How to Cite:
Bhasme, S. N., Sarje, S. K., Roge, A. B., Firke, S., Lavande, J., Patwekar, S., & Bhambar, K. V. (2022). Development and modification of the tragacanth solid lipid nanoparticles with natural polymer. *International Journal of Health Sciences*, *6*(S5), 4874–4884.
https://doi.org/10.53730/ijhs.v6nS5.9646

Development and modification of the tragacanth solid lipid nanoparticles with natural polymer

Sangita Namdevrao Bhasme*
Assistant professor, Nagpur College of Pharmacy, Wanadongri, Hingna road, Nagpur.
*Corresponding author

Shriniwas Keshavrao Sarje
Assistant Professor, Department of Pharmacology, Nanded Pharmacy College, MH, India

Ashish Babanrao Roge
Assistant Professor, Department of Pharmacology, Nanded Pharmacy College, MH, India

Sagar Firke
Assistant Professor, Department of Pharmacology, Nanded Pharmacy College, MH, India

Jiwan Lavande
Associate Professor, Shivlingeshwar College of Pharmacy, Almala.

Shailesh Patwekar
Assistant Professor, School of Pharmacy, SRTM University, Nanded, MH

Kunal V. Bhambar
Mgv's Pharmacy College Panchavati, Nashik

***Abstract*---**Nanobiocomposite recycling is straightforward because nanofillers' physical properties do not modify throughout processing because of their considerable thermal stability. Additionally, the low nanofiller loading has no notable effect on the density of nanobiocomposite during an elevated appearance ratio, designate that nanobiocomposite has a very elevated prospective for use. Under mild situation, we present an easy technique for fabricating silver nanoparticles spontaneously in the presence of gum tragacanth polymer (a natural polymer) without the use of a conventional reducing agent. Silver nanoparticles were formulated by mixing equal

Manuscript submitted: 27 Feb 2022, Manuscript revised: 9 April 2022, Accepted for publication: 18 June 2022

quantities of tragacanth and silver nitrate aqueous solutions at 0.5 weight percent. UV–visible, Fourier transform infrared, X-ray diffraction and X-ray photoelectron spectroscopy were utilized to substantiate the production of silver nanoparticles. Gum tragacanth polymeric chains aid in the reduction process and serve as superior stabilisers throughout the course of six months. A transmission electron microscope was utilized to substantiate the nanoparticle production and stability. The use of organic solvents or reducing agents is not required in the formation of silver nanoparticles among this approach.

***Keywords*---**Tragacanth, Silver Nanoparticles, $AgNO_3$, Silver nanobiocomposite etc.

Introduction

Polysaccharides, proteins and nucleic acids are natural polymers that obey a range of crucial roles in biological systems [1]. The specific natural polymers like cellulose [2] and chitin [3] play an important part in enhancing the structural integrity of cells in plants and animals, while others, like lysozyme [4], dispense biological shield from the environment. These natural polymers are accessible in a broad range of derivations and compositions, each among unique physicochemical and biological properties that could be advantageous in a number of applications [5,6].

Nanobiocomposite made from polymeric matrix mounting among natural fibres has a broad range of applications in a variety of fields because of their superior thermal, mechanical and biodegradable properties. To attain superior performance, nanobiocomposite is broadly employed in the aerospace, automotive, packaging, military, construction, marine, sports, medical and building block industries [7-10]. Nanobiocomposite is usually concede as an environmentally advantageous substance since it is made from bio-based chemicals and disintegrates impulsively, producing CO2 and H2O as biproducts.
Nanobiocomposite recycling is straightforward because nanofillers' physical properties do not modify throughout processing because of their considerable thermal stability. Additionally, the low nanofiller loading has no notable effect on the density of nanobiocomposite during an elevated appearance ratio, designate that nanobiocomposite has a very elevated prospective for use [11]. Nanobiocomposite is made up of two phases, one of that is less than 100 nanometers in size. The word bio in nanobiocomposite designate the use of biodegradable substances [12]. Hyaluronan and methylcellulose nanobiocomposite among poly (D, L-lactic-co-glycolic acid) nanobiocomposite among poly (D, L-lactic-co-glycolic acid) nanobiocomposite among poly (D, L-lactic-co-glycolic acid) nanobiocomposite among poly (D, L-lactic-co-glycolic acid) nanobiocomposite with poly (D, L-lactic- (PLGA) [13]. Contrastingly, the interactivity through the filler matrix and the filler-filler molecules is crucial during the successful production of nanobiocomposite [14]. Nanobiocomposite has enhanced tensile strength, enhanced water/moisture sensitivity, solubility, dissolution, solid state stability

and thermal stability. The thermal stability of nanobiocomposite, on the other hand, can diminish with time [15].
Polymers are generally utilized as steric stabilisers or capping agents in the chemical synthesis of nanoparticles. Poly (ethylene glycol) may be used as a reducing agent as well as a metal ion medium. Poly (vinyl pyrrolidone) (PVP) is a model defensive substance and current study has indicated that PVP can be utilized to synthesise colloidal and triangular silver nanoparticles without the use of a reducing agent in a single step.

