Advance Research in Textile Engineering

Open Access

Austin Publishing Group

Review Article

Toxicity of Synthetic Fibres & Health

Singh Z[1] and Bhalla S[2]*

[1]Department of Zoology, Khalsa College, India

[2]Department of Fashion Designing, PCM S.D. College for Women, India

***Corresponding author:** Sunita Bhalla, Department of Fashion Designing, PCM S.D. College for Women, India

Received: October 05, 2016; **Accepted:** January 03, 2017; **Published:** January 05, 2017

Abstract

Toxicity is the degree to which a substance can damage an organism. Whenever we go for shopping for our clothes, we don't know, how toxic and harmful that piece of fabric could be for our health. Neither do we think of its origin nor its manufacturing process and the toxic load on our body and on environment. The purpose for writing this article is to make the people aware of harmful and dangerous effects of synthetic and semi-synthetic fibres. In older times, most of the fabrics used were made from the fibres that were derived from natural sources like cotton, wool, silk and jute. Those fibres were traditional, eco-friendly and non-toxic to wear by any means. But now a day's many fabrics used in draperies, bedding, automobile furnishing, offices, schools and hospitals are made from synthetic fibres. Many synthetic fabrics are also used for personal applications like designer wear, fashion costumes and seasonal wear because of many properties like wrinkle resistance, easy to wash, easy to store but most of them are manufactured with tons of chemicals. These are highly toxic and are increasing the negative effects on our health. These synthetic fabrics also pose a serious threat to ecological balance.

Keywords: Textile; Chemicals; Toxicity; Synthetic fibres; Health effects

Introduction

Textile industry is one of the largest sector providing jobs to lakhs of workers every year. Textile industries are engaging workers under different job categories. Textile industry is using different kinds of chemicals for different industrial processes. These chemicals used in the industries are found to be toxic in different research studies. Even, textile wastewaters have been tested for the chemicals being present in many studies [1-3]. Fibres are the smallest unit used as raw material for making yarns and fabrics. There are two types of fibres including natural fibres (derived from vegetables, animals or mineral fibres) like cotton, jute, linen, wool and silk; and man-made fibres (synthetic fibres) which are made synthetically in laboratories by using chemicals. These processed fibres are posing serious threats to the health of humans [4,5]. In this paper, an attempt has been made to summarize the chemicals being used in the making of various synthetic textile fibres and their toxicities. Synthetic may also be categorized into semi-synthetic fibres and all-synthetic fibres.

Semi Synthetic Fibres

Rayon fibres are of vegetable origin and are derived from cellulose. We can get rayon fibres by dissolving the natural cellulose to form spinning solution of regenerated cellulose and then forcing this solution through a spinneret to extrude filaments and then coagulating them. Rayon fibres can be produced through various processes

Nitrocellulose process

In this process, the linters are treated with a mixture of sulphuric acid and nitric acid to convert cellulose into nitrocellulose. The nitrocellulose is then dissolved in alcohol or ether and forced through spinneret. The fibre is highly inflammable at this stage. Therefore, it is denitrated by treating with sodium hydrosulphide.

Cuprammonium process

In this process, cotton linters or wood pulp is bleached with chlorine and is boiled in sodium hydroxide solution. Then cuprammonium hydroxide solution is prepared by adding ammonium hydroxide to a solution of copper sulphate and is forced through spinneret into sulphuric acid for coagulation.

Viscose process

Rayon fibres are prepared by treating wood chips with number of chemicals one by one including caustic soda and soda ash (sodium carbonate), hydrochloric acid, carbon sulphate and in the end with sulphuric acid for coagulation.

Acetate rayon

In this process, cotton linters or wood pulp is treated with various chemicals to make the fibres. First of all, these are treated with caustic soda and soda ash; and then are treated with bleaching powder. After this treatment, washing is done with hydrochloric acid and steeped in glacial acetic acid for acetylating of reaction. It is treated with anhydride solution, glacial acetic acid, conc. sulphuric acid, which acts as catalyst. Then ageing is done in acetic acid and sulphuric acid. Titanium dioxide, a delustrant is added to deluster the fibre and solution is forced through spinneret. Titanium dioxide is known for its toxicity in different models [6-12]. When wood pulp is bleached, a by-product called dioxin is released which is known to be toxic [13-18].

