

# Application of nanotechnology in traditional Chinese medicine and current problems

**Puyuan Hao**

Jinan New Channel-Jutes High School, Jinan, Shandong, China

1912231115@mail.sit.edu.cn

**Abstract.** Following the development of nanotechnology, more attention has been paid to nanotechnology and its applications. Nanotechnology can be applied in various fields, and it has demonstrated outstanding performance in medical science. Applications in traditional Chinese medicine are able to promote the development of TCM. In this article, the application of nanotechnology in the traditional Chinese medicine in different fields as well as the preparation and processing methods of nano TCM have been introduced. What is more, the benefits it brings and existing problems have been given. The benefits of nanotechnology applications include helping to increase the bioavailability of drugs through different pathways, enhancing absorption and reducing toxicity of drugs. Some suggestions have also been made for future developments. This article will help to provide the innovative ideas and approaches for the future development of the traditional Chinese medicine, which may possibly combine the ancient wisdom and knowledge with modern technology.

**Keywords:** Nanotechnology, Traditional Chinese Medicine, Nanocarriers.

## 1. Introduction

Nanotechnology refers to the technique of fabricating materials on the scale of individual atoms or molecules. It studies the materials with the structural scale within 1-100nm [1]. With the development of nanotechnology, it has a variety of applications. In terms of traditional Chinese medicine, it has shown positive results and development.

Following the growing awareness and attention drawn to TCM, the demand for TCM has increased. Traditional Chinese medicine has a long historical standing, and many advantages. For example, it is more personalized, and different people with the same type of disease but different symptoms may have different prescriptions. However, it may also have some drawbacks, such as being non-portable and requiring a lot of time to decoct. Some of the medicines may have toxicity, poor internal stability, lower solubility and bioavailability [2], the medicines may decompose and denature under the environment of gastrointestinal acid and digestive enzymes, the absorption will be low [3]. The application of nanotechnology may help alleviate these problems through nanocrystallization and the use of nanocarriers, thus contributing to the development of TCM and increasing the efficacy of TCM.

## 2. Preparation and processing method

There are varieties of traditional Chinese medicine. It not only includes some herbal medicines like Fortune Eupatorium Herb but also some medicines like Testudinis Carapax et Plastrum and mineral

medicines which are very hard. Different kinds of medicines require different processing method. The processing of herbal medicines is relatively simple compared to other medicines like some mineral medicines and Testudinis Carapax et Plastrum since they require more complex steps like high-temp calcining, quenching using vinegar and grind. The processing method for the medicines is time-consuming and some methods are very complicated, and the medicines are insoluble. The nanotechnology can be applied to increase the solubility and save the time. There are two current preparation method, the first is nanocrystalizing traditional Chinese medicine (TCM) directly. The second one is using nanocarriers to carry the drugs and, based on it, blend them in the right amount in modern preparation technology. After super fine crushing, the surface area of the particles in the Chinese herbal medicines will be increased, which will provide lots of activated atoms. Therefore, the medicine can accumulate plenty of physicochemical properties and biological activity that do not exist in normal conditions. The time consumed for the decoction will then be shortened, the solubility will also be improved, and the effect will be strengthened [4].

### 2.1. Mechanical equipment

A machine can be made for the preparation of nano-TCM. The raw materials will be put into the pulverizer to be smashed into particles with size 10-20 mesh. After smashing, the smashed medicines will be passed into the ball mill and mixed with the water that is transferred from a water pump. The amount of water added and the time required for ball-milling will be determined by the amount of medicines added. After the ball-milling, nano-sized ball-milling products will be gained. The products will then enter the feed delivery pipe and will be pumped to the dryer for drying. Finally, nano-sized traditional Chinese medicines will be acquired [5].

### 2.2. Nanocarrier

There are various types of nanocarriers, such as lipidosomes and nanoparticles. The materials of the nanoparticles could either be natural materials like zein or man-made polymer materials [3]. Drug nanocarriers encapsulate the drugs which can change the distribution of drugs in the body. They can also control the drug-release rate and improve the degree of bioavailability of drugs with high insolubility. The targeting of the drug can be improved due to the increased permeability and retention effect of the nanocarriers. Stability is a very crucial factor that may influence the therapeutic purpose of nanocarriers. Therefore, stabilizers are required to ensure the stability [1].

### 2.3. Microemulsion method

Heat the lipid material until it melts, and then add the medicines, emulsifier and co-emulsifier and mix to combine. After this, they are added to the aqueous phase at the proper temperature under stirring to make an O/W type microemulsion. Finally, the microemulsion is stirred with cold water, and nanoparticles are formed [6]. *An example.* In this example we can see that there are footnotes after each author name and only 5 addresses; the 6th footnote might say, for example, 'Author to whom any correspondence should be addressed.' In addition, acknowledgment of grants or funding, temporary addresses etc might also be indicated by footnotes.

