

# Study on Natural Minerals Applying in Developing New Health Textiles

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## Abstract

**This paper introduces types and health functions of natural minerals applied in the textile field, details the processing methods of health textiles containing natural minerals, summarizes the development situation of the health textiles containing natural minerals at home and abroad, and analyzes its potential problems and development direction. Health textiles containing natural minerals have broad developing prospects; the current main task is to solve the problems caused by technical immaturity, improve efficiency and durability of its health properties, and expand production scale.**

## Keywords

**Health Textiles, Natural Mineral, Health Functions, Electrostatic Spinning**

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## 1. Introduction

Health textile refers to a type of textiles which can release far infrared, and generate magnetic fields and anti-bacterial and so on, and can help to balance and improve the body's functions, to achieve health benefits without producing side effects [1]. With the improvement of living standards, people have paid more attention to health. For the dress, people not only require them beautiful, comfortable, and other basic functions, but also require them have certain health benefits. The research and development of health textiles, which not only meet the demand for people's healthy living, but also are in line with the contemporary era theme of green and health, have the considerable economic value and social significance.

Natural ore materials are the basis for the formation of the natural environment, with a variety of natural properties in one, so that they have a wide range of applications in fields of environmental protection, health

care, etc. Health textiles involved in this paper refer to using natural minerals as raw materials, being composed with textiles or added to the spinning process through special processing, so as to achieve health functions such as releasing far infrared, ultraviolet resistance, and antibacterial, producing magnetic fields.

## 2. Natural Ores with Health Functions

### 2.1. Maifan Stone

Maifan stone [2] is a kind of natural drug ores, its main components are  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{CaO}$ ,  $\text{MgO}$ , etc., and also contains a variety of trace elements which can improve the anti-fatigue, anti-anoxia and immunity, and in which Mn, Fe, Mo, P, Mg are anti-cancer elements. Its pharmacological effects and magical effects have early recorded in the ancient Chinese medical book which called “Shen Nong’s Herbal Classic” [3]. Our self-developed maifan stone functional fiber is produced by adding the natural maifan stone particles to the spinning process. Tianjin university of science school [4] tested maifan stone functional fiber by applying 5DX Fourier transform infrared spectrometer and its spectrum emissivity measurement accessories, test results show that the normal emittance of maifan stone functional fiber samples in the far infrared range of 8 - 15  $\mu\text{m}$  is 82%. Bethune Medical University [4] made comparative experiments for maifan stone functional fabric effecting on 21 kinds of trace element content in human serum by using fitting method, the experimental results show that after wearing maifan stone functional fiber underwear, the total increase amplitude of trace elements in human serum is significantly higher than the control group without wearing maifan stone functional underwear, and the absorption rate of trace elements in the maifan stone functional fabric reached up to 2.83%.

### 2.2. Tourmaline

Tourmaline [5]-[7] is a polar crystalline material belonging to a group of silicate minerals compounded with many elements, has a good pyroelectric effect and piezoelectric, can emit far infrared wavelengths from 4 - 14  $\mu\text{m}$ , matched with the infrared absorption spectrum of human body, can be absorbed by human body, accelerate the blood circulation, and the releases of negative oxygen ion can stabilize the body’s nervous system, activate cells, make the oxygen free radicals in the human body [8], a great benefit to human health. There are already a number of textile products containing tourmaline on the market such as bedclothes and other knee pads and so on. In China, tourmaline has a trade name called “rare ice stone”. Wang [9] open a process that rare ice stone are used as functional components to prepare negative oxygen ions modified polyester fiber. The process is adding rare ice stone powders to the spinning melt of polyester to obtain the fiber. The anion test showed: Under friction state, the average number of anions is  $7000/\text{cm}^3$ , the peak number of anions is  $7800/\text{cm}^3$ , anion concentration is equal to that in the field or outside, so as to achieve health benefits.