In the early days of colloid science, plant extracts and gums were substantially utilized to stabilise colloidal metal dispersions. Gum tragacanth is a well-known high-molecular-weight polysaccharide that may be fabricate from the dried sap of a diversity of Middle Eastern bean plants in the Astragalus family. This natural polymer is generally utilized in confectioneries and soft drink manufacturing due to its inherent capacity to emulsify and stabilise a flavouring oil dispersed in an aqueous media. This natural polymer is not only cheap and plentiful, but it additionally has superior emulsifying and surface-active properties, that are beneficial in the design of metal nanoparticles. As a result, we explore a simple and green method for the spontaneous synthesis of silver nanoparticles without the requirement of any reducing agent using gum tragacanth as a reducing and stabilising agent [16-19].

Material and Methods
Material

Silver nitrite was provided by Aldrich Chemical Co., Inc. (Milwaukee, WI), and gum tragacanth (dry gum tragacanth) was furnished by S.D. Fine Chemicals (Mumbai, India). Double distilled water was used in the production of the tragacanth and AgNO3 solutions.

Preparation of Silver nanoparticles

Silver nanoparticles were generated by adding a gum tragacanth solution to an AgNO3 solution and stirring for a few minutes until the gum tragacanth dissolved absolutely. Numerous compositions among diverse concentrations of gum tragacanth (0.1–0.5 wt percent) and AgNO3 (0.1–0.5 wt percent) solutions were produced and left to stand during 24 hours to acquire silver nanoparticles [20].

Characterization

The FTIR spectra of tragacanth and tragacanth–silver particles were recorded using a Thermo Nicolet Nexus 670 spectrophotometer. The ultraviolet–visible (UV–vis) spectra were measured utilizing a Citra 10e UV–vis spectrophotometer (Melbourne, Australia). Xray diffraction (XRD) observations (Cu radiation, k 5 0.1546 nm) were recorded at 40 kV and 40 mA using a Rigaku diffractometer (Tokyo, Japan). X-ray photoelectron spectroscopy (XPS) was performed using a Kratos Axis 165 apparatus (Manchester, UK). TEM images were captured using a Tecnai F 12 transmission electron microscope (Phillips, Oregon, USA). After removing excessive solution using filter paper, 2–3 droplets of a tragacanth–silver nanoparticle solution was scattered beyond a copper grid and dried at room temperature.

Result and Discussion

The production of metal nanoparticles utilising polymeric templates without the use of typical chemical reduction agents has been the focus of recent research. In addition to the recognised methodologies, we used a simple and highly facile template-based technology to synthesise silver nanoparticles with gum tragacanth polymer without the use of any reducing agent. The nanoparticles may be manufactured at room temperature, which is the most advanced component of this technology. Although polyethylene glycol possesses reducing and stabilising qualities, producing nanoparticles at higher temperatures (80–110°C) is required. In this investigation, we noticed that adding silver salt to gum tragacanth solutions changed the colour of the reaction mixture from yellow to grey or brown. This is a straightforward indicator of the generation of silver nanoparticles. The lack of colour change in the solution after 24 hours, on the other hand, indicates that the majority of the Ag ions have converted to Ag nanoparticles. The ion-exchange process occurs in the first phase, when silver cations (Ag1) are coupled with an aqueous tragacanth polymer solution and the glycoprotein carboxylate group (COOH) of gum tragacanth is changed to COO Ag. These carboxylate-bound silver ions are subsequently converted into silver nanoparticles in-situ and stabilised by the gum tragacanth polymer chains. The sections that follow give a more detailed explanation.

Absorption peaks in the 380–500 nm wavelength range in UV–vis spectra have been convincingly attributed to silver nanoparticles in numerous past experiments due to their surface plasmon resonance. We monitored the temporal evaluation of UV–vis absorption spectra for the samples AgNO3 5 0.5 wt percent and tragacanth 5 0.5 wt percent at different intervals to evaluate the production of silver nanoparticles. Figure 1 shows the UV–vis spectra of the generated silver nanoparticles.

