Synthesis and Characterization of Corn Starch Grafted Guar Gum Composite with Tamarind Kernel Powder

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ABSTRACT

In this work, a composite of corn starch grafted (-g-) guar gum was synthesized by a polymerization process using tamarind kernel powder as a polysaccharide. Firstly, grafting was done with corn starch and saponification with alkali, i.e., sodium hydroxide. It was further derivatized with tamarind kernel powder through a condensation process and was thermally treated at different temperatures. This leads to some chemical and structural changes in the compound. The characteristics of this composite were studied by ^{1}H NMR (Nuclear Magnetic Resonance), which showed the protonic environment found in the CS-g-GG TKP composite. The FT-IR (Fourier transform infrared spectrum) showed the presence of different functional groups found in the CS-g-GG TKP composite. Scanning electron microscopy (SEM) showed the surface morphology of the composite. Mass spectra showed the molecular weight of the newly synthesized composite.

Keywords: Polymerization, Condensation, Grafted guar, Grafting, Corn starch.

INTRODUCTION

Gums are naturally occurring complex carbohydrates, forming gels and mucilages. They are soluble in water. They have specific characteristics, like gelling, moisture retention, stabilization, and emulsification[1]. Gums have wide applications in various fields, like in the food industry, the medicinal industry, paint formulations, etc[2]. They are not very efficient under natural conditions, so we must modify some chemical properties to increase the quality by derivatization of functional groups, cross-linking, or grafting with polymers[3,4]. In this work, guar gum was grafted with corn starch and derivatized with tamarind kernel powder (TKP). Guar gum (GG) is a novel agrochemical non-ionic polysaccharide that is processed from the endosperm of cluster beans[5]. It is derived from the seeds of the Cyamopsis tetragonoloba plant and is a member of the Leguminosae family, also known as guaran[6,7]. GG is a linear chain of β-1,4 linked mannose residue to which the galactose residue is 1,6 linked at every second mannose, resulting in short side branches[8]. Guar gum is an excellent thickener and stabilizer for use in cosmetics, food, and pharmaceutical preparations[9]. It has some properties like water-binding capacity, low-temperature functioning, high viscosity even at very low concentrations, and hydrocolloid compatibility, which makes it useful in various applications.
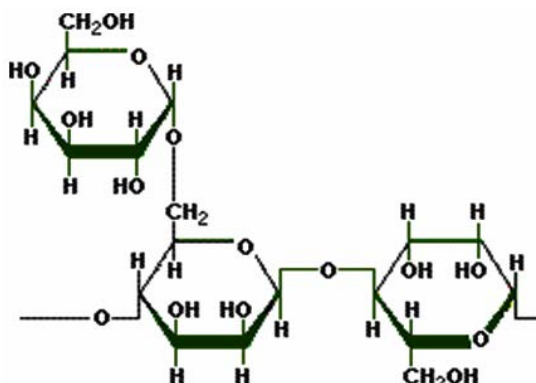
Fig. 1. Structure of Guar gum

Tamarind is native to tropical Africa with the botanical name Tamarindus indica and belongs to the Fabaceae family[10]. It is a perennial fruit species known for its fruit production and adaptability to different climatic conditions[11]. Tamarind seed polysaccharide have properties such as high viscosity, excellent water absorption, good binding, adhesivity, etc[12].
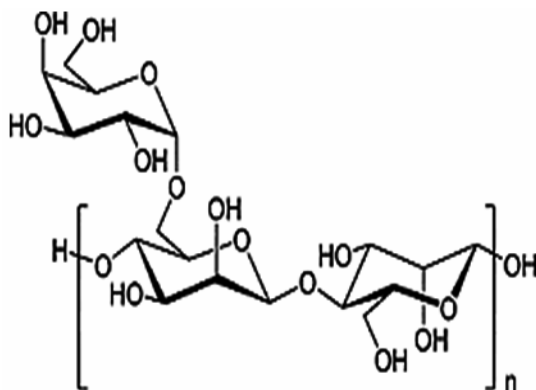

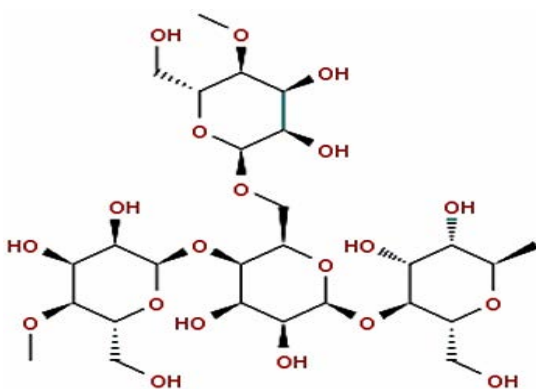**Fig. 2. Structure of Tamarind Seed Kernel Powder**

Fig. 3. Structure of Corn Starch

Corn starch was used for grafting because of its biodegradability[13]. Such composites degrade gradually and enable the bond to transfer gradually from the material to newly grown bone by inducing new bone growth[14]. This improved the thermal stability of guar[15]. There are many grafting methods, but the most widely used method is the polymerization condensation method because of its higher grafting efficiency, low cost, less degradation of the polymer backbone, etc.[16] In this work, we have tried synthesizing and characterizing a new composite based on guar gum and corn starch.

