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MINI-REVIEW

Carboxymethyl Cellulose (CMC) based Green Synthesis of Metal and Metal Oxide Nanoparticles and its Applications

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Due to its distinct and unique surface morphology, mechanical strength, tunable solubility in water, viscous properties, ease of access and enormous amount of raw materials, low-cost synthesis process and similarly several more opposing characteristics, carboxymethyl cellulose (CMC) based materials have wide applications. While synthesizing nanoparticles, CMC appears to be better as both a reducing and stabilizing agent. CMC would have no detrimental effects on human health or the environment and also is non-toxic and biodegradable. Hence, CMC mediated metal and metal oxide nanoparticles have multiple benefits in the areas of antibacterial, antimicrobial, antidiabetic, anti-inflammatory, wound healing, antioxidant, as well as optical properties. In this mini-review article, the role of carboxymethyl cellulose (CMC) is highligted in the fabrication of nanoparticles.

Keywords: Carboxymethyl cellulose, Green synthesis, Biological activities.

INTRODUCTION

The science of modifying matter at the microscopic and molecular scale is referred as nanotechnology. In nanotechnology the size of materials are reduced which enhanced the physical properties of materials. The ability to create precise machine components and molecularly small components is essential towards nanotechnology [1]. One of the ideas in research and technology that has seen rapid development is nanotechnology, which has undergone tremendous advancements in recent years. With its distinct physico-chemical features, nanomaterials have the potential to inspire the development of novel systems, structures, methodologies and nanoplatforms with applications in many different fields [2,3]. Innovative applications of nanotechnology can be found in the areas of technology, electricity production, optics, drug delivery and environmental sciences [4]. Nanoparticles are composed of carbon, metal, metal oxides or organic matter and differ in size from 1 nm to 100 nm [5]. Nanoparticles have advanced significantly due to their distinctive properties over the base material, which include their size, morphology, distribution, form, *etc*. [6,7].

Role of carboxymethyl cellulose (CMC) in green synthesis: Water-soluble carboxymethyl cellulose (CMC) is a linear polysaccharide in which 1,4-glycosidic bonds bonded with the adjacent repeating units. Only few anionic carboxymethyl groups (*i.e.* -CH_2COOH) in the CMC structure. The major difference in the structure of the CMC and cellulose is that in CMC some hydroxyl group of cellulose is replaced by carboxyl group [8]. The synthesis of CMC was first based on particular wood-based plants because of the archetypal celluloses were often derived from wood and certain other plant based precursors that usually seemed to have a significant percentage of fibres. Moreover, daily cellulose containing items have been recommended in the literature by various researchers as appropriate substitute possibilities in this situation (Fig. 1) [9].

Researchers have shown an interest using waste product in the manufacturing of CMC by using textile waste, cotton grain wastes, *etc*. [10-15]. Due to its ecological, sustainable and non-toxic properties, carboxymethyl cellulose (CMC), a class of known water-soluble polysaccharides, is extensively utilized in the medicinal, ecological and agriculture sectors

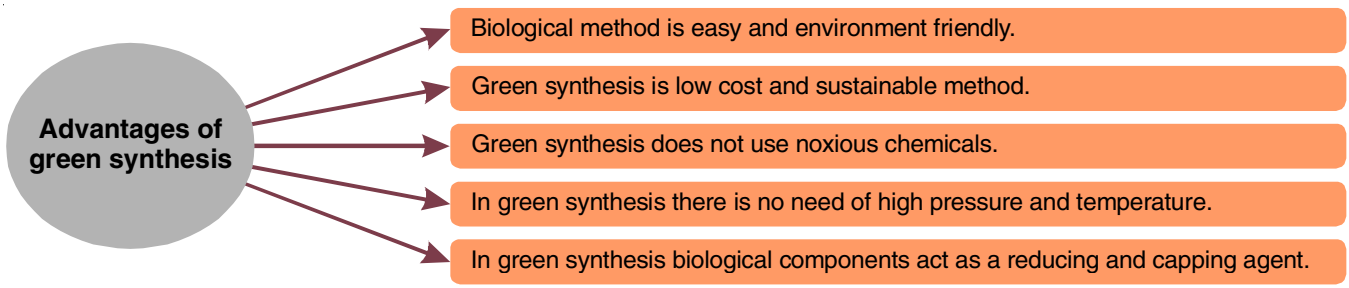

Fig. 1. Advantages of green synthesis used in the fabrication of nanoparticles

[16]. The materials synthesized by using CMC heavy good antimicrobial and antioxidant due to their pH and hygroscopic nature [17-21]. Because of their extensive use in food products and their packaging as thickeners, emulsion stabilizer, adhesive stabilizers and moisture binds. High agitation is required for the proper mixing of sugar and other dry ingredients in the CMC solution. CMC is often used in beverages and beverage dry mixtures to offer rich sensation because of its excellent solubility as well as clarity of solutions [22].

CMC mediated metal oxide nanoparticles: CMC gels are one of the most promising materials for use as drug carriers in therapeutic applications, and as such, they have received a great deal of interest from researchers. To further reduce drug toxicity and adverse effects, CMC mediated metal oxide nanoparticles can keep drug concentration at a constant level for an extended period of time *via* gradual release. Drug-loaded CMC mediated metal oxide nanoparticles have been shown to effectively prevent the growth of several malignant tumours, including cervical cancer, liver cancer, glioma and others.