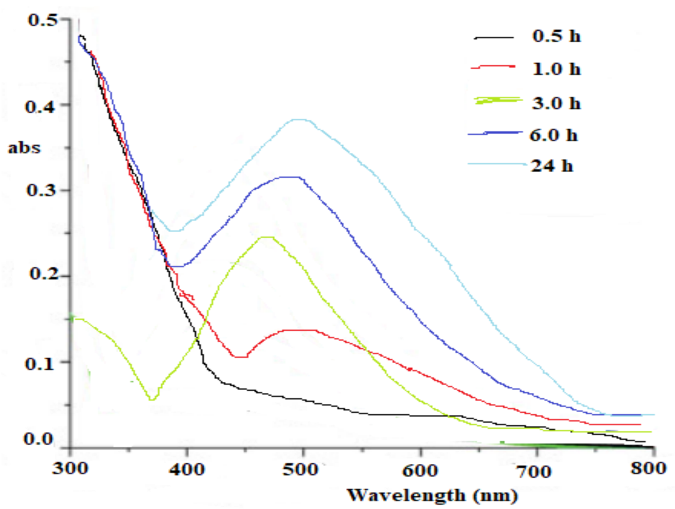
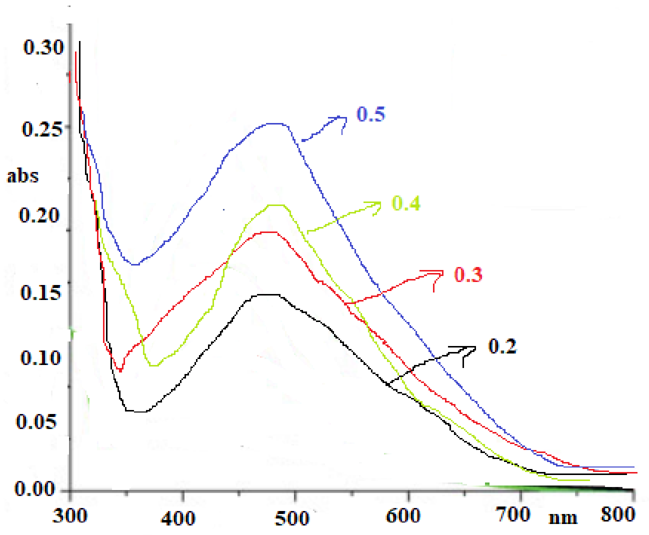


Fig. 1: UV–vis spectra of nanoparticles at different times

It shows that reduction occurs early in the reaction, with nanoparticle formation apparent after 30 minutes and practically complete after 24 hours. Surface plasmon absorption at 420 nm increases over time and remains constant for 24 hours, although the peak position does not shift. This lends credence to the notion that the loss in potentiality becomes more pronounced over time. To analyse the reduction efficiency of Ag1, we looked at different amounts of the tragacanth polymer and AgNO3, and their relative UV–vis spectra are presented in Figure 2.

a)



b)

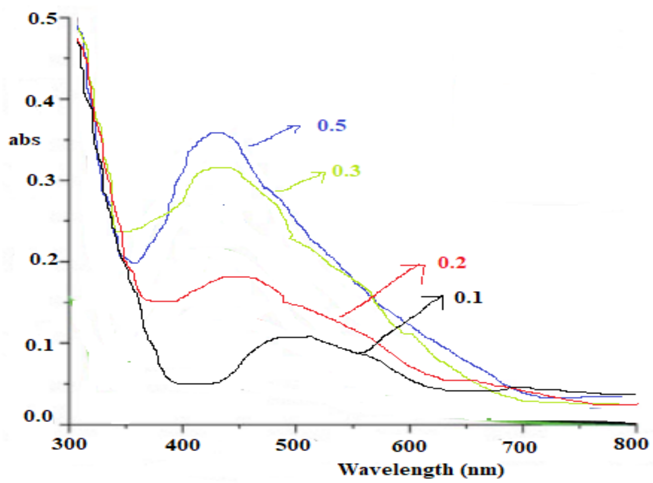
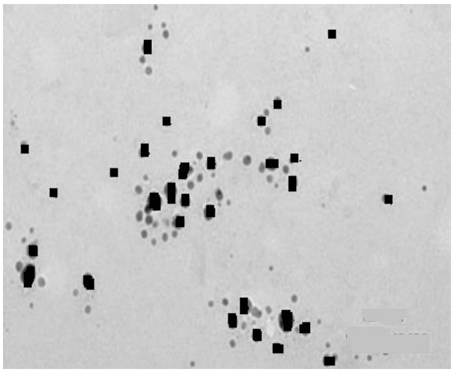