The processing treatment can use several toxic chemicals. The combination of these chemicals can linger on the clothing causing rayon wearers to suffer from nausea, vomiting, headache and chest pain. More serious health issues include necrosis, anorexia, polyneuropathy, paralysis, insomnia and Parkinson's disease.

Citation: Singh Z and Bhalla S. Toxicity of Synthetic Fibres & Health. Adv Res Text Eng. 2017; 2(1): 1012.

Table 1: Side effects of the chemicals used in the textile fibre manufacture.

Sr. No.	Name of the Chemical used	Name of the Fibre	Side effects on health
1.	Sulphuric acid	Used in manufacturing process of rayon	Can cause skin rashes, itching, redness, dermatitis, necrosis and anorexia
2.	Carbon disulphide	Emitted from rayon fabric	Can cause nausea, headache, vomiting, chest and muscle pain; and insomnia
3.	Nitric acid	Used in rayon	Can produce injuries to the skin, eye, respiratory and gastrointestinal tract
4.	Ethylene glycol	Used in manufacturing of polyester fibre	It can cause dysrhythmias and heart failure
5.	Hexamethylene diamine	Used in manufacturing of nylon fibre	Can irritate skin, eyes, nose, throat and lungs; may also damage the liver and kidneys, infertility in men
6.	Dimethyl formamide	Used in spinning process of acrylic fibre	Causes skin rashes and liver damage
7.	Formaldehyde	Used in spandex, acrylic, nylon and polyester fibres	Causes skin allergies and eye watering
8.	Barium sulphate	Used as antistatic substance in the finishing of polyester, nylon, spandex and acrylic fibres	Causes hyper skin pigmentation, dermatitis, dizziness, headache and spine pain
9.	Terepthalic acid	Used in manufacturing polyester fibre	Carcinogenic
10.	Acrylonitrile	It is used in manufacturing of acrylic fibre	Carcinogenic and has bad effects on central nervous system

All Synthetic Fibres

All-synthetic fibres include Nylon, Polyester, Lycra and Spandex. These are synthesized from various elements into large molecules by reacting various chemicals with each other. Biological monitoring has been done before in many studies for the ill effects the chemicals used in the synthetic fibre formation [4,19]. These are used for wide variety of apparels, home furnishing and industrial products, swim wear, foundation garments hosiery and sportswear. These are popular because they are thermoplastic, resilient, elastic and very strong.

Polyester

Polyester fibres are synthetic textile fibres formed by condensation polymerization of two monomers: dicarboxylic acid or terephthalic acid and ethylene glycol. Terephthalic acid is obtained by oxidizing para-xylene and nitric acid at 200°C using cobalt toluate as catalyst. Para-xylene is derived from petroleum during polymerization. It is a component in the production of terephthalic acid for polyesters such as polyethylene terephthalate. Xylene has been shown to have toxic effects [20-27]. If terephthalic acid is being used then hydrochloric acid is added as catalyst. If diethyl terephthalate is used, then sodium is added as catalyst. Both terephthalic acid and ethylene glycol are known carcinogens. Since the monomers are toxic, the toxicity of their polymerization product should not be ignored.

Monomeric forms are not completely removed from fibres, but they are trapped during manufacturing process. These forms may enter the human body through skin. Phytoestrogens are emitted by polyester which act as endocrine disrupters and also cause certain type of cancers. As the polyester fibre is bad conductor of heat and sweat, it is responsible for acute skin rashes, redness, and itching. On wearing for a long time, it can cause acute and chronic respiratory infections. Polyester is also responsible for reproductive system disorders like reduced sperm counts.

