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Carboxymethyl Tamarind Kernel Gum Nanoparticles; As an Antioxidant Activity

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ABSTRACT

The incorporation of biopolymer nanoparticles with potential antioxidant properties into biomaterials for human health care is significant. The current study focuses on nanoparticles carboxymethyl tamarind kernel gum (CMTKG) composite materials because of their potential applications. The co-precipitation method was used to create carboxymethyl tamarind kernel gum nanoparticles (CMTKG-NPs). This technique was used for the first time to create carboxymethyl tamarind kernel gum nanoparticles. The strength of nanoparticle conformation is reported to be influenced by co-precipitation and stirring time. Nanoparticles were characterised using high-resolution transmission electron microscopy (HR-TEM), field emission scanning electron microscopy (FE-SEM), fourier transform infrared (FTIR), x-ray diffraction analysis (XRD), and thermo-gravimetric analysis (TGA). Suspense particle sizes have been determined to be in the 40-60 nm range. It was concluded that similar nanoparticles could be used in antioxidant activities.

1. INTRODUCTION

When compared to petroleum-based polymers, biopolymers are eco-friendly and naturally abundant polymer alternatives which are extensively used in the pharmaceutical, medical, agricultural, food packaging, biological activity, and environmental industries due to their particularly renewable, sustainable, and nontoxic properties [1].

Green synthesis, electrodeposition, combustion, in situ, ex-situ, wet method, hydrothermal, and co-precipitation have all been used to create biopolymer nanoparticles [2-3]. Natural biopolymer nanoparticles are increasingly being used in applications such as pollution control, agricultural applications, adsorption, drug delivery, antibacterial activity, antioxidant activity, anti-cancer activity, and catalytic activity [4-9].

Tamarind kernel polymer (TKP) is produced from the seeds of the Tamarindus indica tree. The seeds contain xyloglucans, which are widely used as food thickeners and gelling agents in Japan. In the United States, it has primarily been used as a wet additive in the paper industry, replacing starches and galactomannans [10]. Tamarind is a tropical evergreen tree native to India and other parts of the world. India is currently the world's largest tamarind producer [11]. Carboxymethyl tamarind kernel gum (CMTKG) is an anionic water-soluble polymer derived from Tamarind Kernel Powder (TKP) that undergoes a chemical reaction to make it cold water soluble (Carboxymethylation). Carboxymethyl groups (-CH2-COOH) are introduced along the polysaccharide chain to allow the molecule to be hydrated in cold water [12].

Carboxymethyl Tamarind Kernel Gum (CMTKG) is an anionic Tamarind kernel gum chemical modification. It is composed of D-xylose, D-galactose, and D-glucose in a 1:2:3 molar ratio [13]. This polysaccharide is composed of a carboxymethylated chain of D-(1- 4) linked glucopyranosyl units (main chain) and a side chain containing a single xylopyranosyl unit that is further coupled to every second, third, and fourth D-glucopyranosyl unit via a -D-(1-6) linkage, while one xylopyranosyl unit CMTKG' [14]. CMTKG is a natural biopolymer that is extracted from the seeds of tamarinds indica and is composed of xylose, galactose, and glucose. It is biodegradable and non-toxic. CMTKG has been used to create pellets, films, hydrogel nanoparticles, nanocomposites, and other products. CMTKG nanoparticles have a wide range of applications, including antioxidant, antibacterial, antifungal, anti-fouling, organic/inorganic impurity removal, drug delivery, medical field, anticatalyst activity, and so on [15-22].

The focus of this research is to use the co-precipitation approach to make new CMTKG nanoparticles. The prospective application of the synthesised nanoparticle for antioxidant activity was also studied in this work, which has no less cytotoxicity or greater compatibility.