MATERIALS AND METHOD

Materials

Guar gum (Shri Ram Industries, Basni, Jodhpur), Corn Starch, Potassium persulphate (KPS, Sigma Aldrich), Ascorbic acid (Ases Chemical, Jodhpur), Tamarind Kernel Powder (Ases Chemical, Jodhpur), Methanol, Ethanol (Ases Chemical, Jodhpur), Ammonium hydroxide (5.0 N) and Sodium hydroxide (1%) were used without any further purification.

Method
Synthesis of Corn starch (CS)-g-guar gum

For grafting, guar gum (2 g) with an equal amount of ascorbic acid and corn starch was added to distilled water (250 mL). This mixture was heated for 30 min at 35ºC before adding potassium persulfate as an initiator[17]. This mixture was allowed to rest for 1 h for grafting and poured into a large quantity of DMF (Dimethylformamide) to separate corn starch CS-g-guar gum from the solution and wash it with DMF.

Saponification of CS-g-guar gum

Corn starch was saponified with an alkali NaOH solution (1%) and heated for 1-2 h at 100ºC. The saponified guar gum was separated using methanol, and washed with ethanol.

Preparation of CG-GT (Corn starch-g-guar gum with TKP) composite

A saponified sample was dissolved in distilled water. In another flask, TKP was dissolved in the required amount of ethanol. Both the solutions were mixed, and then ammonium hydroxide (5.0) was added at room temperature and kept for 18–20 hours. The mixture was then washed with distilled water, and the excess liquid was evaporated by

heating at a different range of temperatures, from 20 to 100ºC. The composites were allowed to dry.
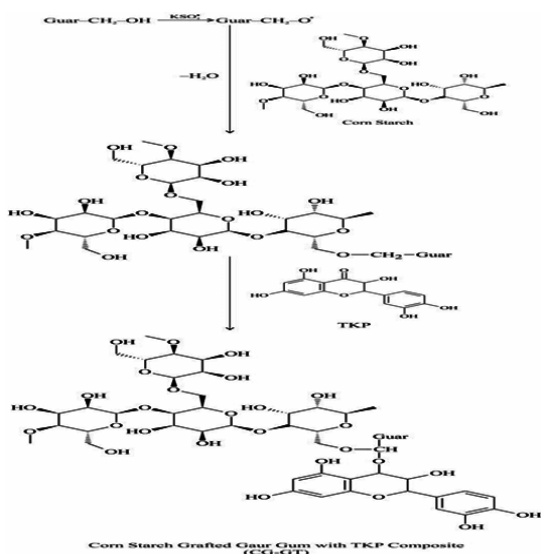
Scheme

RESULTS AND DISCUSSION

FT-IR Analysis

For the characterization of the CG-GT composite, FT-IR analytical spectra were used. The Figure depicts the assignment of several peaks detected in the FT-IR spectra of the newly synthesized composite. The peaks at 3281 and 2924 cm^{-1} are broad due to O-H and C-H aliphatic stretching, respectively. This is the peak of guar gum present in the polymer as its backbone. The 1643 cm^{-1} peak is caused by C-H bending. This indicated that an aromatic component was present. Stretching of the C=C aromatic group produced a 1558 cm^{-1} peak. The absorption of CH$_2$ bending vibration was recorded at a peak of 1325 cm^{-1}. The peak at 1150 cm^{-1} is due to the stretching of the C-O-C bond[18], and the peak at 1077 cm^{-1} is due to C-O-C stretching. The 924 cm^{-1} peak is due to O-H bending, which shows a carboxylic group[19]. C=C bending causes the peak at 850 cm^{-1}, indicating the existence of alkene. All these distinct peaks indicate grafting and composite formation.
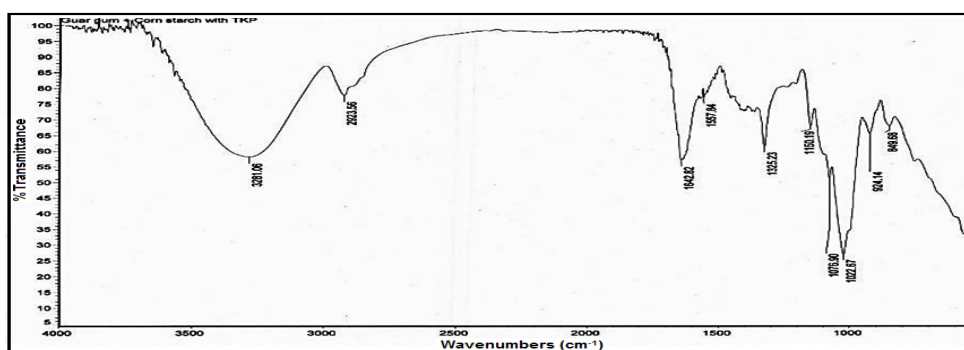