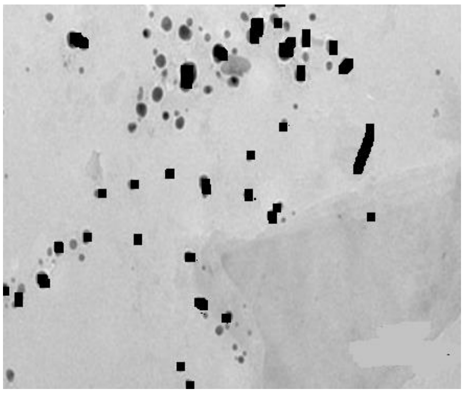
Fig. 2: UV–vis spectra: (a) a tragacanth concentration of 0.3 wt % and different concentrations of AgNO3
(b) an AgNO3 concentration of 0.5 wt % and different concentrations of tragacanth.

The UV–vis data reveal that increasing the silver salt or polymer content in the preparation greatly increases the reduction efficacy. The absence of peaks at 335 or 560 nm in all UV–vis spectra shows that Ag nanoparticle aggregation or Ag cluster formation are not present. To put it another way, the nanoparticles that originate from this interaction are widely dispersed throughout nature. After 5 months at ambient temperature, the nanoparticles showed good stability (no aggregation). Figure 3 shows that the amount of tragacanth polymer used in the formulation has a big impact on the size of the silver nanoparticles that form.

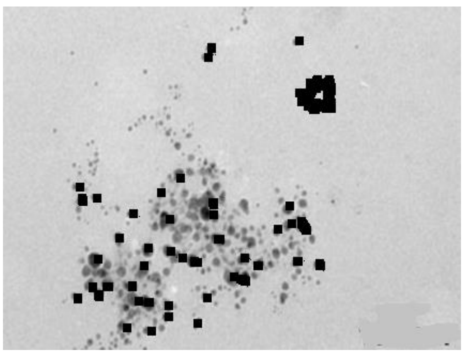
a)



b)



c)



d)

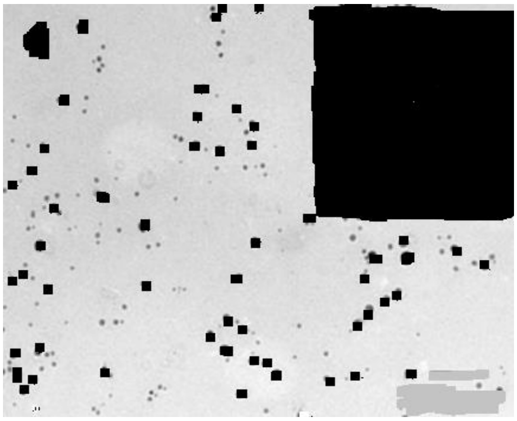


Fig. 3: TEM images for silver nanoparticles prepared with an AgNO3 concentration of 0.5 wt % and different concentrations of tragacanth: (a) 0.1, (b) 0.2, (c) 0.3, and (d) 0.5 wt %.

The size of the silver nanoparticles decreases from 17.34 - 5 8.45 to 6.65 - 5 0.69 nm as the tragacanth concentration increases from 0.1 to 0.5 wt percent at a constant reducing agent (AgNO3) concentration of 0.5 wt percent. This demonstrates that [AgNO3] 6 0.5 wt% and tragacanth 6 0.5 wt % create a good composition for creating 5 nm-silver nanoparticles in aqueous conditions. A different method, based on bulk thermosensitive hydrogel nano templates, produces silver nanoparticles with a diameter of 4 nm, but it involves a number of steps, including hydrogel synthesis, metal salt insertion and a reduction procedure. This study proved to be successful in generating nanoparticles in a single step. The nature of the silver created in this technique was investigated using XRD and XPS studies.