2. EXPERIMENTAL

The CMTKP was provided by Bhiwani, Haryana, India (carboxymethyl tamarind kernel powder). It was used without purification in the same way that carboxymethyl tamarind kernel nanoparticles were made. This method was used to create CMTKG nanoparticles (NPs). A small fixed amount of carboxymethyl tamarind kernel powder was added to 100 mL DI water in a beaker. The mixture was then stirred for 24 hours. As a result, we have a solution that is both clear and viscous. After that, the solution was sonicated for 1 hour. After sonication, we obtained the suspended colloidal solution. The solution was then dropped by drop with continuous stirring into acetone, yielding a white precipitate. Desiccators should be used to dry items to 10–20 °C. This material should be crushed. This method yields carboxymethyl tamarind kernel gum nanoparticles. Figure 1 depicts a graphical representation of the production of carboxymethyl tamarind kernel gum nanoparticles. A small amount of these nanoparticles were suspended in the appropriate amount of DI water for testing. Morphologies, particle sizes, and structural studies have all been investigated.

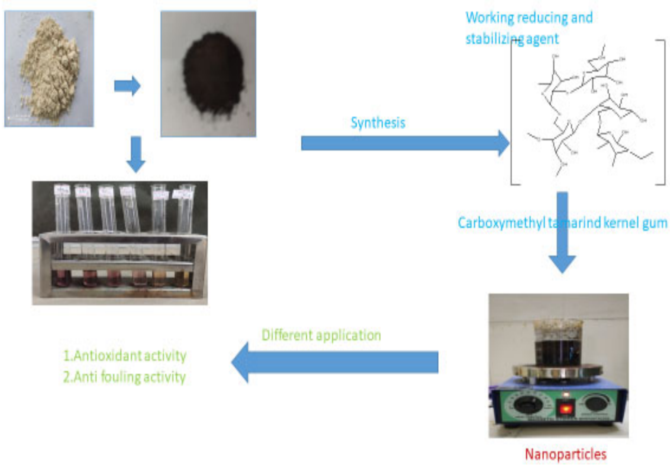


Figure 1. Diagrammatic presentation of carboxymethyl guar gum nanoparticles synthesis

2.1 Reagents and chemicals

Hindustan gum and chemicals ltd., Bhiwani, Haryana, produces carboxymethyl tamarind kernel powder gum (CMTKG). India. All solutions were made using zinc acetate, potassium dichromate (CDH) acetone, pure alcohol, and double distilled water.

2.2 Synthesis of carboxymethyl tamarind kernel nanoparticles

In the conical flask, add 1 g carboxymethyl tamarind kernel gum with 150 mL double distilled water. In order to gain viscous solutions, the mixture was magnetically stirred at 40°C. These are the options available . Stirring continuously in 75°C for 24 hours and mixing until a clear solution was obtained. To remove any loose debased particles, the mixture was stirring at 10,000 rpm for 20 minutes and rinsed with acetone. The precipitate was then washed with C_2H_5OH and dried in a hot air oven at 50 °C. CMTKG was ground into a powder. This was stored in desiccators and cleaned with acetone to remove any loose debased particles before being used with different adsorption methods.

2.3 Characterization Fourier transform infrared (FTIR)

Analyses' infrared spectra (4000–400 cm^{-1}) had been examined on a (Perkin Elmer FTIR- BX2 Instrument). The pellets were made by combining 10 mg of the test and 200 mg of KBr Spectroscopic grade.

Field emission scanning electron microscopy (FE-SEM)

Surface morphological analysis of CMTKG/ZnO nanocomposite were analysis by Scanning Electron Microscope (Model: JEOL JSM-6610LV).

High Resolution Transmission electron microscopy (HR-TEM)

In a sonicator, 5 mg of dry CMTKG/ZnO nanocomposites were dispersed in 25 mL of C2H5OH. A 10 mL dispersion of nanocomposites was placed on a completely coated copper grid (chloroform 1 percent arrangement of formvar in spectroscopic grade) and dried in vacuous. (JEOL:JEM 2100 plus model).

X-ray diffraction (XRD)

X-ray diffraction studies of synthesized CMTKG/ZnO nanocomposites were carried out using an X-ray diffractometer (P Analytical X'Pert Pro) at the current and voltage of 40 mA using Cu K α radiations (k = 1.5406 nm and λ=1.5406 Å) and Scanning angle 2θ in the range of 0-80°.

Thermal Gravimetric Analysis (TGA)

Thermal Gravimetric Analysis (TGA) of CMTKG nanoparticle were performed with 10 °C/min of uniform heating rate and inert nitrogen atmosphere (25-900°C) using a Perkin Elmer Differential Thermal Analyser.