### 2.3. Jade

Jade has been preserved as health clergyman since ancient times; it is rich in minerals and trace elements which are beneficial to human body, such as Zn, Mg, Fe, Cu, Se, Gr, Mn, Co and so on. Mineral medicine research prove that [10] jade can produce the high strength photoelectric effect, can focus on energy storage in the processing process, form a magnetic field, and can produce beneficial to human body after wearing. In addition, special molecular structures of jade can emission the far infrared electromagnetic waves in the wavelength range from 8 to 15 microns which can be absorbed by human body, the electromagnetic waves have very good biological effect on the human body. Jade fiber [11] is a new type of our self-developed health nano fibers, long-term wearing jade fiber products can help to improve blood circulation, promote metabolism, timely discharge wastes in the body, make human cells and tissues be more dynamic, to achieve cooling blood, reducing blood pressure, relieving fatigue and other health functions.

### 2.4. Tachi stone

Tachi stone’s main ingredient is  $\text{SiO}_2$ , as well as a variety of trace metal minerals. Its high-frequency resonance frequency is very close to that of human cells molecule. It can assist the human body to absorb and supplement magnetic energy released by the earth’s natural magnetic field, and can promote the body to absorb and gather positive energy. Taichi stone can release far infrared, emission rate is as high as 93.36%, and can improve blood

circulation, promote metabolism. In addition, tachi stone has many other excellent health functions such as anti-ultraviolet, antibacterial and so on. At present, there are many researches of applying tachi stone for developing health textiles. For example, Shanghai Ordifen Lingerie Boutique Co., Ltd. [12] has open a Taichi stone cup with a high-frequency resonance effect function, the processing method is to add Taichi stone particles embedded in the cup, making their health functions play a direct role in female breast. Fujian Federation Sanhe Co., Ltd. [13] has open a health fiber which can promote human microcirculation and its preparation, this fiber is obtained by adding tachi stone nanoparticles to the spinning solution to make it has health functions.

### 3. Technologies of Natural Minerals Applying in New Health Textiles

Currently, there are three kind of processing technology of using natural ore minerals in developing health textiles (Figure 1): the first is after special treatment, putting the natural ore directly embedded into textile products; the second is producing health functional fiber containing natural ore minerals; the third is giving fabrics health functions through fabric finishing technology.

#### 3.1. Natural Ore Directly Embedding into Textile Products

Putting the natural stone directly into textiles is one of initial methods to develop health textiles. Shanghai Ordifen Lingerie Boutique Co., Ltd. [12] has open a cup containing Taichi stone with a high-frequency resonance effect function. This cup is processed by putting 1 - 99 pieces of taichi stone particles which are irregular ellipsoids with the diameter of 20 mm to 50 mm. These particles can not only produce natural magnetic fields, natural positive energy will be gathered directly effect on the female breast, but also can release far infrared, and promote breast blood microcirculation and metabolism. The preparation technology of this method is simple, but the use has limitations, applies only to bat products. The products produced by this method although can play health properties of natural minerals, but the durability of health properties will reduce with the increasing of washing times. In current market, there are many women underwear products produced by putting natural minerals or magnets embed in pads, but its persistence of functions and the comfort level of the products cannot get consumer's recognition.

#### 3.2. Producing Health Functional Fibers Containing Natural Minerals

##### 3.2.1. Surface Coating Modification

This method is using surface treatment technology and resin finishing technology to make the treatment solution which are contained natural mineral particles attach to fibers surface during the process of producing fibers. Japan [14] used coral fossils particles, sugar, acidic aqueous solution and prescriptive fungus to ferment the mineral liquid for long time at a high temperature, then coated on fibers to make health functional fibers of releasing negative ions. This method can scatter functional agent evenly on the fibers, and produce health functional fibers with good durability. But after surface coating modification, the mechanical property and thermal stability of fibers will be affected, so that the spinning, weaving and other crafts of this kind of fibers will be affected. Therefore, when using this method, this kind of fibers should performance testing, and the subsequent technology lines