## 3. Application

### 3.1. Application of nanostructured lipid carriers (NLC) in anti-tumor

The nanocarriers are very effective at encapsulating the indissolvable drugs, increasing their bioavailability and facilitating cell uptake of the drugs. This will help to achieve efficacy enhancement and toxicity reduction for the chemotherapy drugs [7].

*3.1.1. Oral medication.* Since the bioavailability of oral medication is extremely low, the use of NLC can improve this phenomenon. Using NLC to encapsulate the insoluble medicines can reduce the particle size of the medicines and change the characteristics of the molecules which will then improve

the absorption of the drugs [8]. Most TCMs for anti-tumors have a very low oral utilization rate, the use of NLC will offer a lot of help.

*3.1.2. Injection administration.* An injection is an essential method for curing tumor since its bioavailability is high and take effect more rapidly compared to other methods. However, many monomeric active ingredients of traditional Chinese medicines have low water solubility, which brings difficulty to the development. Generally, some cosolvents will be used to increase the solubility, but this may be ineffective if the medicines are highly insoluble and this may also bring adverse reactions sometimes. The use of NLC can reduce the particle size of the medicines and decrease the adverse reactions to some extent. By modifying the surface, the target drug delivery can be gained [8]. This will then increase the solubility of the monomeric active ingredients of TCM, the bioavailability will also be increased. Also, an increase in targeting will result in a better efficacy of medicines and this will minimize the harm to the normal cells in the body.

*3.1.3. Drug delivery system—liposome.* Liposomes are vesicles with a biofilm bilayer structure formed by phospholipids and cholesterol in water. They have relatively large hydrophilic internal cavities and hydrophobic bilayer membranes. Their most significant advantage is their ability to encapsulate both water-soluble and lipid-soluble drugs [7]. Since the varieties of traditional Chinese medicines are in great amounts, there will be many differences between medicines. Ingredients in TCM will differ since some may be water-soluble and some may be lipid-soluble. Since the liposomes can both encapsulate water-soluble and lipid-soluble medicines, the application of liposomes will be very effective. There have been several literature reports demonstrating that breviscapine with preparations employing the film dispersion method shows great bioavailability [7].

### *3.2. Masks*

The mask is a kind of protective equipment that can avoid inhalation of some harmful gases, viruses and specks of dust. It is made up of multiple layers of non-woven fabrics which can filter the dust and droplets out. The use of masks can help to reduce the spray of viruses. Combining traditional Chinese medicine with masks may have better effectiveness in protecting against the virus.

The traditional Chinese medicine masks basically are the combination of filtration of modern masks with the ancient sachets' fragrance and anti-epidemic effects. They belong to the scope of smell and suction therapy in traditional Chinese medicine. Astragalus membranaceus, radix isatidis and interferon can be used to prevent and treat colds by placing the drug carriers into the inner core of the masks. When the patients or people tighten the ear loop of the masks, the carriers will be raptured and the medication will volatilize and enter the respiratory tract and thus play a therapeutic role [9].

Using nanotechnology can enhance the efficacy of the TCM and may promote filtration and air permeability which can make the masks more comfortable. Adding the TCM waterproof nanomaterial coatings which contain medicines such as *Scutellaria baicalensis*, *Fructus forsythias* and honeysuckle with the effect of antibacterial and virus killing, will preventing the masks from losing efficacy when they are exposed to water. The middle layer of the masks uses the polymer nanofibres with TCM. While they are able to kill the bacteria, the pore size of the nanomaterials can be used to intercept the germs physically [9]. Since the nanofibre is small in size, the air permeability will be better. These kinds of masks will have better filtration and are able to kill the germs at the same time. These will be very suitable for people who want to prevent from getting cold and for people with rhinitis.

### *3.3. Essential oils*

Traditional Chinese medicine essential oil is a volatile and strongly scented compound extracted from aromatic Chinese medicine [10]. It has the ability to be anti-bacterial, anti-inflammation, and antioxidant and it can alleviate insomnia and anxiety. However, ingredients in the essential oil are unstable, they are easy to decompose and volatilize when under high temperature. Nanotechnology can be applied to increase the stability of the essential oil. Solid lipid nanocarriers can be used as they have hypotonicity

very high stability [10]. Using the nanocarriers to encapsulate the TCM oil can prevent oxygenolysis and reduce the volatilization.

#### *3.4. Brain diseases*

Traditional Chinese medicines can be used to treat and relieve the brain diseases like Alzheimer's Disease, but it's hard to cure completely since it cannot achieve the focus directly. This is mainly due to the blood-brain barrier. The nanotechnology can be applied to increase the ability for the drugs to pass through the blood-brain barrier and improve the efficiency of drug transport into the brain since the nano TCM can increase the bioavailability [11].