2.4 DPPH scavenging activity

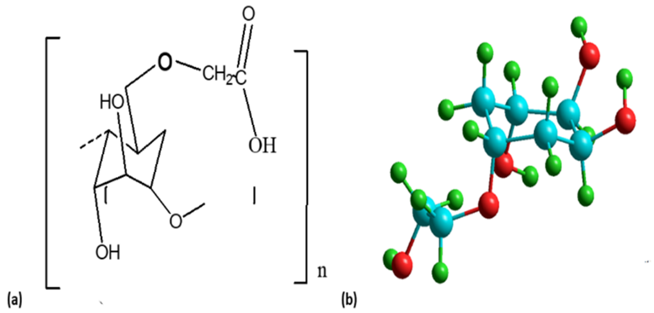
The ability of carboxymethyl tamarind kernel gum to scavenge 2,2-dyphenyl-2-picrylhydrazyl (DPPH) free radicals was investigated [18-19]. The DMSO was diluted to 1 mg/mL using the CMTKG stock solution. Diluted solutions (1 mL each) were coupled with DPPH (3 mL) and absorbance was measured at 517 nm after 30 minutes in the dark at room temperature, much like the control samples. [20]
The % inhibition was calculated using the formula below:

$$\textbf{Inhibition }\% = \frac{\textbf{Absorbaceof blank} - \textbf{Absorbance of sample}}{\textbf{Absorbanceof blank}} \times \mathbf{100}$$

3. RESULTS AND DISCUSSIONS

3.1 Synthesis of CMTKG nanoparticles

In the conical flask, mix 1 g carboxymethyl tamarind kernel gum with 150 mL double distilled water. To produce viscous solutions, the mixture was magnetically swirled at 40°C. These solutions Continuous stirring for 24 hours at 75°C and mixing until a homogenous solution was obtained. The mixture was shaken at 10,000 rpm for 20 minutes before being rinsed with acetone to remove any remaining debased particles. Finally, the precipitate was washed with C_2H_5OH and dried in a hot air oven at 50 ° C. CMTKG bio composites were prepared as a dry powder. This was stored in desiccators for use with various adsorption approaches, and it was washed with acetone to eliminate any loose debased particles.



Schematic-1 Representations of interaction of (CMTKG)[21]

3.2 Characterisation

3.2.1 High Resolution Transmission electron microscopy (HR-TEM)

HRTEM images were used to determine the form, size, and lattice spacing of the CMTKG nanoparticle shown in fig. (2). The TEM images show fine spherical nanoparticles of 20-50 nm, as well as a few larger particles and clusters in the size range 50–70 nm. These clusters could be caused by drying-induced aggregation during TEM grid preparation. [5].

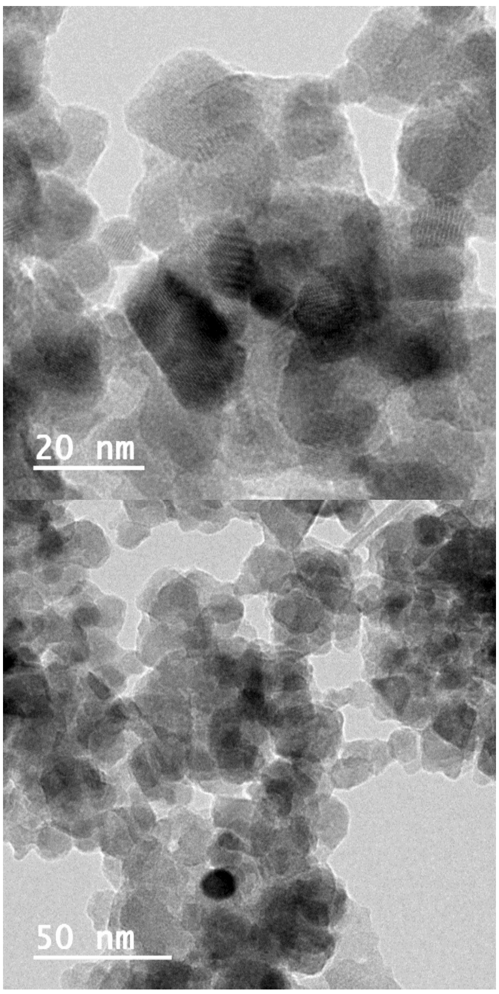


Figure 2. High Resolution Transmission electron microscopy of CMTKG nanoparticles