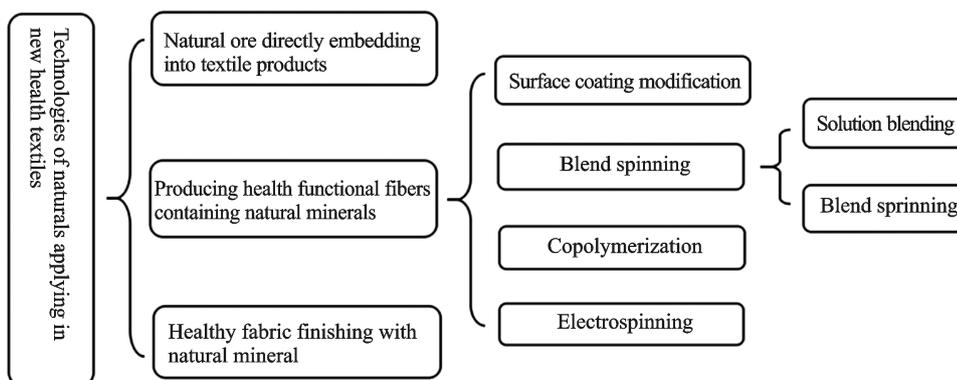


Figure 1. The flowchart of the processing methods of health textiles containing natural minerals.

such as spinning should be improved.

### 3.2.2. Blend Spinning

Blend spinning [15] is putting natural ore particles with healthy functions directly into or made of natural mineral master batch added to the polymer melt or spinning solution to prepare healthy functional fibers. According to the mixed state, the method can be divided into solution blending and melt blending.

Solution blending is putting natural ore particles or natural mineral master batch uniformly dispersed in the polymer solution, and then make the two parts sufficiently stirred and mixed into a spinning solution at a certain temperature, spinning to obtain functional composite fibers. Jilin Chemical Fiber Group Co., Ltd. [4] make the Changbai maifanite and Chinese medical stone added to the spinning solution through special processing, so that the trace elements of maifan stone firmly attached and combined on the cellulose macromolecules, to make of maifan stone functional fibers with good firmness and durability.

Melt blending is making natural ore particles or natural mineral masterbatch directly blended with the polymer and heated together to the glass transition temperature of the polymer or above crystalline melting temperature to do mechanical mixing, make natural ore particles uniformly dispersed in polymer matrix using heat and force to obtain functional combine fibers by melt blending. Jiangsu ShengHong chemical fiber co., Ltd. [16] have open a kind of micro-biological and chemical jade fiber, this fiber is processed by applying jade as the main body, as well as aluminum, silicon, titanium, zirconium and other element compounds to make of sub-nanometer particle size with nanotechnology, and then melt into the spinning melt to obtain. Adding jade can make the jade products have healthy functions such as promoting the blood circulation, promoting metabolism and other functions.

Blend spinning is one of the main methods of producing modified synthetic and functional synthetic. Compared with the method of surface coating modification, the fibers produced by this method have better durability. The processing technology of Solution blending is simple, but there are two problems: first, due to natural mineral particles are nanoscale particles, so they are easily to reunite to disperse unevenly in solution, to affect all kinds of fiber properties; second, solvents used in solution blending not only easy to remain in fibers to affect properties, but also damage to the environment. Compared with solution blending, melt blending does not need to use solvent, so as to avoid the influences of using solvent on the fiber and the environment pollution, but due to their high melt viscosity, natural ore particles dispersed more difficult.

