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A detailed study on the effect of side chains of amino acids for the synthesis of zinc nanoparticles

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In the present work, a simple one-step synthetic method was demonstrated for the synthesis of zinc nanoparticles using amino acids as reducing and stabilizing agents in aqueous medium. The formation of the nanoparticles was strongly influenced by varying the pH of the solution and the structure of the amino acid. The yield and properties of the synthesized amino acids capped zinc nanoparticles were compared. The synthesized nanoparticles were characterized by using UV-Vis and FT-IR spectral studies.

Keywords: Amino acids, nanoparticles, pH, zinc, L-cysteine.

Introduction

Zinc nanoparticles are synthesized enormously because it can be used as anti-fungal, anti-microbial and anti-biotic agent when incorporated in plastics, alloys and textiles etc.[1]. New techniques have been developed to synthesize high quality zinc nanoparticles with greater photophysical properties[2]. Among them, capping agents are commonly used to improve the stability and properties of the nanoparticles. Biomolecules like enzymes, amino acids and biomaterials from plant extracts are commonly used as capping agents[3,4]. Among them, amino acids stabilized nanoparticles are non-toxic, easy to handle, low-cost and biodegradable. Various methods were available in the literature[5–7] to examine the influence of the side chain of the amino acid in the formation of nanoparticles. There is still room to fine-tune the methods of formation of nanoparticles.

In the present work, amino acids like L-cysteine (having thiol group in the side chain), DL-phenylalanine and L-tryptophan (have aromatic ring), glycine (have no side chain), L-leucine (have methyl in the side chain), DL-threonine (hydroxyl group in the side chain) capped zinc nanoparticles were synthesized by using a simple chemical precipitation method. Compared to the literature reported methods[5–7], our method requires very less time and can be carried out at room temperature. The synthesized nanoparticles were characterized using UV-Vis and FT-IR spectral studies. The yield and properties of the synthesized zinc nanoparticles were compared.

Experimental

Zinc acetate dihydrate salt and amino acid were taken in 1:5 molar ratio. 0.5 *M* of amino acid in 5 ml of water was mixed with 0.1 *M* of zinc acetate dihydrate in 5 ml of water. The pH of the solution was 5. Then the pH was adjusted to the basic condition with the use of sodium hydroxide (0.1 *M*) under stirring condition to yield the corresponding amino acid capped Zn nanoparticles.

Results and discussion

Amino acids capped zinc nanoparticles were synthesized and characterized by UV-Vis and FT-IR spectral techniques.

Usually ultraviolet absorption spectra of most of the amino acids[8] show λ_{max} at 200–220 nm. The UV-Vis spectra (Fig. 1) of the amino acids capped Zn NPs showed characteristic peak at 278 nm, 276 nm, 279 nm, 247 nm, 259 nm and 324 nm for Zn-Phen, Zn-Gly, Zn-Tryp, Zn-Threo, Zn-Leu and Zn-Cys nanoparticles respectively which confirmed the formation of amino acid capped zinc nanoparticles. The formation of the amino acid capped zinc nanoparticles was mainly depended on the structure and nature of the amino acid.

From the FT-IR spectra of the synthesized amino acids capped zinc nanoparticles (Fig. 2), it was confirmed that threo-