Nylon

Nylon is also made by condensation polymerization. The raw material is converted into two coal tar products: adipic acid and hexamethylene diamine. These are heated to form condensed product called nylon salt which is a polymer. The petrochemicals used for polymerization of nylon are non eco-friendly. Chemicals in the form of residues are retained by nylon fabric even after complete manufacture. As nylon fibre is bad conductor of heat, it does not allow the sweat and body heat to pass through. Formaldehyde in fabrics emitted by body heat causes skin allergies, eye watering and is a known potent carcinogen also. Delustrant chemical (titanium oxide), barium sulphate an antistatic substance cause hyper skin pigmentation, dermatitis and functioning of central nervous system as disorientation, dizziness, headache and spine pain. Green house gases like nitrous oxide and harmful volatile organic compounds are also emitted by nylon fabric.

Spandex

Spandex is an elastomeric fibre means it has a superior elasticity and has a smooth finish due to which it is commonly used for making shorts, tights, leggings, shirts and undergarments. It is molecularly described as to be composed of a chain like arrangements of soft stretchable segments of polyurethane linked together for reinforcement by hard segment. During manufacturing process of spandex fibre, a linear soluble polyurethane is dissolved in a strong solvent like Di Methyl Formamide (DMF), dimethyl acetamide or dimethyl sulfaoxide. Due to use of these strong chemicals in the manufacturing process of spandex fibres, wearing these fibres for long time, it can cause skin allergies. Occupational health status of the workers in spandex industry has also been reported [28]. As the fibres don't have the ability to absorb sweat, once you start sweating beneath spandex, chemical could be released into the skin from the dyes and formaldehyde used on the fabric which causes allergies. Contact dermatitis due to spandex is a commonly seen side effect [29-34]. Due to the inability of spandex to absorb sweat, skin can become fertile ground for different bacterial infections. Folliculitis and impetigo is also fairly common & caused due to long wear of spandex fibres.

Acrylic

Acrylic fibre is any long chain synthetic polymer composed of at least 85% by weight of acrylonitrile units. Acrylonitrile may be made from acetylene or from ethylene. Both are petroleum derivatives. When the ethylene is treated with hyprochlorous acid, a chlorohydrin is reacted with sodium hydroxide to form ethylene oxide. Hydrocyanic acid is added to ethylene oxide producing cyano-alcohol which is dehydrated to yield acrylonitrile.

The acrylonitrile is then polymerized into polyacrylonitrile resin, a long chain linear polymer. The polyacrylonitrile is dissolved in DMF and extruded through a spinneret and stretched to form fibre. Delustrant is also added to make it semi dull. In spite of their antistatic finish, heat setting and water repellency finish is also given using many chemicals. It is designed for use in bulky knits and in hand knitting yarns. DMF used in spinning process of acrylic fibres is easily absorbed through the skin and can cause liver damage and other adverse health effects [35-39].

If one is facing some mysterious health symptoms like skin rashes, nausea, fatigue, burning, itching, headaches and breathing problems and you cannot seem to get control over, it is worth checking out whether your clothes could be the problem. All these symptoms may be associated with chemicals which are used in manufacturing the fabrics. Table 1 shows the side effects of the chemicals used in the manufacture of different fibres.

Conclusion

A number of toxic chemicals are used in the manufacturing process of the synthetic fibres. Keeping in mind, all the bad effects of toxic chemicals being used in the manufacturing process of synthetic fibres, we should try to use textiles and fabrics which are made from natural fibres and are eco-friendly. Organic clothing should be chosen for the garments which remain closest to the skin most of the time including underwear's, sleepwears and camisoles. We should move in a healthier direction with our right choice of clothing to reduce our chemical load.