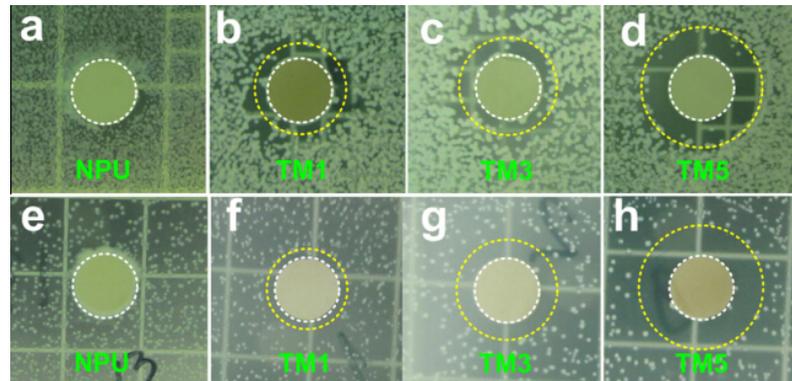
### 3.2.3. Copolymerization Method

Copolymerization is an effective method of preparing functional fibers, it belongs to the chemical reaction, is added natural mineral particles in the process of polymer monomer polymerization reaction to make them uniformly dispersed in the polymer matrix, to initiate monomer situ polymerization to obtain natural ore slice to spin. Copolymerization can form stable covalent bonds between natural ore particles and polymers to enhance the bonding strength by the polycondensation reaction, to improve the dispersing performance of natural mineral particles in the polymer matrix. But compared with the former two techniques, copolymerization has complex process and high technical requirements.

### 3.2.4. Electrospinning Technology

Electrospinning [17] [18] is using high electric field strength to make the polymer solution or melt pump long and pull fine, to be solidified by Solvent evaporation or melt cooling, and ultimately get the non-woven mat on the collection device, or use additional means to obtain the cluster of yarns. In recent years, functional nanofibers have been prepared by the electrostatic spinning method are payed more attention by researchers both at home and abroad. Tijing *et al.* [19] added tourmaline nanoparticles to the polyurethane spinning solution to prepare tourmaline/polyurethane composite nano-functional fibers by electrospinning, to make the resulting fiber has super-hydrophilic surface and a good antibacterial function. According to the antimicrobial experimental tests (Figure 2) show that pure polyurethane fiber membranes do not have antimicrobial properties, with the increasing of tourmaline mass fraction in fiber membrane, the anti-bacterial properties will be better. Wei *et al.* [20] also prepared tourmaline/PVA nanofibers by electrospinning, adding tourmaline nanopowder to PVA spinning solution to blend spinning, the resulting fiber has releasing negative ions, releasing far infrared and other health functions.

Electrospinning is one of popular technologies of preparing new functional fibers, the advantages of healthy



**Figure 2.** Zones of inhibition tests for TM/PU composite nanofiber mats ((a) and (e) neat PU and hybrid samples: ((b) and (f))TM1; ((c) and (g))TM3; ((d) and (h)) TM5 utilizing Gram-negative *E. coli* (a-d) and Gram-positive *Streptococci* (e-h) bacteria).

functional fibers produced by this technology have larger surface area, high porosity and so on, can make the natural ore particles in fibers better play its efficacy. But electrospinning technology is not mature enough, its spinning production is low, spinning device of electrospun fibers is still in development stage. Thus, improving electrospinning production and researching the spinning device of electrospun fibers is one of the development direction of the electrospinning.

### 3.3. Healthy Fabric Finishing with Natural Mineral

Finishing technology is using healthy functional finishing agent for fabric finishing, to make fabric play healthy functions. The processing method is to make healthy functional natural minerals disperse in binders, and then adhere to fabrics by padding, laminating or printing and other finishing processes. Finishing technology is one of the most widely used and the most sophisticated technology in the development of health textiles, the advantage is applicable to all textile fabrics and its process is simple, but it will have some effects on the fabric handle and permeability, and the durability of healthy functions will be lower.

The blankets containing tourmaline manufactured by Japan [21] is making the aqueous solution which are containing tourmaline powder for size of 5 - 15  $\mu\text{m}$ , anionic dispersing agents, non-ionic polymer resin emulsion adhesives and other polysaccharides adhere to the blanket through finishing technology, to make the blanket with releasing negative ions. Cheng *et al.* [22] have opened a kind of underwear which are containing nano-silver, and can release anion far-infrared. This kind of underwear is processed by making tourmaline nano-powders, maifan stone nano-powders, Chinese medicine and so on through nano-pulverization, after high-tech nano special treatment, with the aid in a certain percentage made of finishing agent, and then coating and padding the fabric, to make the finishing agent uniformly coat on the fabric. The underwear not only has tourmaline functions such as automatically generating negative ions, but also has maifanite functions to resist disease and enhance immune function.

