertension. Both the WHO and U.S. agencies classify cadmium as a human carcinogen, with evidence linking chronic exposure to cancers such as pulmonary adenocarcinomas. These health risks could simply be caused by the use of products purchased from those companies. The fact that hazardous chemicals are detected in multiple products of AliExpress, Temu, and Shein raises safety concerns and suggests a certain danger in the consumption of these companies.

Although for some chemicals, there are available replacements in terms of chemical alternatives, to prevent the spread of hazardous chemicals practically, there are legal limits on those chemicals allowed to be found in products. Still, direct overseas commerce from China is relatively unregulated by national policies compared to companies that are in the nation; there are numerous products that do not comply with the laws. Since it is nearly impossible for individual countries to run an inspection for every single product from direct overseas commerce, the consumers' health risk depends on the consumers' choice.

Nonetheless, there were a few limitations of this paper. Since it is a literature review, even though the products that failed the safety inspection by SECC reveal the prevalence of hazardous chemicals across products from AliExpress, Shein, and Temu, the paper fails to address the total proportion of those unsafe products among all the products available on e-commerce platforms. Also, there are copious factors that influence exposure to chemicals from the products, other than their amount. For instance, if a certain chemical is detected in the part where it's rarely exposed, it might have less effect on humans. Therefore, it is the consumer's responsibility to be aware of what they are buying and the potential risks that follow.

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