3.2.2 Field emission scanning electron microscopy (FE-SEM)

HRTEM images have been used to determine the shape, size, and lattice spacing of the CMTKG nanoparticle shown in Figure (3). In the TEM images, fine spherical nanoparticles of 20-50 nm, as well as a few larger particles and clusters in the size range 50–70 nm, can be seen. The clusters could be caused by drying-induced aggregation during TEM grid preparation. [10]

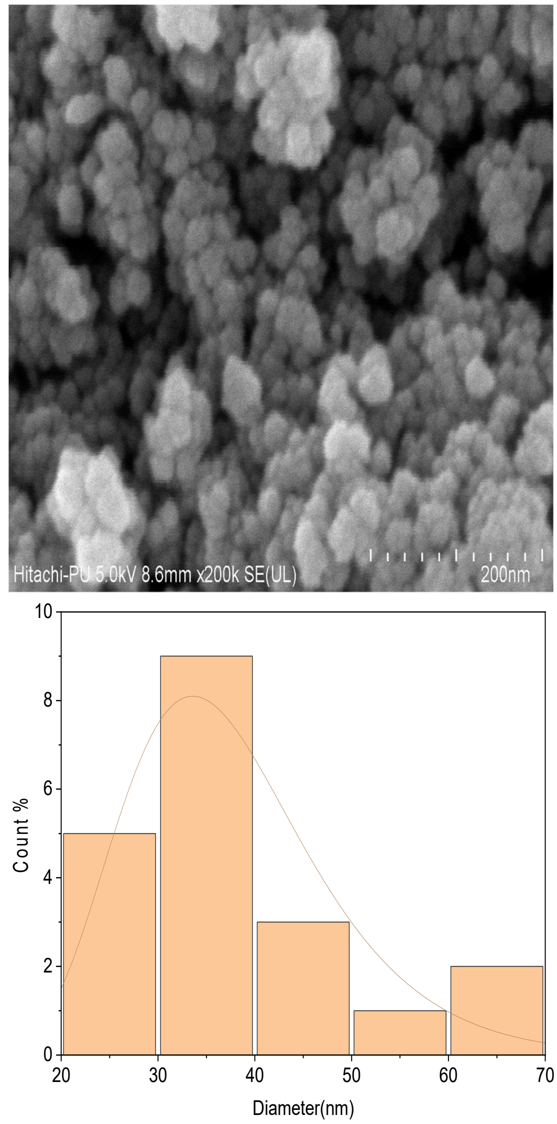


Figure 3. Field emission scanning electron microscopy of CMTKG nanoparticles

3.2.3 X-ray diffraction (XRD)

Nanoparticles in CMTKG have been examined using XRD analysis to determine their crystalline structure. Figure 3 shows the X-ray patterns of CMTKG nanoparticles. These results are consistent with nanostructure creation, as XRD patterns of CMTKG reveal nearly identical patterns with sharp peaks. The following debye-Scherrer equation was used to estimate the nanoparticle size of CMTKG nanoparticles.

$$D = \frac{K\lambda}{\beta\cos\theta}$$

The wavelength of a source 1.5 the (FWHM), and the angle direction are all represented by k=0.9. CMTKG nanoparticles were discovered to have an average size of 42.50 nm. A similar finding has been made in the literature. [16].