## 4. The Development of Health Textiles Containing Natural Mineral at Home and Abroad

Development and application of natural mineral in health textiles have been highly regarded by foreign researchers; there are several patents issued and a variety of products available. For example, Zavala *et al.* [23] have open a kind of protective products of female sanitary and incontinence towels, gauze/bandages and surgical dressings for treating wounds based on tourmaline. This products has absorbed tourmaline to bring moisture proof, antibacterial, releasing negative ions and other healthy functions; Panasonic [24] have applied natural mineral successfully developing an epoch-making product-tourmaline fibers, AP man-made fibers; Japan's Nishinbo [25] has pushed out negative oxygen ion products called "IONAGE", Japan's Kurashiki has produced "HOLIC" fabric, etc. which are added tourmaline particles during processing.

In recent years, the development of health textiles containing natural ore has made great progress in domestic. Using natural ore particles making of master batch, applying blend spinning or Copolymerization method to

modify fibers to develop rare ice stone anion polyester fibers, maifan stone fibers, jade fiber and other healthy products. Recently, Fujian Federation Sanhe Co., Ltd. [13] has open a health fiber which can promote human microcirculation and its preparation, and get attention and favor in the international textile exhibition. This kind of fiber is produced by transforming taichi stone, silver, spices and other fixed material into particles with nanotechnology, and adding them to the spinning solution spun into fibers, and then spun into yarn and woven into cloth, to form a healthy fabric. Compared with other countries, the development and application of health textiles containing natural ore in domestic are still in the initial stage, the technology is not mature enough. However, our country is rich in mineral resources, and has a variety of natural ore, in-depth studying on natural minerals using in the textile field, and developing more health textiles rich in natural minerals have broad development prospects.

## 5. Conclusion

With the rapid development of high technology, the combination of natural minerals and textiles is not novel, but it is still one of the hot spots of developing new health textiles. At present, there are still many technical problems in developing natural mineral health textiles to be solved. First, uneven dispersion of adding natural ore with nanoscale into fibers or fabric is the main problem. Uneven dispersion of nanoparticles will affect firmness, stability and persistence of healthy functions of fiber and fabric, and affect the overall performance of products; therefore, exploring and solving the problem of uneven dispersion of nanoparticles are two of the necessary jobs to develop health textiles. Second, how much the amount of natural ore particles should be added can effectively play health benefits and not affect other properties of the fiber or fabric is a question worth exploring; therefore, exploring natural ore particles content is one of the important jobs of research and development with health textiles containing natural ore. Finally, the development and production of health textiles containing natural minerals are not mature enough and cannot meet the needs of society to quantify productions, and prices are generally high; therefore, improving production technology and expanding production scale of health textiles are two of the main directions of their development. In a word, using natural ore to produce health textiles with high efficiency and durability, and integrating them into all levels of society are the significance of the development of health textiles.

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## References

- [1] Zheng, K. and Shen, H. (2010) Care Textiles Development and Application. *Textile Industry and Technology*, **39**, 50-52.
- [2] Fang, C.S. and Meng, J.G. (2008) Maifan Stone Fiber Properties and Its Application. *Hebei Textile*, **3**, 32-34.
- [3] Zhao, B. (2008) Features and Develop Applications of Maifan Stone Fiber Properties. *Foreign Silks*, **23**, 38-40.
- [4] Jilin Chemical Fiber Group Co., Ltd. (1999) Maifan Stone Functional Fibers. *Silk*, **9**, 52-52.
- [5] Pirajno, F., Seltmann, R. and Yang, Y.Q. (2011) A Review of Mineral Systems and Associated Tectonic Settings of Northern Xinjiang, NW China. *Geoscience Frontiers*, **2**, 157-185. <http://dx.doi.org/10.1016/j.gsf.2011.03.006>
- [6] Wang, Y., Wang, J., Wang, L., *et al.* (2012) The Tuerkubantao ophiolite mélange in Xinjiang, NW China: New Evidence for the Erqis Suture Zone. *Geoscience Frontiers*, **3**, 587-602. <http://dx.doi.org/10.1016/j.gsf.2012.02.002>
- [7] Kaygusuz, A., Sipahi, F., Ibeyli, N., *et al.* (2013) Petrogenesis of the Late Cretaceous Turnagöl Intrusion in the Eastern Pontides: Implications for Magma Genesis in the Arc Setting. *Geoscience Frontiers*, **4**, 423-438. <http://dx.doi.org/10.1016/j.gsf.2012.09.003>
- [8] Wu, C.C. and Lee, G.W.M. (2004) Oxidation of Volatile Organic Compounds by Negative Air Ions. *Atmospheric Environment*, **38**, 6287-6295. <http://dx.doi.org/10.1016/j.atmosenv.2004.08.035>
- [9] Wang, G.W., Wang, W.H. and Yu, J.K. (2002) Negative Oxygen Ions in Polyester Fiber and Preparation: China, CN1360092A [P]. 2002-07-24.
- [10] Liu, Y., Cui, S.L. and Yin, F. (2008) A New Fiber: Jade Advent of Fiber. *Hebei Textile*, **4**, 39-42.
- [11] Han, Y.H., Meng, J.G. and Li, N. (2011) New Health Fiber-Jade Fibe. *Textiles*, **29**, 47-48.

