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Full Length Article

# Metal oxide curcumin incorporated polymer patches for wound healing

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ABSTRACT

Sodium alginate and Poly vinyl alcohol (PVA) based scaffolds are very well used for wound healing purpose. Sodium alginate is a natural polymer which is used for many biomedical applications. PVA is a biocompatible polymer used in many biomedical applications. Incorporation of Titanium dioxide ($TiO_2$) nanoparticles in the scaffold increases the wound healing property of the scaffold. $TiO_2$ nanoparticles are biocompatible. They enhance the wound healing activity by photo catalytic property. Curcumin is used for the treatment of inflammation. It is the main active compound of turmeric Curcumin is used for treatment of wound and inflammation. It had antimicrobial and antioxidant property.

## 1. Introduction

Incorporation of metal oxide nanoparticles inside polymer scaffolds has been of great interest nowadays. These scaffolds are used in the wound healing activity. This incorporated nanoparticles increases the antibacterial efficiency of the scaffold [1]. Hemostasis, inflammation, proliferation and remodelling are the four steps of wound healing. Infections creates lots of problem in wound care management. They cause exudate formation. It will delay wound healing. The infectious microorganisms will enter the body through the wounds. Then it forms colonies. The internal portion of the body will also be invaded by the microorganisms. This condition will lead to lethal infections. The best way to avoid such serious conditions is by using wound healing scaffolds with antibacterial property [2–5].

Titanium dioxide nanoparticles ($TiO_2$ NPs) are biocompatible materials. There is no toxicity with $TiO_2$ nanoparticles both *in vitro* and *in vivo*. It can be used in biomedical applications for various applications like drug delivery, antibacterial coatings *etc.* It has antibacterial, antifungal and anticancer properties. It is an inert material *in vivo*. $TiO_2$ is a very important material that can be used in life science. The reactivity of titanium dioxide nanoparticles is very high. The $TiO_2$ is widely used in paint, pharmaceutical, and cosmetics industries [6,7].

Alginates are used for man biomedical applications. They are biocompatible polymers. They are non-toxic polymers. They are used for many applications like drug delivery, drug targeting, wound healing *etc.* Alginates cannot be processed other than spherical forms because of its rigid and fragile nature. They are biocompatible and biodegradable in nature. Alginates are unbranched binary copolymers. The structure of alginate is 1-4 glycosidically-linked b-Dmannuronic acid (M) and its C-5 epimer a-L-guluronic acid (G). It is obtained from marine brown algae. Sodium alginate is used as gelling agent, as stabilizers and as blood expander in pharmaceutical industry. It forms a viscous solution when dissolved

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in water [8–12]. Poly Vinyl alcohol (PVA) is used in biomaterial application for a long time. It is s synthetic polymer. It is non-toxic, biocompatible. Poly vinyl alcohol belongs to the group of poly hydroxy polymer. Poly vinyl alcohol is water soluble. It forms fibre, it is resistant to chemicals and it is biodegradable. The interaction between sodium alginate and poly vinyl alcohol is through hydrogen bonds. Due to these advantages poly vinyl alcohol is used in medical, cosmetic, food, pharmaceutical and packaging applications.

In this work we have prepared SA/PVA composite scaffolds by gel casting method. $TiO_2$ nanoparticles were prepared and characterized. Before casting $TiO_2$ nanoparticles and curcumin were added to the SA/PVA composite. The resultant scaffold is characterized and analysed for antibacterial property.

## 2. Experimental procedure

### 2.1. *Synthesis of titanium dioxide nanoparticles*

Titanium tetra isopropoxide was added to $HNO_3$ and agitated for 2 h. The pH was maintained as 3. The suspension was centrifuged and washed with $H_2O$. $TiO_2$ nanoparticles were dried for 1 h at 100 °C. The resulting powder was then calcinated 450 °C for 3 h [13].

### 2.2. *Synthesis of patches*

The solutions of Sodium alginate (2%) and Polyvinyl alcohol (16%) are prepared by dissolving them separately in 100 ml of distilled water. PVA solution is stirred and simultaneously heated up to 80–90 °C to prevent from gel formation. The solution of Sodium alginate is made to spin in the spinner. But, the ratio 1:1 of SA and PVA combination could obtain a fine fibre. Thus 0.5 g and 4 g of SA and PVA are dissolved and stirred in 25 ml of $H_2O$ separately and 5 ml from each solution is taken and allowed to spin in an Electro spinner about 10 min with 750 rpm.

5 ml solution of SA and PVA are mixed together and allowed to spin for few minutes. In this polymer, 0.1 g of $TiO_2$ nanoparticles are added slowly to form a composite fibre of SA/PVA/$TiO_2$. Then in a solution of Dichloromethane (5 ml) containing 0.5 g of curcumin is dissolved and stirred. From this 0.5 ml of the solution is added to the composite containing SA/PVA/$TiO_2$.