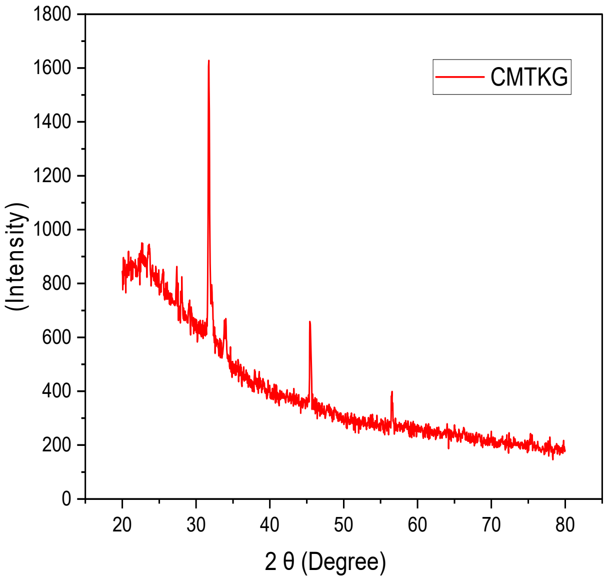


Figure 4. X ray diffraction of CMTKG nanoparticles

3.2.4 Fourier transform infrared (FTIR)

CMTKG's FTIR spectral band is shown in Figure (5). CMTKG has a strong absorption peak at 3430 cm1 for -OH stretching vibrations. Absorption at 2925 cm1 was linked to C-H stretching vibrations. –COO- symmetric vibrations cause absorption at 1630 cm1, while connected O-H bending and C-O stretching vibrations cause absorption at 1410 cm1 and 1114 cm1 [16].

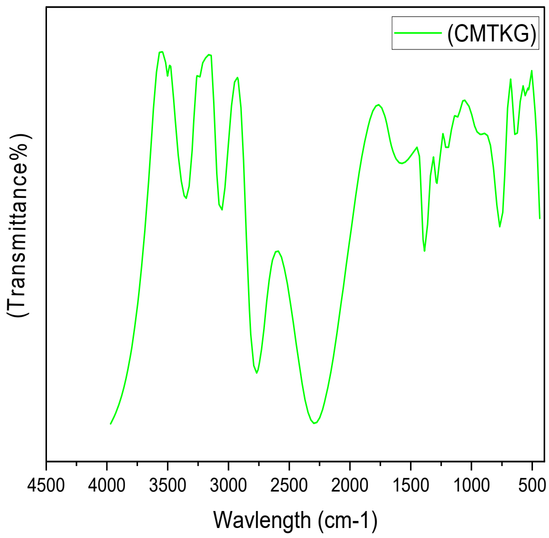


Figure 5. Fourier transform infrared of CMTKG nanoparticles

3.2.5 Thermo-gravimetric analysis (TGA)

As a consequence, a thermal analysis comparison was made to confirm this characteristic. The CMTKG Thermogram in CMTKG investigations, weight loss was investigated at three different stages. The weight decreases by -5.75 percent at the beginning stage (32–158°C), which is typical of moist expulsions from the biopolymer. The second stage of weight loss (188–421 °C) could be attributable to biopolymer backbone reductions, as well as dissolutions of CMTKG carboxymethyl and hydroxyl groups. With 3.95 percent weight loss, the third stage of degradation (652–724 °C) occurred. [3][21].

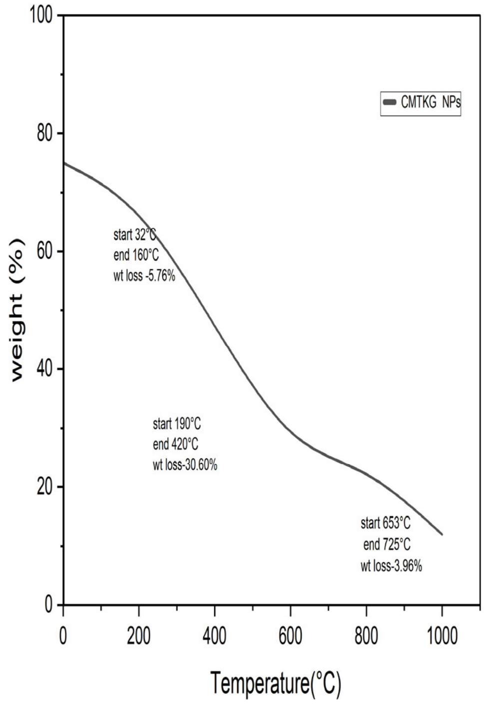


Figure 6. Thermo-gravimetric analysis of (CMTKG) nanoparticles

3.3 Antioxidant activity of CMTKG

At room temperature, the efficiency of CMTKG nanoparticles and a conventional anti - oxidant to scavenge free DPPH• was investigated with DMSO concentrations ranging from 25 µg/ml to 500 µg/ml. With increasing CMTKG and DMSO concentrations, a dose response scavenging effect was seen (Fig. 7). CMTKG nanoparticles at a concentration of 500 µg/ml were reported to have the greatest value [5][6].