- [12] Shanghai Ordifen Lingerie Boutique Co., Ltd. (2013) A Taichi Stone Cup with a High-Frequency Resonance Effect Function. China Patent No. 201210017287.X.
- [13] Lin, R.Y. and Xu, H.G. (2014) A Health Fiber Which Can Promote Human Microcirculation and Its Preparation. China Patent No. CN104153031A.
- [14] Shiro, N. (2001) Patent Laid Flat 13-123374.
- [15] Sano, Y., Saegusa, T. and Kimura, Y. (1995) Antistatic Modification of Synthetic Fibers by Blend-Spinning of Polymers Containing Zwitterionic Antistatic Modifiers and Their Copolymers. *Die Angewandte Makromolekulare Chemie*, **224**, 153-166. <http://dx.doi.org/10.1002/apmc.1995.052240116>
- [16] Hao, X. (2007) Micro-Biological and Chemical Jade Fiber. China Patent No. CN101070626A.
- [17] Verreck, G., Chun, I., Peeters, J., Rosenblatt, J. and Brewster, M.E. (2003) Preparation and Characterization of Nanofibers Containing Amorphous Drug Dispersions Generated by Electrostatic Spinning. *Pharmaceutical Research*, **20**, 810-817. <http://dx.doi.org/10.1023/A:1023450006281>
- [18] Jirsak, O., Sanetnik, F., Lukas, D., Kotek, V., Martinova, L., *et al.* (2009) Method of Nanofibres Production from a Polymer Solution Using Electrostatic Spinning and a Device for Carrying out the Method. US Patent No. 7585437.
- [19] Tijjing, L.D., Ruelo, M.T.G., Amarjargal, A., Pant, H.R., Park, C.-H., *et al.* (2012) Antibacterial and Superhydrophilic Electrospun Polyurethane Nanocomposite Fibers Containing Tourmaline Nanoparticles. *Chemical Engineering Journal*, **197**, 41-48. <http://dx.doi.org/10.1016/j.cej.2012.05.005>
- [20] Hong, W., Li, Q.S., Liu, J., Wang, L.P. and Xing, G.Z. (2011) Study of Fibre Tourmaline/PVA Nanofibre Prepared by Electrospinning. *Advanced Materials Research*, **295**, 41-45. <http://dx.doi.org/10.4028/www.scientific.net/AMR.295-297.41>
- [21] Dao, N. (2001) Patent Laid Flat 13-204611.
- [22] Cheng, J.X. and Cheng, G. (2012) A Kind of Underwear Which Are Containing Nano-Silver, and Can Release Anion Far-Infrared. China Patent No. CN102302224A.
- [23] Zavala, J. and Damian, G.C. (2014) Female Sanitary and Incontinence Towels, Gauze/Bandages and Surgical Dressings for Treating Wounds Based on Tourmaline. US Patent No. 20140330231.
- [24] Guo, L. (2004) Tourmaline-Multi Environmental Protection and New Materials. *Ore of China*, **43**, 56-58.
- [25] Japanese Textile Industry to Break through Nanotechnology. China Textile News, 2003-8-26.