### 2.3. *Cross linking of sodium alginate/PVA/$TiO_2$ patch*

The sodium alginate/PVA/$TiO_2$ patches were treated with 2% glutyraldehyde vapours for 48 h and then dipped in 1% calcium chloride solution for 1 h.

### 2.4. In vitro *evaluation of antibacterial and antifungal activity*

The antibacterial activity of titanium dioxide nanoparticles were done against *Bacillus subtilis, Klebsiella pneumonia, Staphylococcus aureus, Escherichia coli* and antifungal activity against *Candida albicans and Aspergillus niger* using agar diffusion method [14]. The antibacterial activity of scaffolds were analysed against *Bacillus subtilis, Klebsiella pneumonia.* The patches are placed on the agar plates. Nutrient Agar (NA) plates were inoculated with test organisms. The plates were evenly spread out. Then wells were prepared in the plates with a cork borer. The well was loaded with 10 μg of Streptomycin dissolved in 1 ml of DMSO was used as a Positive control for antibacterial activity. The plates were incubated for 24 h at 37 °C. The development of inhibition zone around the well was measured and recorded.

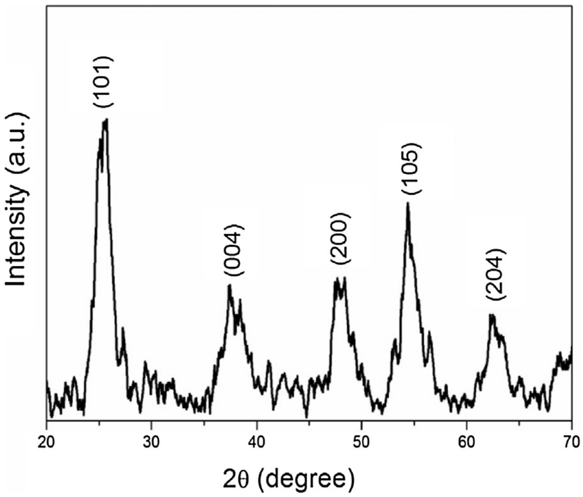

**Fig. 1.** XRD of $TiO_2$ Nanoparticles.

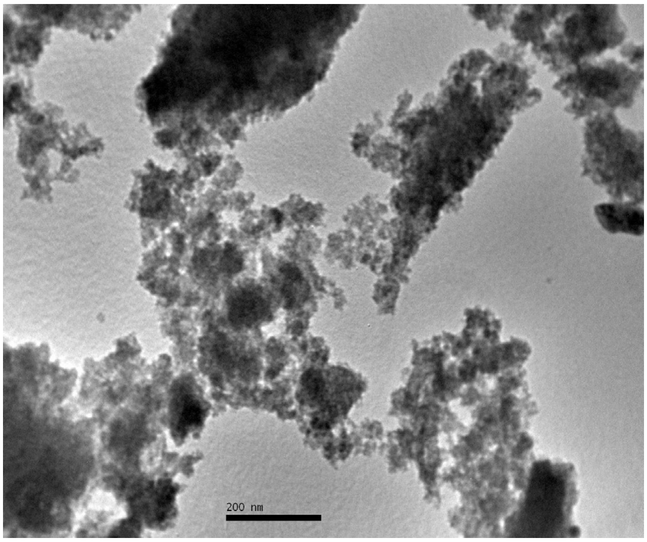

**Fig. 2.** TEM of $TiO_2$ Nanoparticles (Insert DLS).

## 3. Results and discussion

The XRD image of $TiO_2$ nanoparticles annealed at 450 °C is given in Fig. 1. The synthesised sample is confirmed as anatase phase by XRD image. The peaks which appears at $2\theta$ values of 25.20°, 37.80°, 48.04°, 53.890° and 62.68° correlates to the planes (101), (004), (200), (105) and (204). This confirms that the nanoparticles formed is titanium dioxide anatase phase.

The titanium dioxide nanoparticles nanoparticles synthesised are very small and spherical in shape. The size of the formed particles is found to be around 12 nm. This is confirmed by TEM analysis, Fig. 2. The particles are agglomerated.

Fig. 3 gives the FTIR image of $TiO_2$ nanoparticles. The band at 3500 $cm^{-1}$ is due to the hydroxyl group stretching vibrations. The vibration due to Ti—O—Ti is visible at 1139 $cm^{-1}$. The bending vibration of $H_2O$ and Ti—OH is seen at 1628 $cm^{-1}$ and 1784 $cm^{-1}$. Vibration due to Ti—O bond is seen at 1383 $cm^{-1}$. The vibrations of Ti—O—Ti band and O—Ti—O band are present at 490 $cm^{-1}$ and 400–1250 $cm^{-1}$ respectively [15].

All the six modes of Raman spectrum of anatase $TiO_2$ are shown in Fig. 4. Three of these modes are Raman active and three modes are infrared active. One mode is inactive in both infrared and Raman spectra. The band at 147 $cm^{-1}$ confirms that the nanoparticles

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