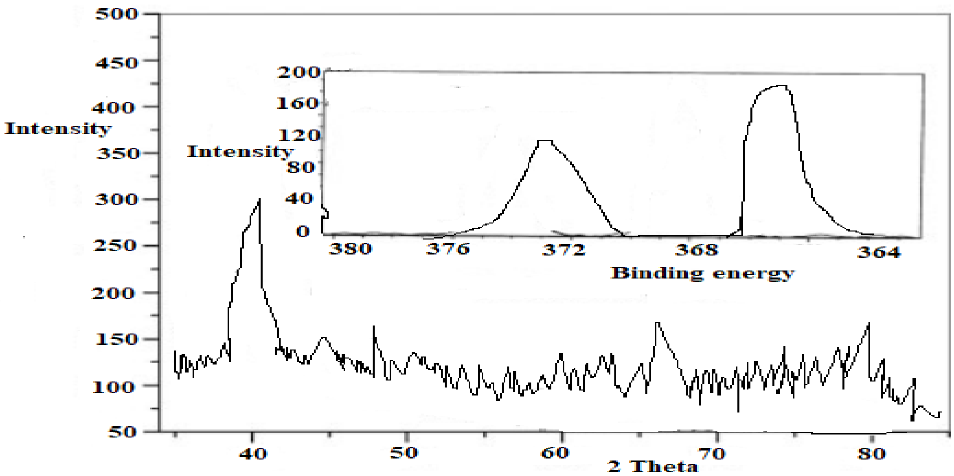


Fig. 4: XRD spectrum and XPS of silver nanoparticles.

Figure 4 depicts discrete peaks at scattering angles (2y) of 37.64, 42.98, 66.12, and 78.34, respectively, corresponding to scattering from the (110), (222), (220), and (310) planes. The face-centered cubic structure of crystalline silver nanoparticles is readily visible in these diffraction peaks. Furthermore, high-resolution narrow XPS scans of the Ag0 stage (3d5/2) reveal a 365eV binding energy peak, confirming the formation of silver nanoparticles (Fig. 4, inset). Because most research shows that polymeric chains stabilise nanoparticles but may not aid in the reduction process, we describe the reduction process in detail in this simple technique. The tragacanth polymer is made up of a high-molecular-weight glycoprotein comprising 90 % carbohydrates and a low-molecular-weight heterogeneous polysaccharide with a large number of hydroxyl and carboxyl groups in the polymer chains. The hydroxyl groups of the tragacanth polymer are thought to be involved in the reduction process, whereas hydroxyl groups of poly (ethylene glycol) or ethylene glycols are known to be effective reducing agents. The hydroxyl groups of the polymer chains reduce the silver metal (AgNO3) to silver nanoparticles via the oxidation mechanism.

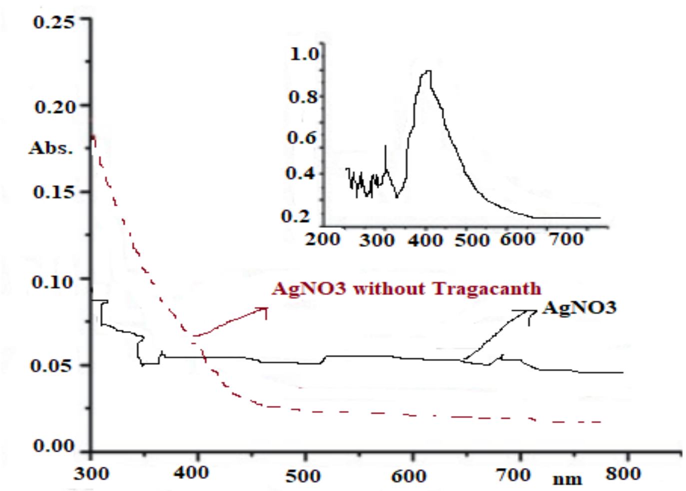


Fig. 5: UV spectra of AgNO3 solutions with and without the tragacanth polymer.

Figure 5 illustrates that in the absence of the tragacanth polymer, the AgNO3 solution has no absorption peak and remains in the Ag1 stage; however, when the tragacanth polymer is present, AgNO3 converts to silver nanoparticles, which can be seen clearly at 421 nm (Fig. 5, inset). As a result, the tragacanth polymer clearly aids in AgNO3 reduction. The endurance of metal nanoparticles is mainly attributed to the adsorption of polymeric chains onto the crystalline planes of the nanoparticles. The development of hydrogen bonds inside the polymeric chains is caused by intramolecular and intermolecular interactions of the tragacanth polymer and these networks provide nanoscopic domains in which nanoparticles can grow, similar to hydrogel network systems.