References

1. Gurung A, Hassan SH, Oh SE. Assessing acute toxicity of effluent from a textile industry and nearby river waters using sulfur-oxidizing bacteria in continuous mode. Environ Technol. 2011; 32: 1597-1604.
2. Roopadevi H, Somashekar RK. Assessment of the toxicity of waste water from a textile industry to Cyprinus carpio. J Environ Biol. 2012; 33: 167-171.
3. Voronin AP. Prediction of the toxicity of organic dyes used in the textile industry on the basis of chemical classification. Gig Tr Prof Zabol. 1978; 7: 16-23.
4. Kafferlein HU, Goen T, Muller J, Wrbitzky R, Angerer J. Biological monitoring of workers exposed to N,N-dimethylformamide in the synthetic fibre industry. Int Arch Occup Environ Health 2000; 73: 113-120.
5. Sanati KA, Yadegarfar G, Naghavi SH, Sadr AH, Gholami M, Hadipour M, et al. Occupational injuries in a synthetic fibre factory in Iran. Occup Med (Lond). 2009; 59: 62-65.
6. Allegri M, Bianchi MG, Chiu M, Varet J, Costa AL, Ortelli S, et al. Shape-Related Toxicity of Titanium Dioxide Nanofibres. PLoS One. 2016; 11: e0151365.
7. Combarros RG, Collado S, Diaz M. Toxicity of titanium dioxide nanoparticles on Pseudomonas putida. Water Res. 2016; 90: 378-386.
8. Cox A, Venkatachalam P, Sahi S, Sharma N. Silver and titanium dioxide nanoparticle toxicity in plants: A review of current research. Plant Physiol Biochem. 2016; 107: 147-163.
9. Li M, Luo Z, Yan Y, Wang Z, Chi Q, Yan C, et al. Arsenate Accumulation, Distribution, and Toxicity Associated with Titanium Dioxide Nanoparticles in Daphnia magna. Environ Sci Technol. 2016; 50: 9636-9643.
10. Venkatasubbu GD, Baskar R, Anusuya T, Seshan CA, Chelliah R. Toxicity mechanism of titanium dioxide and zinc oxide nanoparticles against food pathogens. Colloids Surf B Biointerfaces. 2016; 148: 600-606.
11. Warheit DB, Brown SC, Donner EM. Acute and subchronic oral toxicity studies in rats with nanoscale and pigment grade titanium dioxide particles. Food Chem Toxicol. 2015; 84: 208-224.
12. Yoshiura Y, Izumi H, Oyabu T, Hashiba M, Kambara T, Mizuguchi Y, et al. Pulmonary toxicity of well-dispersed titanium dioxide nanoparticles following intratracheal instillation. J Nanopart Res. 2015; 17: 241.
13. Wang ZF, Ding Q, Wang KX, Wu CM, Qu YH, Zhao XD. Study on dioxin emission for typical non-wood pulp making in China. Huan Jing Ke Xue. 2012; 33: 574-579.
14. Feng L, Wu C, Tam L, Sutherland AJ, Clark JJ, Rosenfeld PE. Dioxin furan blood lipid and attic dust concentrations in populations living near four wood treatment facilities in the United States. J Environ Health. 2011; 73: 34-46.
15. Nakao T, Aozasa O, Ohta S, Miyata H. Formation of dioxin analogs by open-air incineration of waste wood and by fire of buildings and houses concerning Hanshin Great Earthquake in Japan. Chemosphere. 2002; 46: 429-437.
16. Foster EP, Drake D, Farlow R. Polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran congener profiles in fish, crayfish, and sediment collected near a wood treating facility and a bleached kraft pulp mill. Bull Environ Contam Toxicol 1999; 62: 239-246.
17. James WH. The sex ratio of offspring sired by men exposed to wood preservatives contaminated by dioxin. Scand J Work Environ Health. 1997; 23: 69.
18. Kerkvliet NI, Wagner SL, Schmotzer WB, Hackett M, Schrader WK, Hultgren B. Dioxin intoxication from chronic exposure of horses to pentachlorophenol-contaminated wood shavings. J Am Vet Med Assoc. 1992; 201: 296-302.
19. Mak ST, Lui YH, Li KK. Synthetic fibre granuloma of the conjunctiva. Hong Kong Med J. 2015; 21: 77-79.
20. Neuparth T, Capela R, Pereira SP, Moreira SM, Santos MM, Reis-Henriques MA. Toxicity effects of hazardous and noxious substances (HNS) to marine organisms: acute and chronic toxicity of p-xylene to the amphipod Gammarus locusta. J Toxicol Environ Health A. 2014; 77: 1210-1221.
21. Dennison JE, Bigelow PL, Mumtaz MM, Andersen ME, Dobrev ID, Yang RS. Evaluation of potential toxicity from co-exposure to three CNS depressants (toluene, ethylbenzene, and xylene) under resting and working conditions using PBPK modeling. J Occup Environ Hyg. 2005; 2: 127-135.
22. An YJ. Toxicity of benzene, toluene, ethylbenzene, and xylene (BTEX) mixtures to Sorghum bicolor and Cucumis sativus. Bull Environ Contam Toxicol. 2004; 72: 1006-1011.
23. Erickson T, Amed V, Leibach SJ, Bushnik P, Saxon A, Hryhorczuk DO, et al. Acute bone marrow toxicity and pancytopenia following exposure to lead chromate, xylene, and ethylbenzene in a degloving injury. Am J Hematol. 1994; 47: 257-261.
24. Langman JM. Xylene: its toxicity, measurement of exposure levels, absorption, metabolism and clearance. Pathology. 1994; 26: 301-309.
25. Hass U, Jakobsen BM. Prenatal toxicity of xylene inhalation in the rat: a teratogenicity and postnatal study. Pharmacol Toxicol. 1993; 73: 20-23.
26. Ferrando MD, Andreu-Moliner E. Acute toxicity of toluene, hexane, xylene, and benzene to the rotifers Brachionus calyciflorus and Brachionus plicatilis. Bull Environ Contam Toxicol. 1992; 49: 266-271.
27. Mirkova E, Zaikov C, Antov G, Mikhailova A, Khinkova L, Benchev I. Prenatal toxicity of xylene. J Hyg Epidemiol Microbiol Immunol. 1983; 27: 337-343.
28. Jung SJ, Lee CY, Kim SA, Park KS, Ha BG, Kim J, et al. Dimethylacetamide-induced hepatic injuries among spandex fibre workers. Clin Toxicol (Phila). 2007; 45: 435-439.
29. Morley WN. Contact dermatitis from spandex yarn. Br Med J. 1966; 1: 982.
30. Pace JB. Spandex dermatitis. West J Med. 1974; 121: 315-316.
31. Porter PS, Sommer RG. Contact dermatitis due to spandex. Arch Dermatol. 1967; 95: 43-44.
32. Tanenbaum MH. Spandex dermatitis. JAMA. 1967; 200: 899.