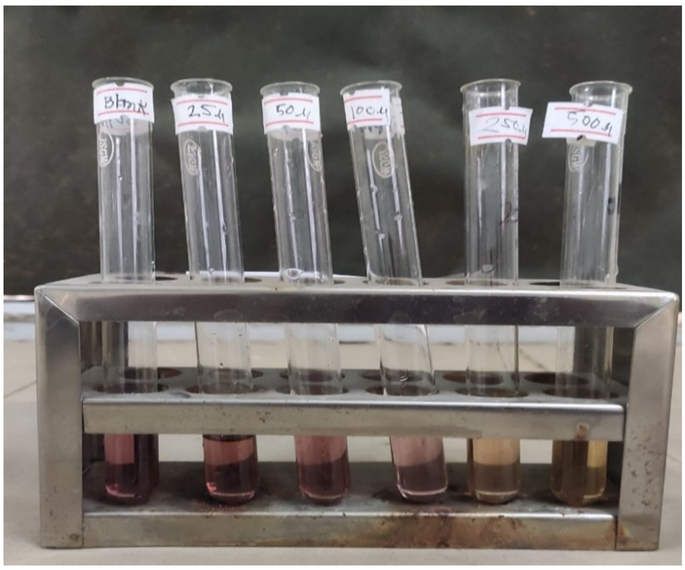


Figure 7. Antioxidant activity of CMTKG nanoparticles

Table 1. CMTKG Antioxidant activity

CMTKG solution	Absorbance (nm)	Colours
Blank CMTKG solution	0.485	Pink
25µg/ml	0.432	Light pink
50 µg/ml	0.401	Very light pink
100 µg/ml	0.387	Brown
250 µg/ml	0.292	Light brown
500 µg/ml	0.231	Very brown

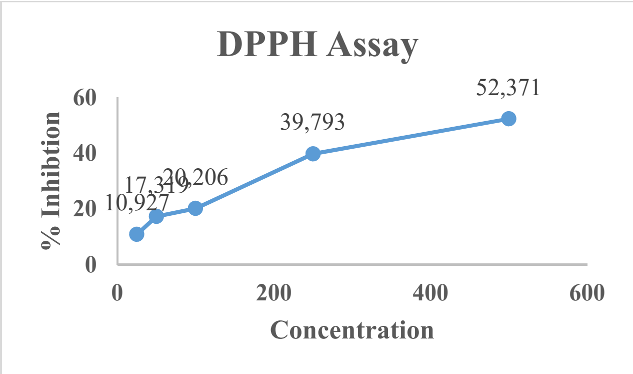


Figure 8. Antioxidant activity of CMTKG nanoparticles

4. CONCLUSIONS

The co-precipitation technique was used to successfully develop carboxymethyl tamarind kernel gum NPs. FTIR, SEM, TEM, , XRD and TGA investigations were used to characterise the physical, structural, and morphological features of CMTKG NPs, such as size, shape, and disparity. CMTKG NPs ranged in size from 40 to 60 nm. It has been shown that different sonication times can be used to make stable CMTKG NP suspensions. The nanoparticles were found to be spherical in shape, with diameters ranging from 20 to 50 nm, as well as scattered huge nanoparticles and clusters of 50 nm, as revealed by TEM. The antioxidant capabilities of the produced CMTKG NPs composites were demonstrated by a radical scavenging model system. All of the outcomes were perfectly matched, just as they had been in the literature. CMTKG nanoparticles created in this manner could be employed as antioxidants. CMTKG NPs exhibit good bioactive, biocompatible, antibacterial properties, and hence can be exploited as a bio-polymeric material in tissue engineering, biomedical, and therapeutic applications, according to the findings of this study.

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Abbreviations CMTKG-Carboxymethyl tamarind kernel gum, N.P.s- Nanoparticle, **%** Inhibition etc.