Asghar *et al.* [23] synthesized silver-based nanocomposite fabricated from carboxymethyl cellulose using *Syzygium aromaticum* buds extract for various therapeutic applications *via* green synthesis. The nanocomposite is successfully evaluated for the antimicrobial, anti-inflammatory, anti-leishmaniasis and antioxidant efficiacy with limited cytotoxic potential.

A nanohybrid of iron oxide and carboxymethyl cellulose for the killing of cancer cell is reported by Leonel *et al.* [24]. In this, a new core-shell super-paramagnetic nanofluids were synthesized using a sustainable colloidal aqueous method. These nanohybrids were composed of magnetic iron oxide and cobalt doped nanoparticles along with the carboxymethyl cellulose. The impact of the molar concentration of cobalt and CMC on the physical and chemical properties of the synthesized nanohybrids confirmed that the electrostatic equilibrium of the charges on the nano-conjugates changed substantially, which results in the greater surface interactions. These magnetic nanohybrids were effective as nanoheaters against brain cancer cells *in vitro*, suggesting their potential applications in oncology and nanomedicine.

Recently, Pagadala *et al.* [25] fabricated an efficient multifunctional nanocomposite containing pectin as precursor incorporated in the zinc oxide nanoparticles. In this synthesis, *Psidium guajava* leaf extract was also used as a stabilizing and capping agent. The antibacterial effectiveness against *E. coli*, *Bacillus*, *Streptococcus aureus* and *Klebsiella*. It was observed that addition of ZnO nanoparticles to the biofilms strengthens their mechanical but also antibacterial capabilities while also providing an excellent water vapour blocking capacity. Similarly, James *et al.* [26] synthesized casein/carboxymethyl cellulose nanocomposite for enhanced antibacterial activity using aqueous bark extract from *Syziguim cumini* (Java Plum) as a stabilizing as well as reducing agent to synthesize gold nanoparticles in CMC and CAN (casein) blend nanocomposites hybrid film. The biological studies were examined *in vitro* utilizing the surface inoculation method. The findings reveal that the addition of nanoparticles to the polymer matrix strengthened the antibacterial activity of the CAN/CMC blend, allowing it to be utilized into food packaging.

Thuy *et al*. [27] also reported a fabrication of biocomposite containing green synthesized silver nanoparticles by using *Plectranthus amboinicus* leaf extract, which act as a reducing and stabilizing agent, which further integrated with carboxymethyl cellulose as well as polyvinyl alcohol (CMC/PVA). In accordance with the DLS findings, biogenic AgNPs had a polydispersity index of 0.44 and then an average particle size of 65.70 nm. The CMC/PVA films that included AgNPs demonstrated higher morphological as well as mechanical capabilities over the neat CMC/PVA film, moreover surpressed few bacterial species *e.g. Salmonella typhi, Staphylococcus aureus, Bacillus spizizenii* and *Escherichia coli*.

The antibacterial, antifungal and anticancer potential of the newly synthesized CMC based silver nanocomposites as reported by Salem *et al*. [28] were also investigated. The antibacterial activity results indicated that CMC-AgNPs possess effective antibacterial effect against both Gram-positive (*Bacillus cereus* and *Staphylococcus aureus*) and Gram-negative bacteria (*Klebsiella oxytoca* and *Escherichia coli*). Antifungal activity of CMC-AgNPs was also demonstrated against the filamentous fungus *Aspergillus fumigatus*, *Aspergillus niger* and *Aspergillus terreus*. The minimum IC_{50} values of the synthesized nanocomposite exhibited that it has good cytotoxic activity for the HepG2 hepatocellular tumor cell. Moreover, the result of this study indicates that the anticancer activity of all these CMC-Ag nanoparticles is carried about through the stimulation of necrosis and fatality in hepatic tumor cell by higher caspase-8 and -9 activities as well as reduced the level of VEGFR-2.

Solomon *et al.* [29] also synthesized silver nanoparticles using carboxymethyl cellulose and honey as a precursor. The electrochemical impedance spectroscopy was also used to analyze the surface assistant of the synthesized nanocomposite. The SEM, AFM and FTIR stuies have been used to compare CMC and CMC/AgNPs composite and the result shows that

the composite show better performance. For the St37 sample, AFM and SEM visualizations demonstrate a smoother texture in the acidic medium along with the inhibitor as compared to the solution without any of the inhibitor.

Fekri *et al.* [30] synthesized strontium nanoparticles in the presence of carboxymethyl cellulose for *in vivo* imaging studies *via* green synthesis. Target substances were layered with wall elements to build microcapsules with in encapsulation method. In this work, an sonochemical methodology for the wet chemical synthesis of strontium nanoparticles within CMC nanostructures was applied provided. During utilization *in vivo* imaging analyses, stronium nanoparticles were trapped in green capping agent either by using different weight percentage to produce an efficient microstructures.

Conclusion

Over the past few years, there has been a greater awareness among scientists of the need to refine and perfect methods for synthesizing nanoparticles. This mini review compiles research on the use of carboxymethyl cellulose in the environmental friendly synthesis of some of the most well-known and efficient metal and metal oxide nanoparticles.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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