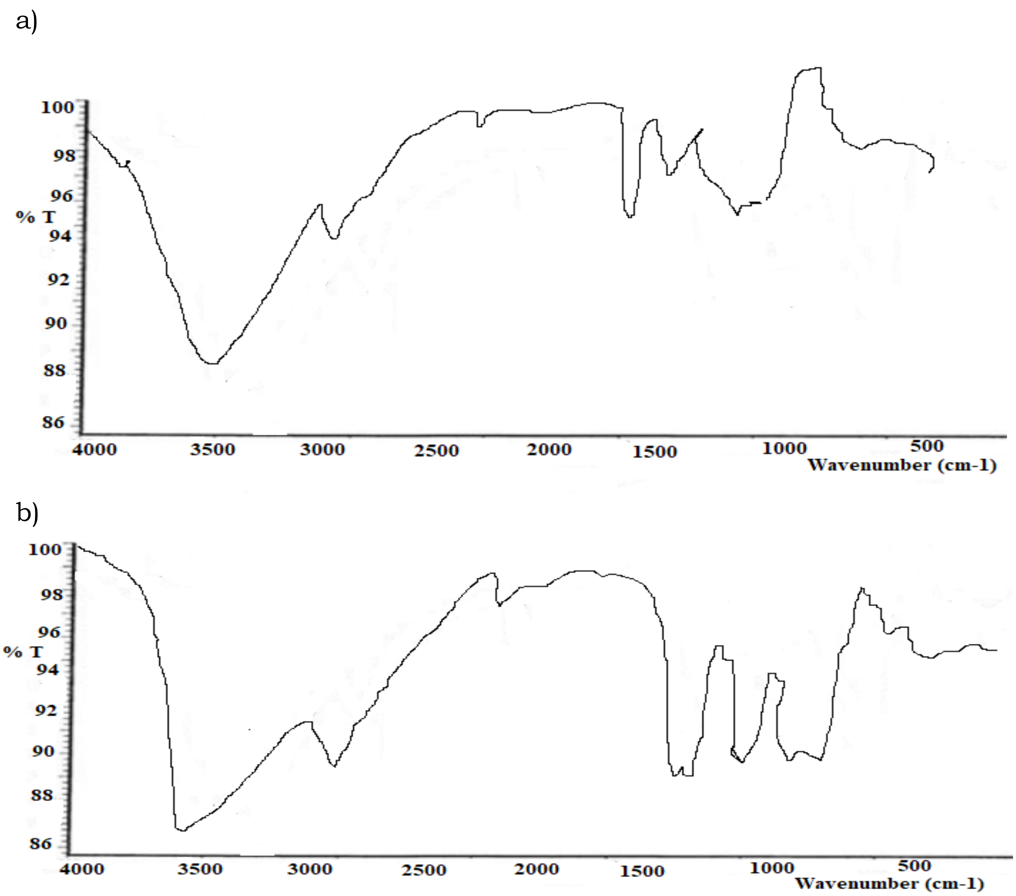


Fig. 7: FTIR spectra of (a) tragacanth and (b) tragacanth–silver nanoparticles.

The particles are surrounded and protected for longer periods of time due to the polymer's ability to mix with silver metal nanoparticles via carboxyl-functional groups in polymeric chains and networks. On the other hand, a significant physical adsorption of the tragacanth polymer onto the surface of the silver nanoparticles indicates better stability. The adsorption of tragacanth polymer chains onto silver nanoparticles is clearly demonstrated by the presence of an extra peak at 1657 cm in the tragacanth–silver nanoparticle system's Fourier transform infrared (FTIR) spectrum [COO2 group linked to silver particles; Fig. 6 (b). In pure tragacanth polymer, this peak is completely gone Fig. 6 (a). Furthermore, the OH and COOH groups at 3504 cm2 had varied shapes and peak positions due to their contributions to the reduction and stabilisation processes.

Conclusion

We discovered a highly superficial, easy, cost-effective and environmentally friendly perspective during synthesizing silver nanoparticles without the requirement of any reducing agent in the presence of the tragacanth polymer. Tragacanth was utilized as a reducing agent and stabilizer in this exploration. The constitution of tragacanth in respect to AgNO3 permit compel control of silver nanoparticle size. The generation of silver nanoparticles by tragacanth polymer networks has been exhibit utilizing FTIR, UV–vis, XRD, XPS and TEM. The silver nanoparticles that have been developed to possess a six-month shelf life. Other metal nanoparticles may additionally be made using this technique.

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