The blood-brain barrier was first proposed by German Edwin Goldman in 1919. He made an assumption that there is a barrier between the blood and the brain which may shield the substances from the blood and prevent them from entering the brain [11]. This indicates that common medicines find it hard to enter the brain and the efficacy will be low. To make the drugs work better, the entry rate of the medicines should be increased. The application of nanotechnology such as nanocarriers and nano-sized TCM can be used to increase the targeting [11]. Since the nano-sized TCM is really small, the solubility and the bioavailability may rise, and it's more likely to penetrate the blood-brain barrier. Thus efficacy can be exerted.

### **4. Advantages**

#### *4.1. To improve the bioavailability, solubility and stability*

Some highly insoluble medicines find hard to dissolve in water which causes them to have a very low bioavailability. Furthermore, some TCM contains complex ingredients like proteins, vitamins and so on, which causes them to have low stability in the body, so their bioavailability is low [2]. The use of nanotechnology like nanocarriers can improve the bioavailability. Also, after nanomatization, the specific surface area will rise, and the contact with the medicines will be increased, therefore the solubility will rise [12]. Since the medicines are being made nano-sized, the cell wall is broken at the same time. Also, the surface area of the drugs is increased. Thus, the active ingredients will be absorbed more easily into the body which can give a better effect of the drug[4]. Nanotechnology have various application in traditional Chinese medicines like oral medication and dressing and so on.

#### *4.2. Enhanced adhesion to the gastrointestinal tract*

The particle size has a significant impact on the adhesion of particles. The nanoscale carrier particle size can significantly improve the adhesion of particles [13]. As the adhesion of the nanoparticles is higher, this means that the drug is not easily effluxed. Drugs can stay in the gastrointestinal tract for longer periods of time, and the efficacy of the drug will be able to last longer. Also, patients do not have to take too many medications.

#### *4.3. Lowering the toxicity of drugs*

Drugs may in some way induce a toxic effect through a number of ways. Many toxic effects were due to the free radical and oxidative damage [4]. Under normal conditions, there is a dynamic balance between the formation and elimination of radicals. In certain cases, however, the balance will be broken, as the formation of free radicals may exceed the elimination of free radicals, which will then produce damage to the tissue. With nanotechnology involved, side effects can be mitigated and toxicity reduced [4].

### **5. Problems faced**

#### *5.1. Production cost*

The application of nanotechnology to traditional Chinese medicine is very rare and unusual in our daily lives, and there is no widespread use of nano TCM yet. This may be due to the diversification of TCM

prescriptions, as well as higher production costs. Due to the relatively high requirements of the equipment used and the environment in which it is produced, the materials required are also very expensive and this requires a large capital investment [3]. Also, research and development, and the creation of new machines will cost a lot.

### 5.2. *Preservation*

The nano traditional Chinese medicine has small particle size, its surface effects, physical properties and other properties have been changed. This will affect the oxidation and reduction of the drugs which may affect the stability [12]. If the stability increases, it will be hard to preserve. For example, the pressure and temperature needed may be different.

### 5.3. *Safety and influence on properties of traditional Chinese medicine*

In the nano processing of the TCM, the particle size will fall, and the structure of the active ingredients may be also damaged, this may cause changes in some physical properties [12]. What is more, since the structure of the ingredients may be affected, the efficacy of the drug may be affected, the drug may be less effective, and some of the toxicity of the drug may be stimulated.

In addition, there is the possibility of changes in the properties of the drug, the lack of standards for safe production and related theories, and the possibility that organic solvents may be left as residues during production, as well as the possibility that the technology may not be mature enough. This could raise some safety concerns.

## 6. **Suggestion**

More research and experiments must be done to check the safety of nano TCM as it is uncertain and the technology is not mature yet. More experiments performed will be helpful in the development of nano TCM. Furthermore, the selection of materials used and the dosage should be strictly controlled to ensure the structure of the properties of the medicines will not change to produce toxic substances. Quality standards and standard production processes must be formulated to ensure the quality of medicines and manufacturing processes. As it is very important, the hygiene of the production environment should be focused to ensure safety.

## 7. **Conclusion**

As traditional Chinese medicine has a time-honored history and culture, it has shown great performance in treating diseases. Some of the drugs, however, have some drawbacks. This can be mitigated by the use of nanotechnology. Nanotechnology applications can help increase the solubility, bioavailability and absorption of drugs by increasing the specific surface area; The toxicity may also be reduced. Nanotechnology has been used in several areas of TCM, such as anti-tumour, face masks, essential oils and brain diseases. It has shown positive results in these areas with improved efficacy. Inevitably, there are some problems, such as production costs, preservation methods. The use of nanotechnology has the potential to alter the structure of TCM, which may cause safety and preservation issues. The high production costs are unavoidable as the technology is new and requires time and finance for research and development. This paper presents the applications, advantages and current problems faced by nanotechnology in TCM, which can give a basic understanding of the application and give innovative ideas for the development of TCM. With more research and experiments on nanotechnology, people will gain a deeper understanding of its application in TCM, and the current problems may be solved, and it will play a more important role in the development of TCM.

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