Fig. 4. FT-IR Spectra of CG-GT composite

Mass Analysis

At m/z 949.6, the molecular ion peak was discovered. It separates into daughter fragments with m/z 158.99, 163.06, 190.01, 301.16, and 415.23 as peaks. The newly produced composite's most noticeable and stable state is located at m/z 143.04. This study provides information that will help effectively synthesize the CG-GT composite.
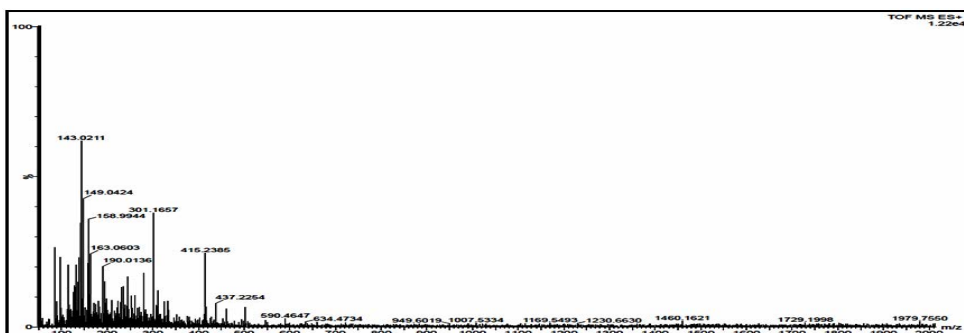

Fig. 5. Mass Spectra of CG-GT composite

¹H NMR Analysis

The protonic environment of the CG-GT composite was determined using ¹H NMR. $CDCl_3$ (Chloroform-d) was used as a solvent. The aromatic proton's peak is at 7.47 ppm. $CDCl_3$ reaches its peak at 7.25 ppm. Alcoholic protons (-OH) linked to the phenyl ring are seen at 5.52 ppm. At 3.54 ppm, the ether group is detected. The peak at 4.90 ppm indicates the presence of the vinylic group.
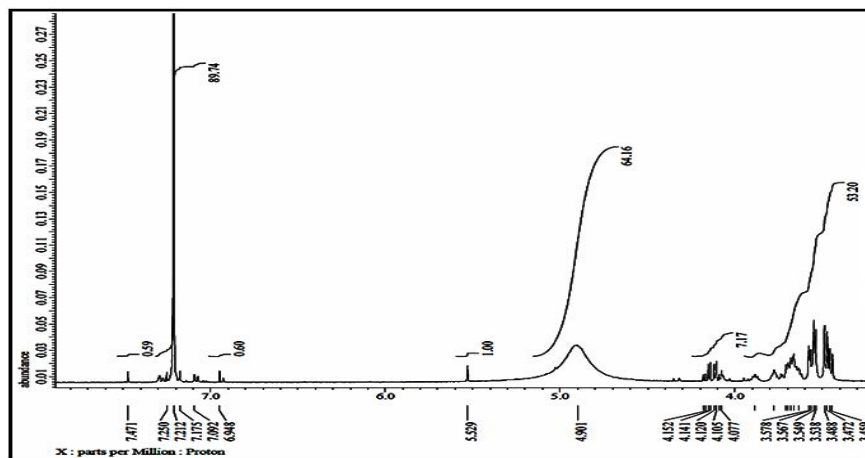

Fig. 6. NMR Spectra of CG-GT composite

SEM Analysis

The surface morphology of the composite was studied using a scanning electron microscope (SEM). The SEM images at various magnifications are shown in Fig. 7. The ZEISS instrument is used for SEM analysis. According to SEM analysis, the composite has a smooth surface and an irregular particle size. The particles are evenly scattered across the entire surface area.
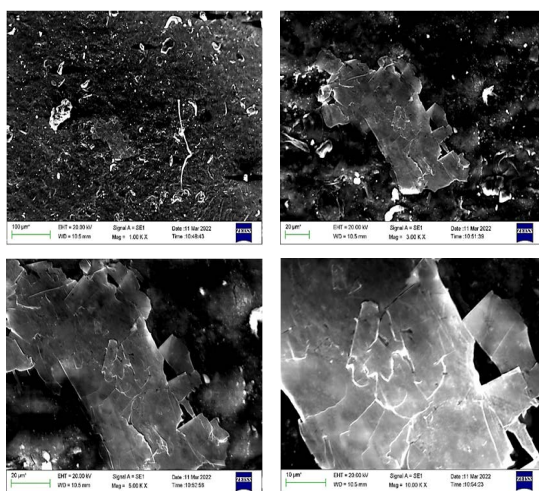

Fig. 7. SEM images of CG-GT composite

CONCLUSION

The synthesized composite consisting of guar gum, corn starch, and TKP was characterized using FT-IR, Mass spectra, ¹H NMR, and SEM. The grafting was confirmed by FTIR spectroscopy. FT-IR analysis was used to identify functional groups. The surface morphology of the synthesized composite was visible in the SEM images. The protonic environment of the composite was revealed by NMR. The manufactured composite can be used to measure the metal binding capacity using mass spectra.

Conflict of interest

All authors have approved the final manuscript and declare that there are no conflicts of interest.

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