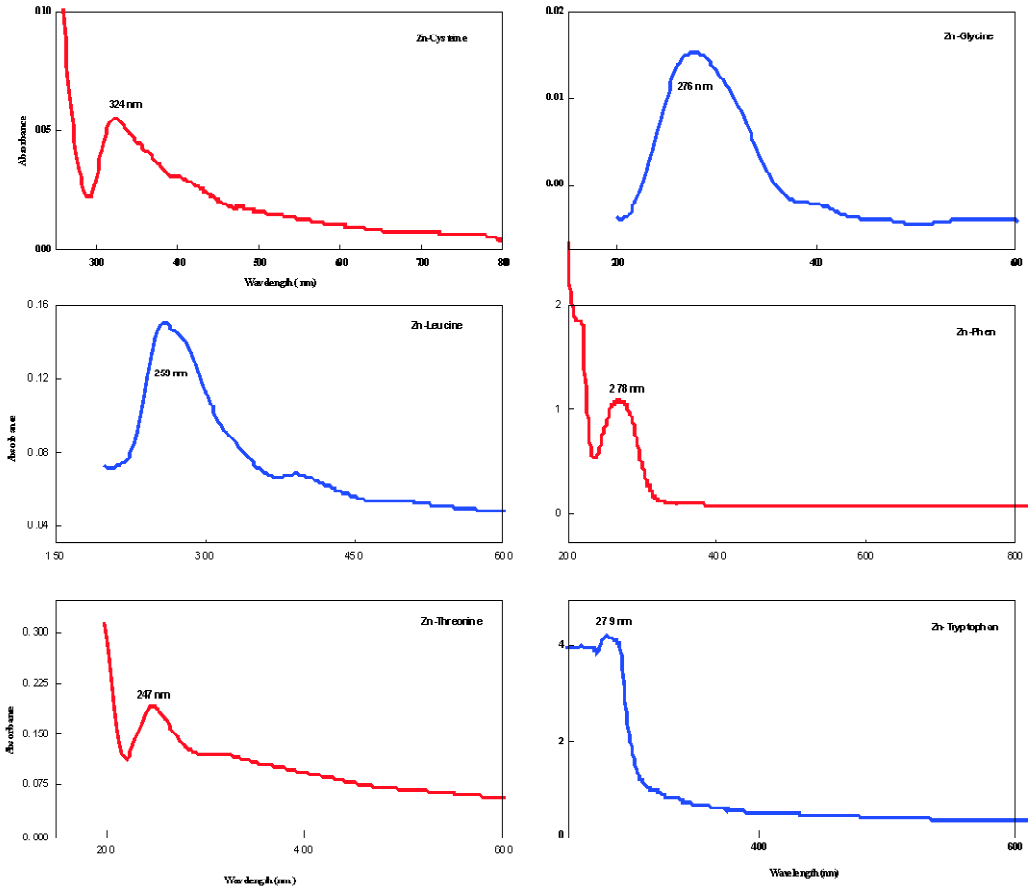

Fig. 1. UV-Vis spectra of amino acids capped zinc nanoparticles.