33. van DE. Contact dermatitis due to spandex. Acta Derm Venereol. 1968; 48: 589-591.

34. van DE. Contact dermatitis due to Spandex. Dermatologica. 1969; 138: 340.

35. Hamada M, Abe M, Tokumoto Y, Miyake T, Murakami H, Hiasa Y, et al. Occupational liver injury due to N,N-dimethylformamide in the synthetics industry. Intern Med. 2009; 48: 1647-1650.

36. He J, Liu J, Kong Y, Yang W, Zhang Z. Serum activities of liver enzymes in workers exposed to sub-TLV levels of dimethylformamide. Int J Occup Med Environ Health. 2015; 28: 395-398.

37. Jin LP, Ding YL, Han CH. Lessons from a case exposed to dimethylformamide of severe chronic toxic liver disease. Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 2012; 30: 70-71.

38. Jyothi K, Kalyani D, Nachiappan V. Effect of acute exposure of N,N-dimethylformamide, an industrial solvent on lipid peroxidation and antioxidants in liver and kidney of rats. Indian J Biochem Biophys. 2012; 49: 279-284.

39. Kilo S, Goen T, Drexler H. Cross-sectional study on N,N-dimethylformamide (DMF); effects on liver and alcohol intolerance. Int Arch Occup Environ Health. 2016; 89: 1309-1320.

Citation: Singh Z and Bhalla S. Toxicity of Synthetic Fibres & Health. Adv Res Text Eng. 2017; 2(1): 1012.