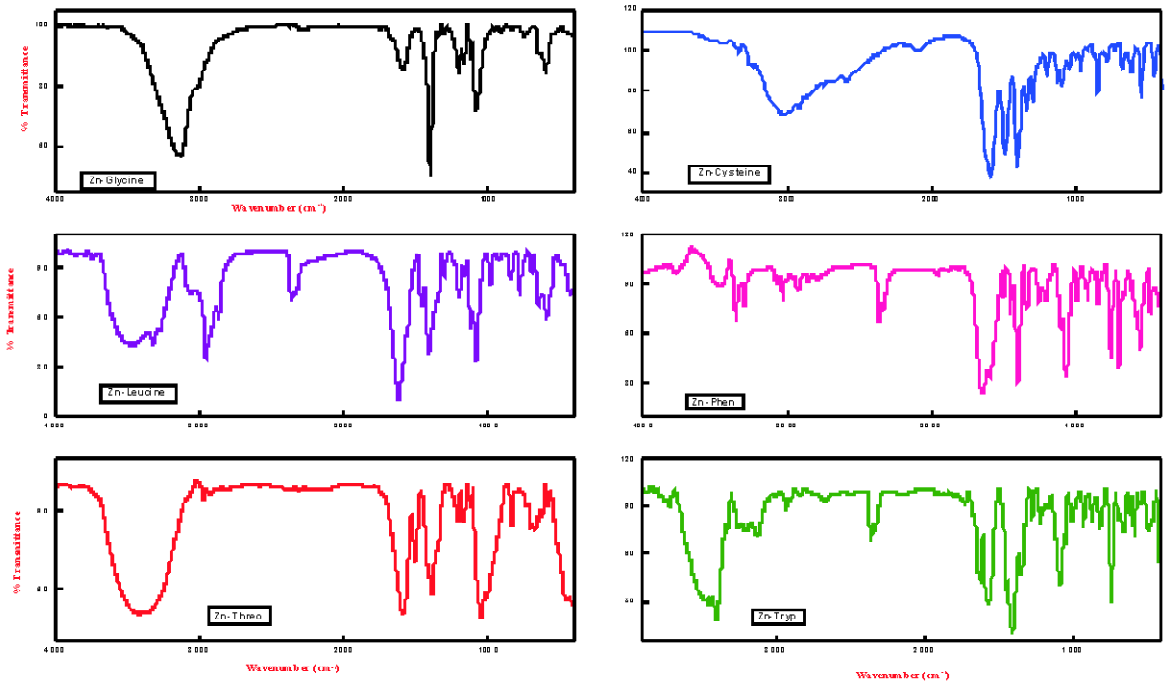

Fig. 2. FT-IR spectra of amino acids capped zinc nanoparticles.

nine was adsorbed on the surface through -OH interactions. Leucine was interacted on the metal surface by its $-CH_3$ group. Glycine was adsorbed through its carboxyl group. Phenylalanine and tryptophan participated in the adsorption on the metal surface through their aromatic ring. L-Cysteine was adsorbed through its thiol group.

The particle diameter of the synthesized nanoparticles (Fig. 3) was calculated from UV-Vis spectrum using the following equation[9]:

$$D = (-6.6521\times10^{-8})\,\lambda^3 + (1.9557\times10^{-4})\,\lambda^2 - (9.2352\times10^{-2})\,\lambda + 13.29$$

The particle size of the synthesized zinc nanoparticles were in the range of 1.3 nm to 1.6 nm.

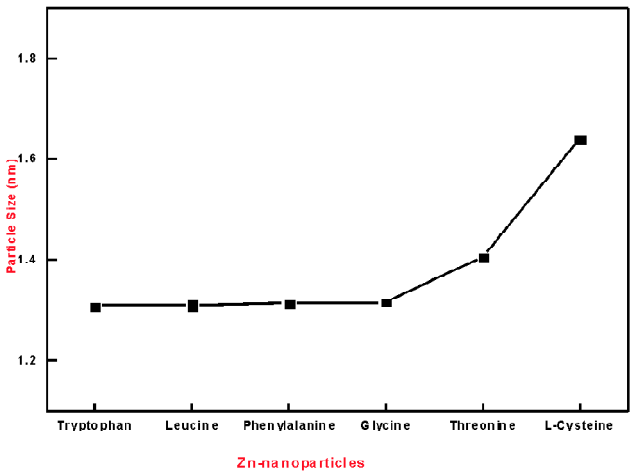

Fig. 3. Particle size of the synthesized nanoparticles.

The yield of the synthesized amino acids capped zinc nanoparticles were compared. Among all the amino acids used, L-cysteine have the capacity to reduce the maximum amount of Zn atom present in the metal salt (Fig. 4). This is because of the sulphur atom of thiol group present in L-cysteine which is very reactive. The presence of sulfhydryl group where hydrogen can be easily replaced by radicals and other groups, makes it possible to form a covalent bond with the other molecules[10]. While the other selected amino acids have methyl, hydroxyl and aromatic substituents in their side chain which are less reactive compared with the sulfhydryl group[11].

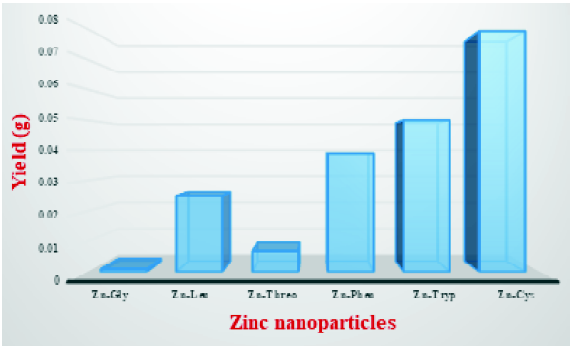

Fig. 4. Yield of the synthesized nanoparticles.

Conclusions

In summary, a simple one-step chemical precipitation method was demonstrated for the synthesis of Zn nanoparticles using amino acids as reducing and stabilizing agents. The nature of the side chain of the amino acid affected the yield of the nanoparticles. Among the synthesized nanoparticles, Zn NPs capped with L-cysteine gave the maximum yield.

Acknowledgement

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